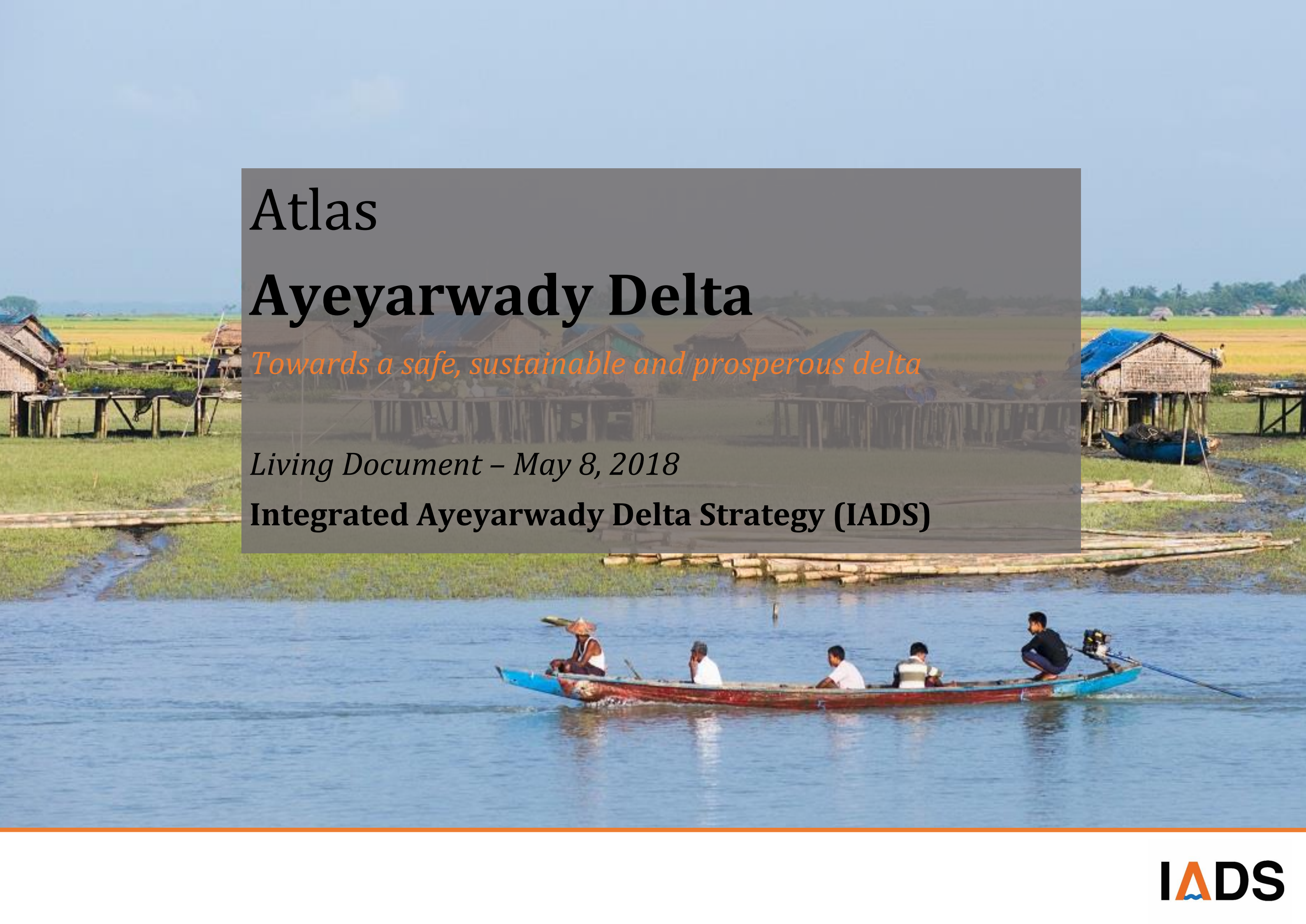




Atlas Ayeyarwady Delta

Towards a safe, sustainable and prosperous delta

Living Document – May 8, 2018

Integrated Ayeyarwady Delta Strategy (IADS)

Disclaimer

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Atlas

Ayeyarwady Delta

Towards a safe, sustainable and prosperous delta

Living Document



A collaborative initiative between Myanmar and the Netherlands

Integrated Ayeyarwady Delta Strategy (IADS) consortium:



Foreword

This ‘Delta Atlas’ has been developed in the framework of the ‘Integrated Ayeyarwady Delta Strategy’ (IADS) Project. This project is initiated by the government of the Republic of Union of Myanmar who has asked for a collaborative initiative with the government of the Netherlands to support them in the development of a strategy and masterplan for the vulnerable Ayeyarwady Delta. The National Water Resources Committee (NWRC) appointed the Delta Development Working Committee to work together with the representative ministries of Myanmar and the IADS Project team, a consortium of Dutch companies, knowledge institutes and Myanmar partners. The ‘Delta Atlas’ is the first delivery in the overarching project of developing a future masterplan for the development of a safe, prosperous and sustainable delta. The multi-stage project involves:

- Determine the state of the delta by creating a ‘Delta Atlas’;
- Develop an adaptive Integrated Ayeyarwady Delta Strategy taking into account the current situation and expected or possible future trends, development and uncertainties;
- Concretize the strategy in adaptive development pathways with short, middle and long-term measures.

This strategy cannot be accomplished on its own, since local knowledge and understanding is essential for the transition and successful implementation of the delta strategy. Therefore, a close pro-active participation of decision makers and local/regional communities is needed, which is why this process is framed as:

“Step by Step Together”

The involvement of Myanmar counterparts takes place by several community sessions, stakeholder involvement meetings and working group sessions. Together a step by step process of mutual understanding and support will result in the safe, prosperous and sustainable strategy of the Ayeyarwady Delta on the long term.

The ‘Delta Atlas’ can be considered as a visual, easy-to-understand and comprehensive mapping of the current state of the delta. The delta exists of the interacting surface and sub-surface elements, that eventually resulted in the current occupation and use of the delta, and supporting governance. The structure of the atlas is in line with the spatial-layer model frequently used in mapping of deltas by dividing a delta in four layers; 1) baseline, 2) network, 3) occupation and 4) governance. The atlas should not be interpreted as a scientific report, but objectives can be stated as:

- A collection of fragmented information sources and data;
- A comprehensive overview, that can be used for easy data search and checking in the future;
- Showing the relation and integration between different components and involved departments;
- Get a feeling of the functioning of the overall delta system;
- A capacity building tool;
- Creating a document for easy communication and further extension of data.

Having this in mind, this atlas could be handled in an updated form in the future, when additional information comes in. In addition, the atlas includes expected and observed trends of development, which can help decision-makers in compiling their policy plans under the uncertain future development. We truly hope that by reading and understanding the atlas, a shift in thinking will be triggered of seeing the whole delta as an interacting system instead of separate components.

Partners & sponsors

National Water Resources Committee (NWRC) and the NWRC Secretariat via Directorate of Water Resources and Improvement of River Systems (DWIR), Ministry of Transport and Communication



The Netherlands Government via the Netherlands Enterprise Agency (RVO)



Netherlands Enterprise Agency

Authors

We would like to thank all the authors who contributed in the development of the Delta Atlas for the ‘Integrated Ayeyarwady Delta Strategy’ project. In particular, we thank:

Johannes de Groot (Arcadis), Rob Steijn (Arcadis), Tanya Huizer (Arcadis), Jasper Verschuur (TU Delft), Enrico Moens (Sweco), Melle Ykema (Sweco), Tjitte Nauta (Deltares), Arie van Duijn (WUR), Peter Kerssens (Haarlem Hydraulics), Hermjan Barneveld (HKV), U Khin Latt (NEPS), U Aye Myint (NEPS), Khin Myat Thu (NEPS), Andrew Wyatt (IUCN), Zin Myo Thu (IUCN) and Zin Thaw Oo.

Acknowledgements

We gratefully acknowledge the generous support and participation of the Myanmar Government and Universities: National Water Resources Committee (NWRC), NWRC Advisory Group, Hydro Informatics Centre (HIC), Ayeyarwady Delta Working Committee, IADS Working Group members, Ministry of Transport and Communication, Ministry of Agriculture Livestock and Irrigation, Ministry of Natural Resources and Environmental Conservation, Ministry of Construction, Ministry of Home Affairs, Ministry of Education, Ministry of Social Welfare Relief and Resettlement, Ministry of Planning and Finance, Ministry of Hotels and Tourism, Ministry of Electric Power and Energy, Ministry of Labour Immigration and Population, Ayeyarwady Region, Yangon Region, Bago Region, Yangon City Development Committee, Myanmar Maritime University, Yangon Technological University, Pathein University, Yangon University and Myanmar Engineering Society.

We also would like to thank all organisations that contributed in many ways to this Delta Atlas: Embassy of the Kingdom of the Netherlands in Yangon, International Water Management Institute, World Wildlife Fund, United Nations Office for Project Services, Hydronumerics, eWater, International Union for Conservation of Nature, International Centre for Environmental Management, Myanmar Information Management Unit, Wildlife Conservation Society and American Red Cross.

Special thanks to the Delta Alliance for delivering great input from previous studies such as the Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar (2015).

Furthermore, we would like to thank all others for their input and suggestions to improve this atlas.

Introduction

Myanmar faces an exciting and challenging future, with a newly established government since March 2016 and all kind of plans for fast development. The government of Myanmar acknowledges that integrated water management is one of the building blocks for the sustainable development towards peace and prosperity. The Ayeyarwady and its Delta are unique in the sense that large parts are relatively undeveloped, while at the same time rapid developments are taking place elsewhere. The Ayeyarwady River Basin, including its Delta, plays a key role in the socio-economic developments of the country, such as food production, water supply and inland water transportation. Different physical stressors have impacted the development options of the delta, such as for example mangrove degradation, salinization, cyclones, floods and poor infrastructure. Climate change and fast socio-economic developments, including demographic developments, will increase the complexity to reach a sustainable future for the delta. But one thing is clear: the need for flood safety and food security is unquestionable.

Adaptive Delta Management

To be able to come up with a future strategy for the delta, the current state must be first determined and documented. This forms the basis for further actions and therefore data collection is essential. The atlas is structured according to a spatial layer model approach, which helps understanding the relations between human activities, and physical and ecological delta conditions. Three physical layers are described: The **Baseline layer**, the **Network layer** and the **Occupation layer**, as shown in Figure 1-1.

These layers are controlled and regulated by governance, adding another layer to the framework, namely the **Governance layer**. It can be stated that governance has the most influence on the occupation layer and least on the baseline layer, whereas the reverse applies for the general public. These layers cannot be seen independent from each other, but are highly interconnected. For example, the geological conditions in the baseline layer to a large extent determine the agricultural output. The atlas setup also enables to envision future trends for each layer based on the drivers of change for each layer. The main drivers of change are economic development, population growth, technological development, climate change and subsidence. However, more drivers can be identified. Economic development and population growth (occupation) are the most direct drivers of change. These trends determine the pressures on the network and baseline layer. Increasing population demands more transportation possibilities, access to water, energy and so on. Therefore, the developments in the occupation layer indirectly show the expected developments in the two other layers supported by government decisions how to accompany these developments.

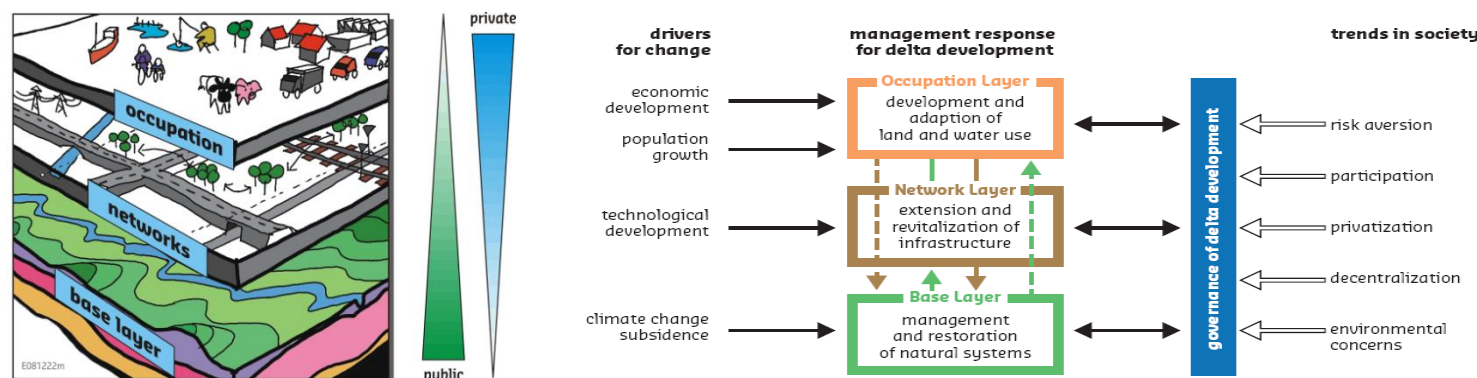


Figure 1-1 Overview of the different layers and connections (Delta Alliance, 2015)⁹

Baseline layer

The baseline layer typically encompasses the geological, climatological and environmental conditions of the delta. For deltas in particular, this is the relation between water and soil. In deltas, especially the sediment dynamics between sea, river and hinterland is important. Disturbance in the original balance, for example sea level rise due to climate change, can result in land losses, whereas the same can happen in case of the construction of a dam upstream. Also, the river branches often do not follow the same profile throughout the year, but morphological responses cause changes of the river.

Network layer

The network layer concerns the extension and revitalisation of infrastructure. Types of infrastructure are transportation networks (like road, water, rail and air), vital infrastructure for health and economy like hospitals, energy, drinking water supply, sewerage and irrigation systems and embankments. The latter two are often important in high flood vulnerable deltas with agriculture as main driver of the national and international economic market.

Occupation layer

The occupation layer describes the developments and adaptation of land and water use. For a large extent, the population settlements are determined by the base and network layer. As is the case with a lot of delta cities, these cities are formed along the river with fertile grounds for agriculture, opportunities for fishery and favourable locations for transport and trade. It shows the sociological, economical and agricultural developments over time.

Governance layer

The governance acts on all three layers by a mix of government responsibilities and private or non-governmental actor roles. The governance can enact influence on the occupation layer by mainly zoning regulation and building codes. For the network layer, the government is responsible for the development and maintenance of infrastructure. However, some infrastructural networks such as drinking water and energy supply are often transferred to a public-private cooperation or private ownership. Furthermore, the government has an important role in protection and management of the base layer, for example controlling the extraction of natural resources (water, oil and gas). The instruments for this are legitimized by means of national and international laws and obligations. This often happens in a multi-actor environment with government, non-governmental organizations and other stakeholders.

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Baseline Layer



1 Baseline layer

1.1 Geography

Myanmar, known as the golden land for its fertile land and rich natural resources, lies between latitude about 10°N to 28°N and longitude 92.5°E to 101.5°E. It is located between Bangladesh and India in the west, China to the north and Laos and Thailand to the east. The country is enclosed by the Bay of Bengal in the west/southwest and the Andaman sea in the south. A horse shoe shaped high mountain range caps the country. Wide plains and river valleys are commonly seen in the central part. There are three parallel chains of forested mountain ranges that run north to south. The four major river systems: the Ayeyarwady, the Chindwin, the Sittaung and the Thanlwin cover most of the country. The Ayeyarwady River is the most important water way for transportation in the country. The river originates from the Himalaya mountains, and is fed by glacier melt water as well as precipitation bringing sediments down from the mountainous areas. Torrential rains and floods occur in the mountainous areas and low-lying places like the Ayeyarwady Delta.¹ The delta system of the Ayeyarwady River extends in a great alluvial fan from the limit of tidal influence near Myan Aung (18°15'N) to the Bay of Bengal and Andaman Sea, 290 km to the south. This alluvial plain is bound to the west by the southern Rakhaing Yoma range and to the east by the Bago Yoma. The city of Yangon, situated on the southernmost spur of the Bago Yoma, lies at the south-eastern edge of the delta. The landscape of the delta region is very flat and monotone, with only a few blocks of erosion-resistant rocks that are never more than 18 meters in height.² The basin is divided in two parts, the Ayeyarwady valley and the smaller Sittaung valley. Fertile alluvial material from the river basins make the Ayeyarwady delta very suitable for agricultural practice. Next to that, the delta is rich in minerals, including metal ores, petroleum, and natural gas.

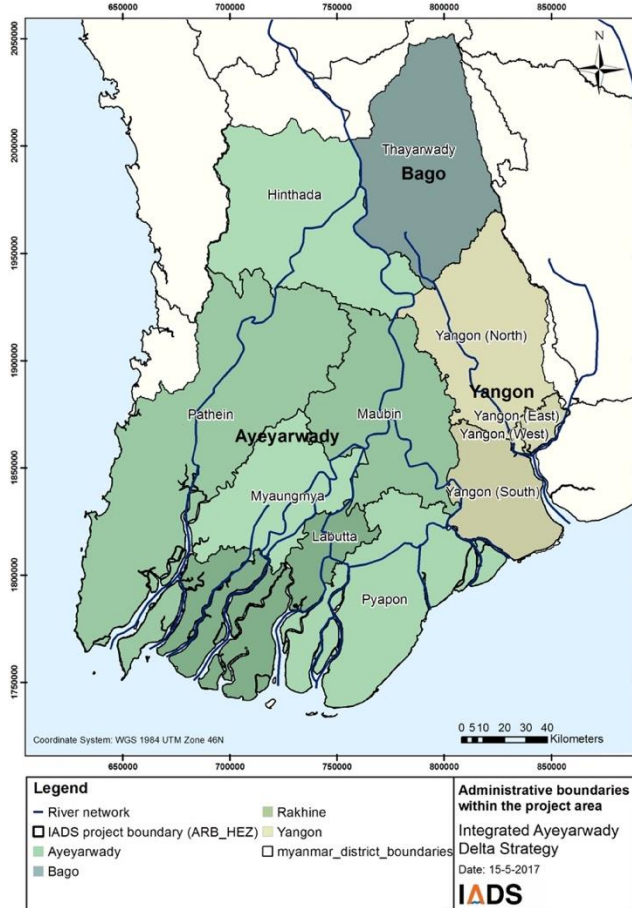
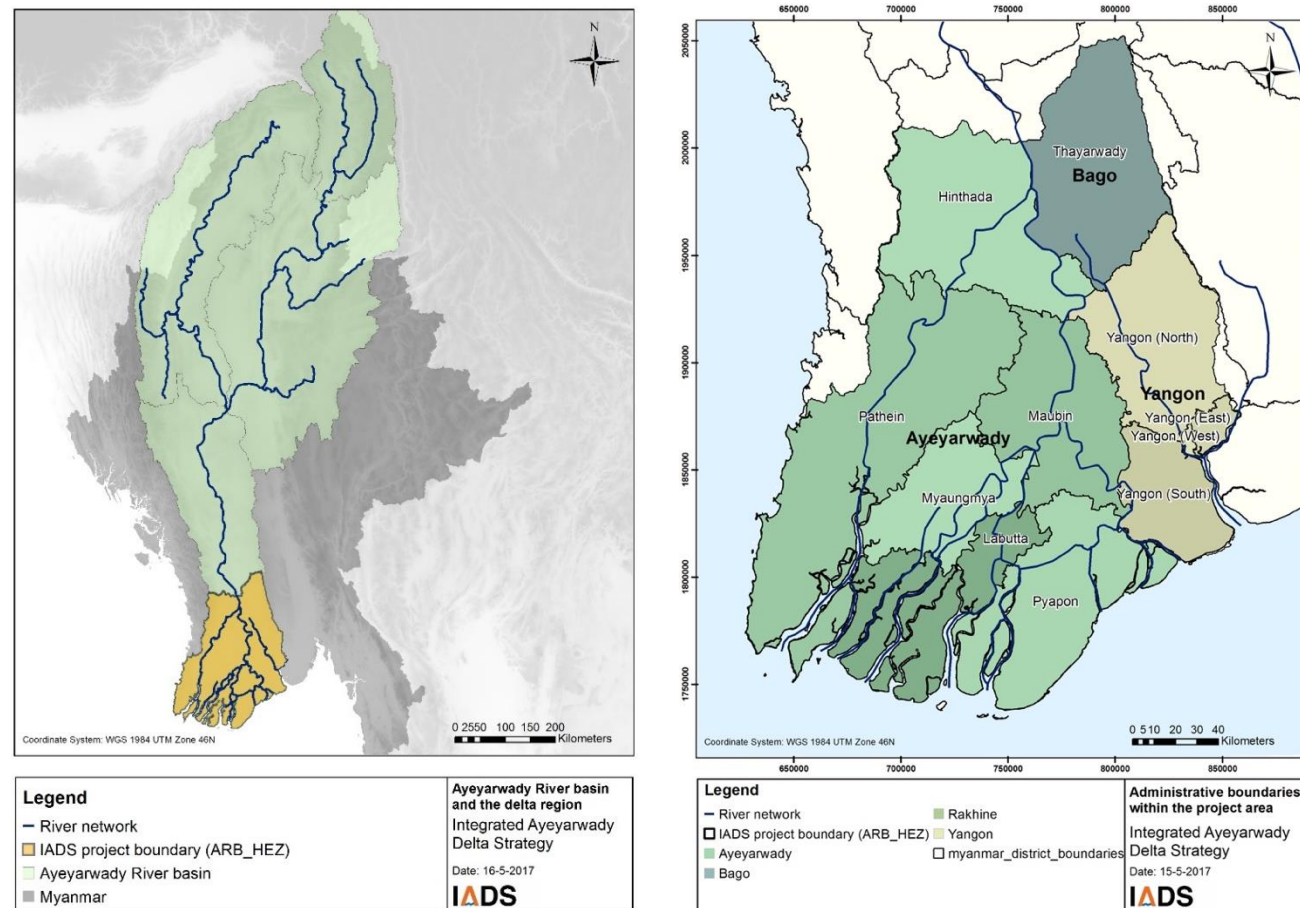


Figure 1-1 Left: the Ayeyarwady River basin and (project) boundaries of the delta. Right: region and district boundaries (MIMU, 2017)

¹ Zaw Lwin Tun, & Hla Oo New (2010), Flood Management at the national level, Myanmar.

² US Army Corps of Engineers (2008), The Geology of Burma (Myanmar)

Most of the delta area is part of the Ayeyarwady region (see Figure 1-1), the remaining area is part of Yangon Region and Bago Region. With a terrestrial area of 35000 km², the Ayeyarwady region is the 10th largest region by surface area from the total of 14 Myanmar States and Regions. The boundaries for the Integrated Ayeyarwady Delta Strategy project are based on the hydro-ecological zone (HEZ), which is defined for the Ayeyarwady Integrated River Basin Management (AIRBM) project (Figure 1-1). The hydro-ecological zone is extended to include the entire city of Yangon, which originally contained only the eastern part of the city. The reasons for extending this hydro-ecological zone are the urban/economic developments in this largest city of the country. These developments will influence the delta region in the form of pressures and larger needs for agricultural activities in the delta. The increasingly popular beach resorts near Chaung Tha and Ngwe Saung in the west of the Ayeyarwady Delta increase the demand for improved road networks and energy supply in the delta. The coastal boundaries for the project are defined 12 miles offshore, although interaction with the environment further offshore is inevitable and important for the delta. However, the focus lays on the current state and future developments of the Delta and not the state and developments of the marine zone. The Delta can be separated even more into three zones with their own characteristics, as will become clear in the baseline chapter, for example distinct cropping pattern, land-use, ecological zone, land-cover, river dynamics and so on (Figure 1-2). The zones are the Upper Delta, Middle Delta and Lower Delta respectively. In addition, two urban zones are covered in general, which are urban Yangon and urban Patheingyi.

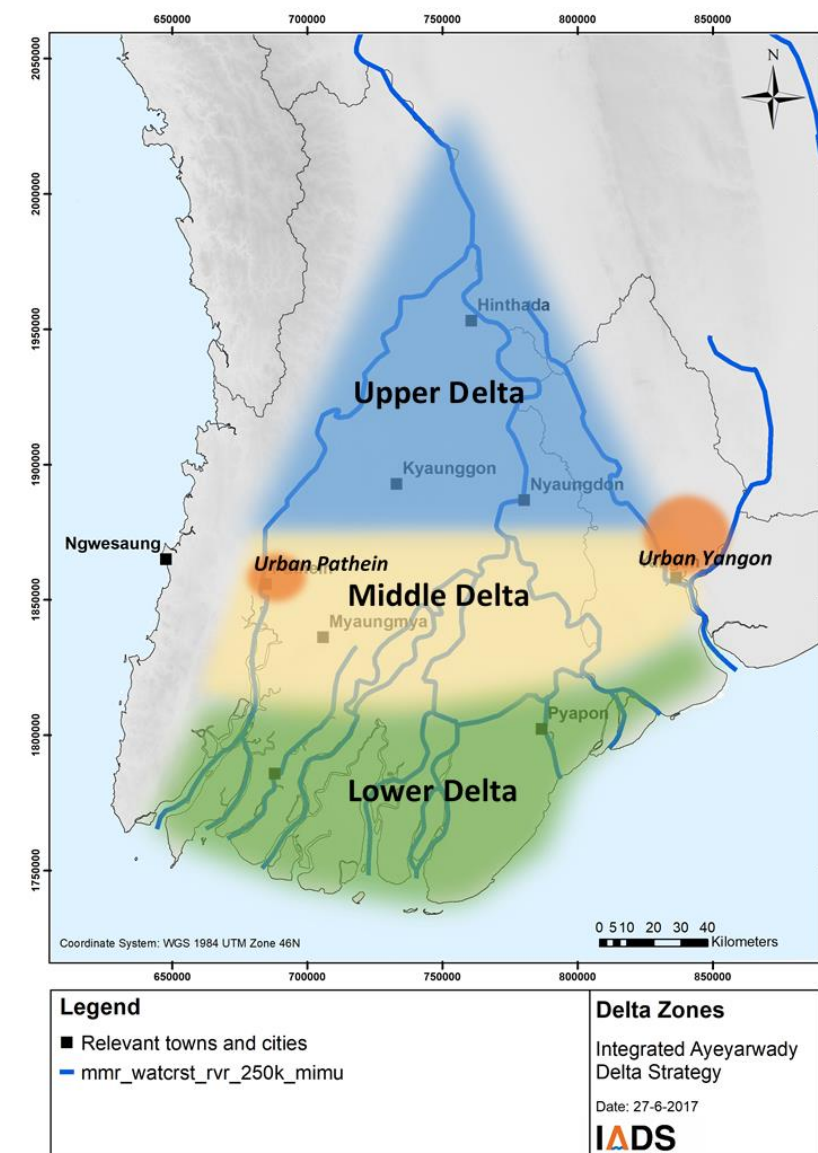


Figure 1-2: Different Deltas Zones as defined in the IADS project

1.2 Geological setting

1.2.1 Geological formations

The Ayeyarwady delta is surrounded by the Rakhine Yoma (west) and the Bago Yoma (east) mountain ranges. These form the hydrological boundaries of the Ayeyarwady delta. The Rakhine Yoma mountain range is created by tectonic movements between the Indian Plate and the Myanmar Plate in the western part of the country. Movements between the Myanmar Plate and the Sunda Plate in the east created the Bago Yoma mountain range (Figure 1-3). The 1500 km long active Sagaing Fault crosses the country from north to south, close to the cities of Mandalay, Nay Pi Taw and east of Yangon. Tectonic movements along the faults are regularly causing earthquakes in the northern part of the country.

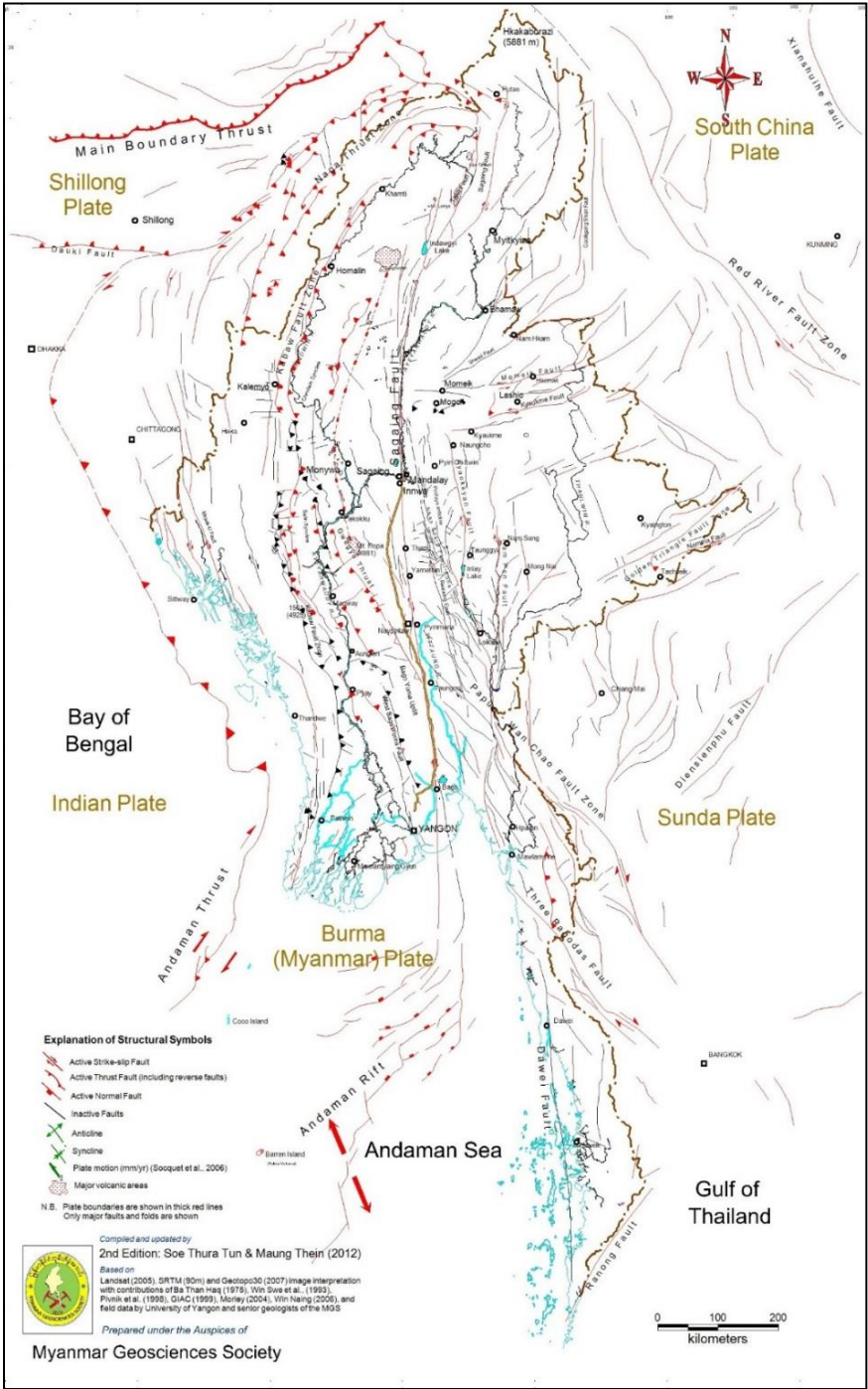


Figure 1-3 Geological structures and movements ³

1.2.2 Soil types

The Ayeyarwady delta is formed by alluvial activities during the Holocene era. This thick but relatively young soil layer is deposited by the branches of the Ayeyarwady River system. Three main types of soil have developed: meadow clay clay soils, meadow swampy soils and saline clay soils (Figure 1-4). The soil map shows the main soil types of the top layer. The properties of deep laying soils are generally sand, sandstone and siltstone formed during Miocene. ⁴ In contrast to the fertile alluvial deposits, some areas in the Ayeyarwady Delta are defined as being acid-sulphate soils. These soils have concentration of pyrite in its sub- and topsoil, which under exposure with atmosphere conditions undergo an oxidation process. In this process, a lot of acidity is produced in the soil lowering the pH. This occurs usually in swampy areas, being intermittently inundated by seawater during low and high tide (mangrove areas). Soil samples taken by the ‘Forest Research Institute’ ⁵ at the west-Pathein Township suggest acid sulphate soils with a pH of 5.5 at the surface and 3.8 at a depth of 50-60 cm. For comparison, the Bogalay township soil measured pH values of 6.8 at the surface and 6.6 at 50-60 cm depth. The difference can be explained by the different geological age of soils and the corresponding different type of soil. These acid-sulphate soils often lack certain minerals such as Ca and Mg, being essential for the growth of for example rice. This can be solved by adding lime or basalt, but large volumes may be needed. The soil samples of the west-Pathein Township and Bogalay township showed essentially a lack of Phosphorus, Calcium and Natrium in the acid soils, but they have high concentrations of Natrium and Magnesium. However, information about acid grounds in the rest of the delta is unknown.

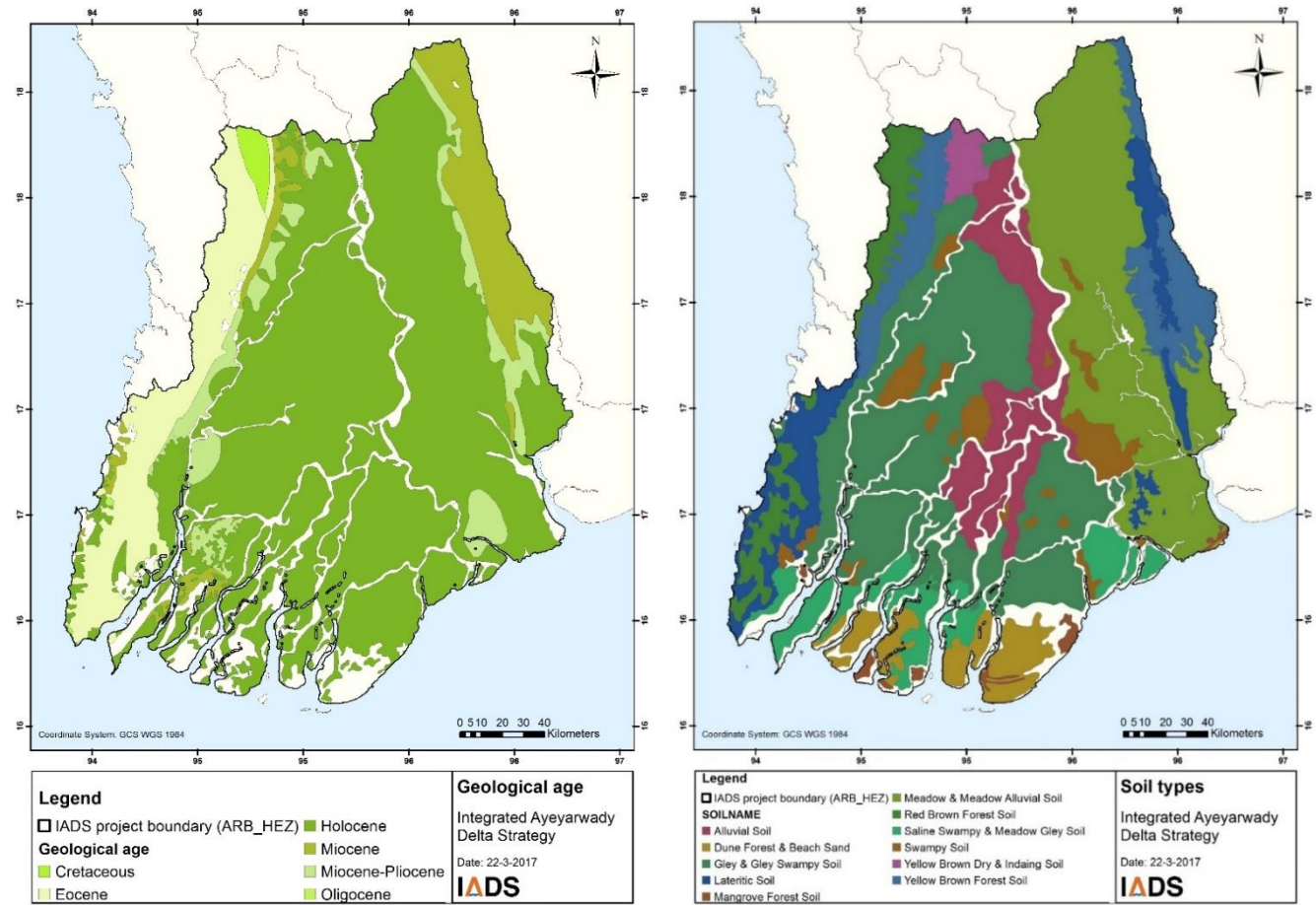


Figure 1-4 Geological age and soil types ⁶

⁴ Wandrey, C.J. (2006), Eocene to Miocene Composite Total Petroleum System, Irrawaddy-Andaman and North Burma Geological Provinces, US Geological Survey Bulletin 2208-E, 26p.
⁵ Daw Tin Tin Ohn and U Sein Thet (1991), Physical and Chemical Properties of Mangrove Forest Soils (1991), Forest Research Institute
⁶ FAO (2002), Myanmar Agricultural Atlas (2002)

1.2.3 Elevation and subsidence

The flood plain of the delta covering about 31,000 km² is less than about 15 m above mean sea level.⁷ Except for a few scattered hills and terraces the elevation differences are very low. Figure 1-5 shows the Digital Elevation Model (DEM) of the Ayeyarwady delta. So far, only DEMs are created by using satellite images with a low vertical accuracy. Nevertheless, the DEM can be used for exploring low laying areas, such as (abandoned) river branches.

Most deltas worldwide are subjected to the natural geological process of long-term subsidence. Additionally, extraction of groundwater and fossil fuels may cause significant lowering of the delta surface on the short term. Other short-term processes leading to delta surface lowering at a more local scale are shallow compaction and oxidation of organic materials (peat), which may also result from human activities. So far, no reliable data on subsidence in the Ayeyarwady delta is available. Some authors suggest a subsidence rate of 6 mm/y, although care should be taken when using this value⁸. Aggradation rates of 2 mm/yr and 1.4 mm/yr are suggested by the same authors for respectively the 20th and the 21st century.

The establishment of a structural ground water extraction and subsidence monitoring system should be considered for subsidence prone areas zones such as Yangon Region, where due to increasing urbanisation, population growth and industrial development the ground water extraction can be expected to increase due to higher fresh water scarcity.⁹ Especially in Yangon, expected subsidence rates are rather height bearing in mind the ongoing developments. Half of the domestic water use is supplied from city managed reservoirs, whereas the other 50% is supplied by other means. Largest share of the latter is via direct extraction of groundwater from the subsoil. Using data from the Sentinel-1 satellite, subsidence rates of 9 mm/y were found in part of Yangon.¹⁰ However, these rates cannot be validated using ground measurements, since such information doesn't exist. Therefore, subsidence rates for the delta and Yangon city are still rather hypothetical, but both results show some traces of subsidence, which cannot be left unaccounted for in further studies.

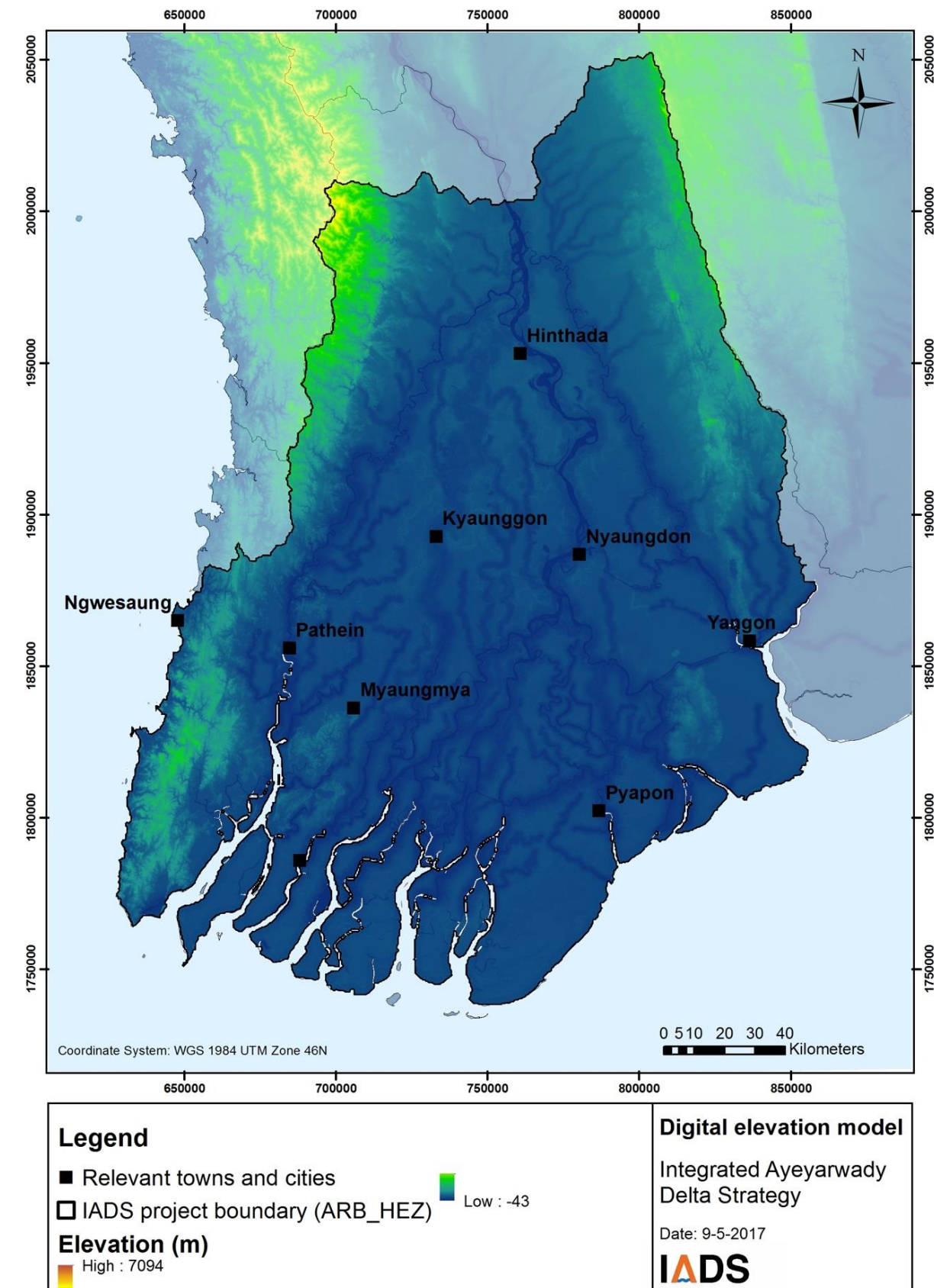


Figure 1-5 The Hydrosed digital elevation model (Lehner et al. 2008)

⁷ Hydraulic Research Station Wallingford (1982), A one-dimensional analysis of the tidal hydraulics of deltas, p4

⁸ Syvitski, J.P.M., Kettner, A.J., et al. (2009), Sinking Deltas due to Human Activities, Nature Geoscience, 2, 681-686

⁹ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

¹⁰ van der Horst, T. (2016), Sinking Yangon, Delft University of Technology

1.2.4 Groundwater

The country of Myanmar has 11 different types of aquifers, depending on their lithology and depositional environments. Therefore, groundwater aquifers largely vary in quality and quantity. Compared with neighboring countries Bangladesh and India, groundwater resources have been barely tapped, offering great potential. Figure 1-6 shows the groundwater potential (mm) per district. In Maubin and Pyapon districts, where most water of the Ayeyarwady River flows through, , the groundwater potential is the largest.

In many areas in the country arsenic is found in the groundwater aquifers. Arsenic in groundwater is of geological origin, and this contamination (if detected) can be flushed out by means of groundwater recharge. The degree of contamination depends on factors such as: depth, type of aquifer, topography, groundwater flow and hydraulic gradient, mineral composition of the aquifer, the boundary layers and the age.¹¹

In general, groundwater in some areas under confined conditions can be found in three different layers of aquifers. The first aquifer corresponds to the dug-well depth 20-50 ft. (6 – 15 m) and is assumed to be less safe for drinking water purposes because of contamination. The second aquifer is around 50- 250 ft. (15 – 75 m) and is contaminated with arsenic and iron. The third aquifer is located around 200 – 500 ft. (60 – 150 m) and seems to be free of arsenic. Most of the shallow tube-wells where the drinking water comes from are in the second aquifer. Although the third aquifer is most abundant in safe drinking water, it is hardly used since it requires advanced drilling technology, making it more difficult and costlier to get it.¹¹

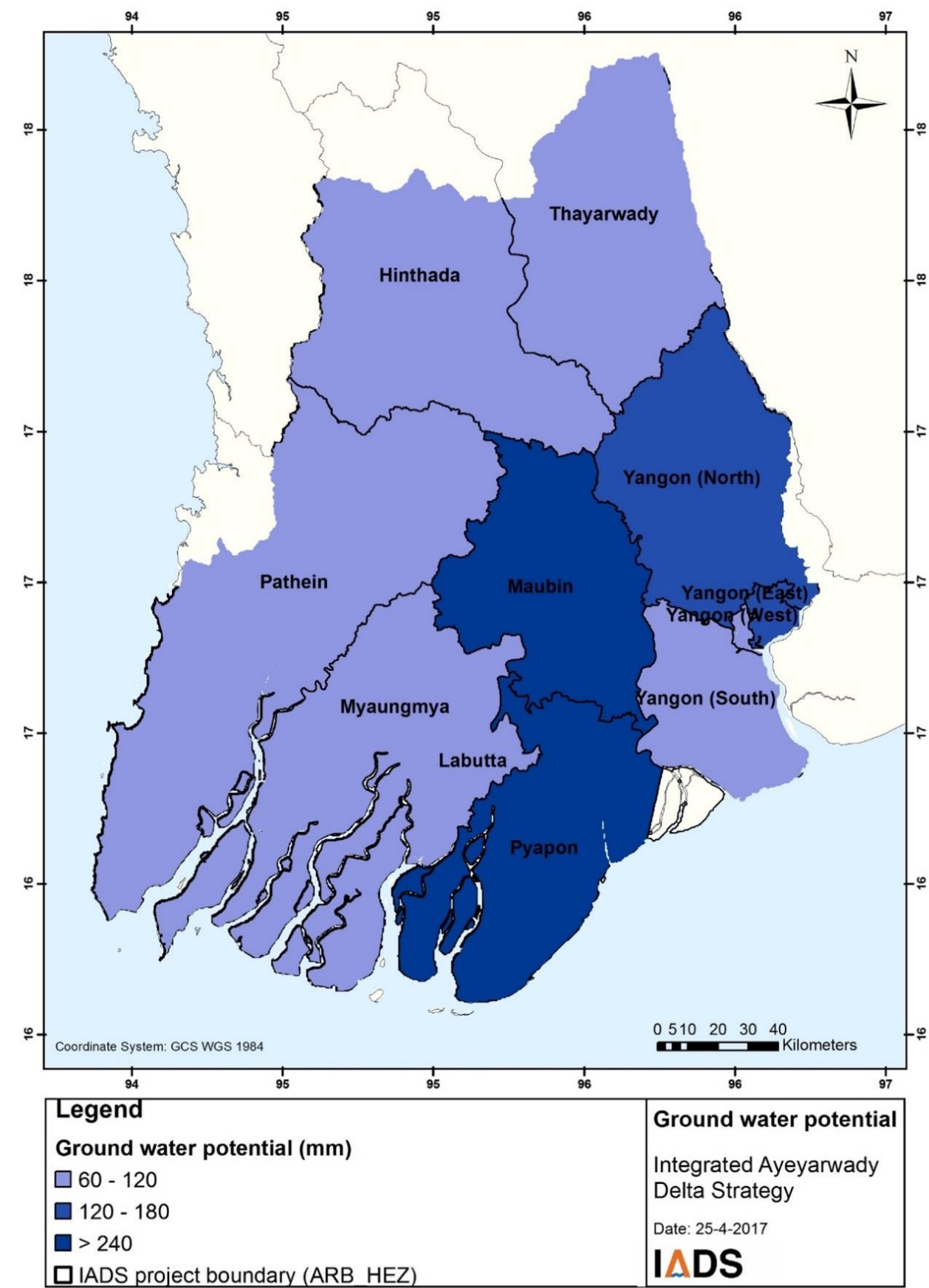


Figure 1-6 Ground water potential (mm) per district (FAO, 2002) ⁶

¹¹ Tet Nay Tun (2001), Water quality survey in 327 villages and wards located Pyonpyaw, Hinthada, Laymyathna and Thabaun Townships in Ayeyarwady Division, WatSan programma. Save the Children, Myanmar

1.3 Climate

Because of diverse landscapes of the country of Myanmar, several climates can be classified. For the delta, it is classified as a tropical monsoon climate. The climate is largely influenced by the Indian summer monsoon and convective rainfall from the Bay of Bengal.¹² Also, easterly winds and remnant of typhoons from the South China Sea can cause post monsoon rains from mid-October to the end of November.

The average annual rainfall in the delta is 1,500-2,000 mm in the north, increasing to 2,500 mm in the southeast and 3,500 mm in the southwest (Figure 1-7). Over 90 percent of the rain falls in the monsoon season, which starts mid-May and ends mid-October. Over these months, rainfall will increase with a maximum in July reaching rates of 600-700 mm per month in many places in the delta July (Figure 1-8). During this season, the maximum and minimum temperatures in the coastal zone are about 37°C and 22°C, respectively (Figure 1-9 and Figure 1-10). There are often strong winds from the south and southwest, causing rough seas. Cyclones can cause serious storm surges. The period from mid-October to mid-February is generally dry and cool. Temperatures rise after February, March, while in April and May the early monsoon is characterized by hot, variable weather with pre-monsoon squalls. Humidity is high throughout the year, but usually highest in monsoon season with humidity percentages of over 90% (Figure 1-10).

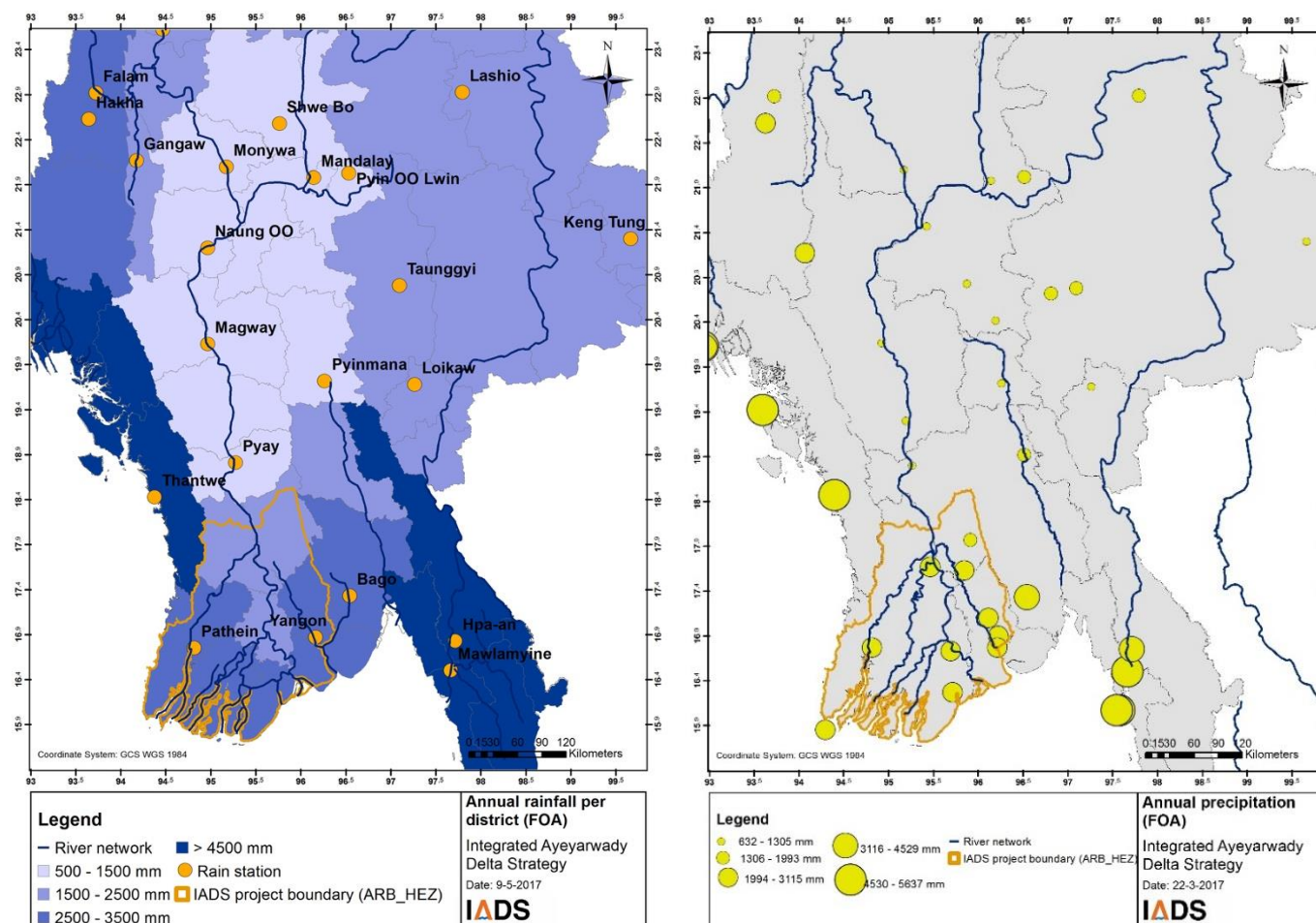


Figure 1-7 WMO Rainfall annual average and FOACIM Total annual precipitation (FAO, 2002)⁶

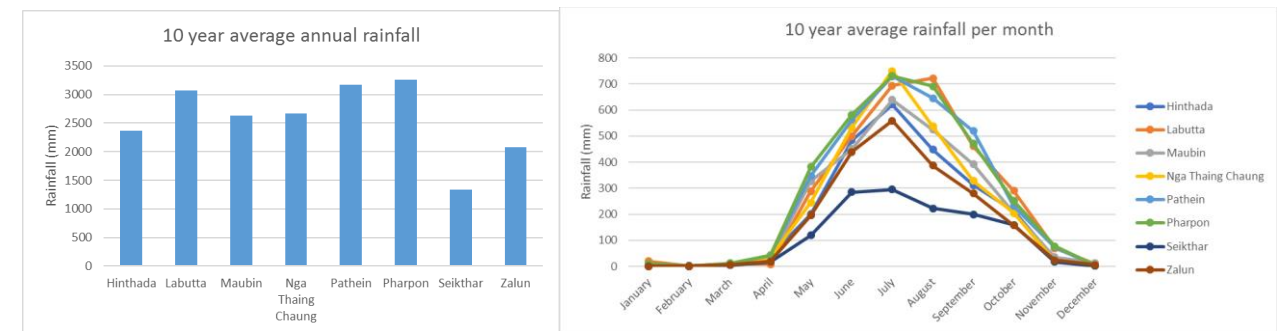


Figure 1-8 Left: 10-year average rainfall at various locations in the delta. Right: 10-year average rainfall per month (DMH, 2017)

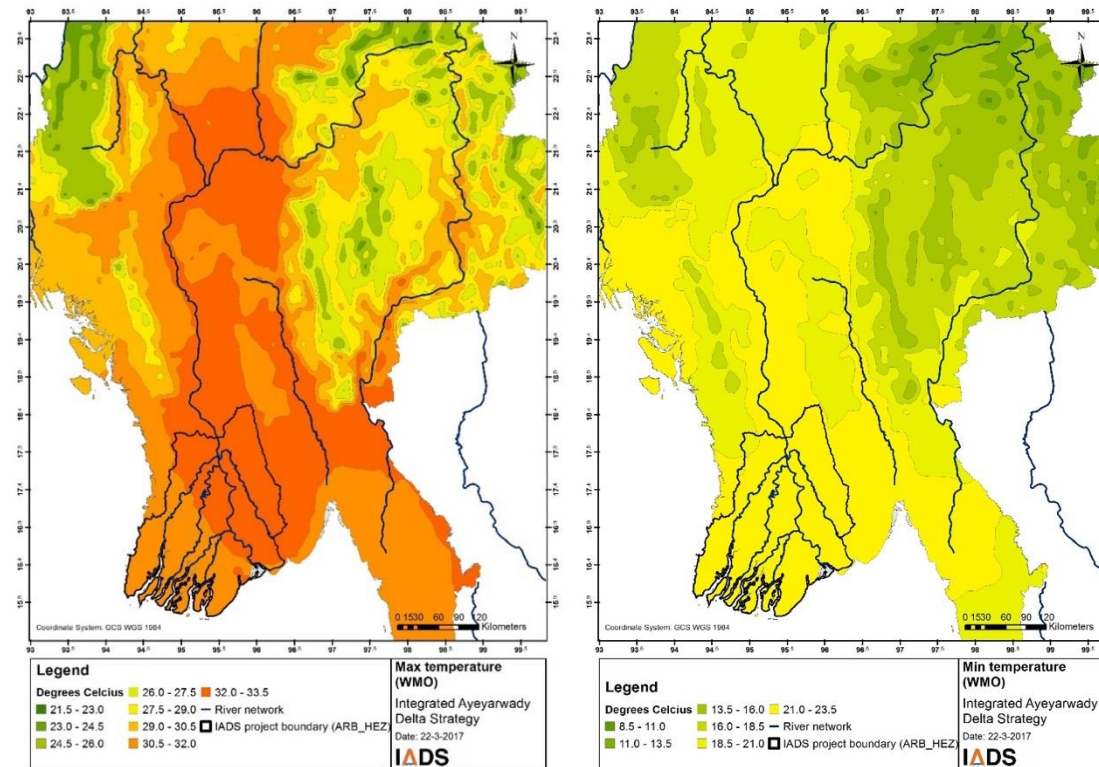


Figure 1-9 Maximum temperature (left) and minimum temperature (right), FAO (2002)⁶

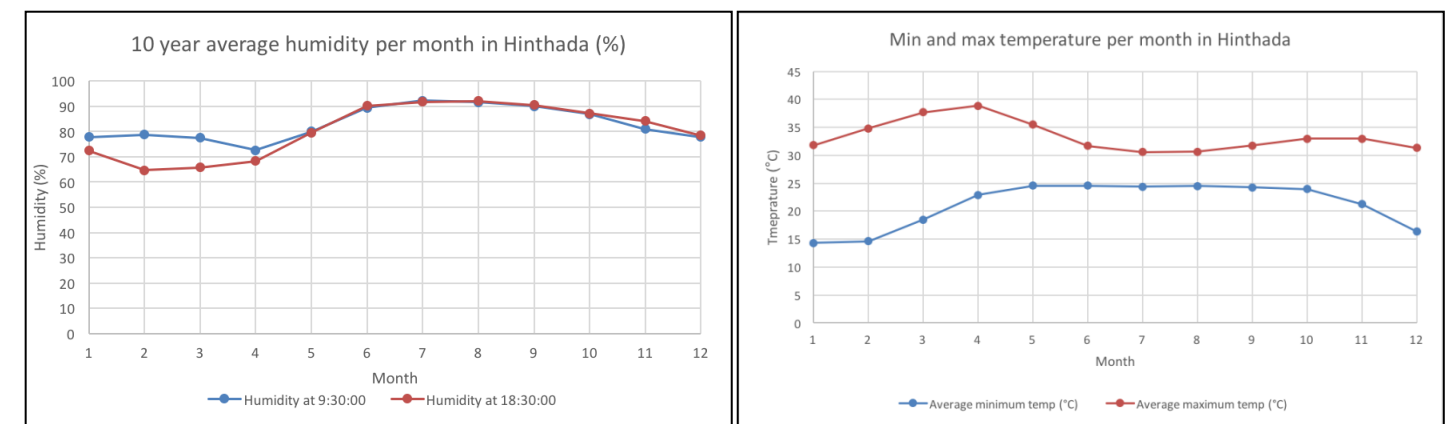


Figure 1-10 Temperature and humidity at Hinthada DMH station (DMH, 2017)

¹² Taft, L. and Evers, M. (2016), A review of current and possible future human-water dynamics in Myanmar's river basins, Hydrology and Earth Science, 20, 4913-4928

1.4 River hydrology and dynamics

1.4.1 River branches

The Ayeyarwady River distributes its water over many different branches in the delta (Figure 1-11). At the apex of the delta, about 40 kilometers north of Hinthada, the river splits up into three different branches: Pathein River, Ayeyarwady River and the Hlaing River. These rivers are only connected to the Ayeyarwady River during flood season. Further downstream, the Ayeyarwady River divides the water into a complex network of river channels, creating many islands within the delta. Most waterways are un-engineered natural water courses, and there is no extensive system of dredged canals. The only major canal is the Twante Canal, linking Yangon with the western part of the delta. Figure 1-12 shows many smaller channels and the estuary river mouths, created by the tidal movements in the lower part of the delta. So far, no accurate dataset of the river system has been created.



Figure 1-11 TM5 satellite image of the middle and lower Ayeyarwady delta (FAO, 2002)⁶

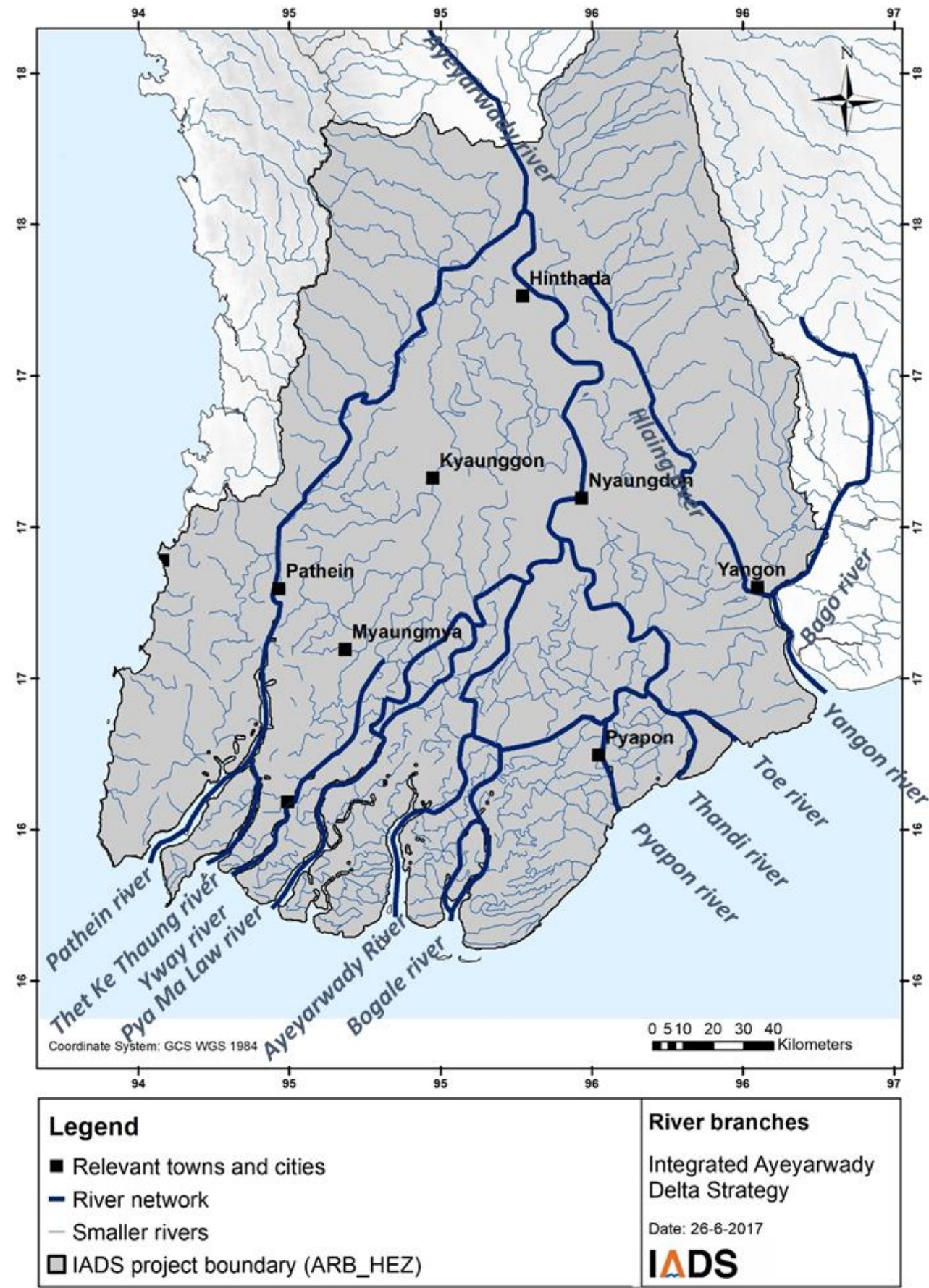


Figure 1-12 The main and smaller river network in the Ayeyarwady delta, FAO (2002) and MIMU (2017)

1.4.2 Discharge

The discharge in the Ayeyarwady River is at its lowest in February and March, with a sharp rise in April-May because of melting snow in the upper catchment. This rise is further enhanced in May-June with the onset of the monsoon. The maximum flow occurs in July and August in line with the maximum precipitation rates.

Various sources can be used to investigate the river discharge. Figure 1-13 (top) shows 15 years of discharge, measured by DMH, at the gauge station near Pyay. This location is located north of the first bifurcation of the river, containing an enormous amount of water before it distributes over the channel system in the delta. This station can be assigned to the Ayeyarwady River and the discharge entering the delta. During the months June, July and August (flood season), the average discharge is usually somewhere between 20,000-25,000 m³/s. The peak discharge reached almost 50,000 m³/s in the last 10 years.

River Watch¹³ is an experimental satellite-based river discharge measurement system, that measures the discharge by using passive microwave radiometry. At two locations in the delta, measurements are available: at Nyaunghtaw (100 km downstream of Pyay) and at Ngathaingchaung (Patheingyi river).

The measured discharge is compared with these remote sensing data (Figure 1-13 middle and bottom). The bottom graph shows the differences between the datasets. It shows that the remote sensing data underestimates the discharge during the flood season and over estimates the discharge during the dry season.

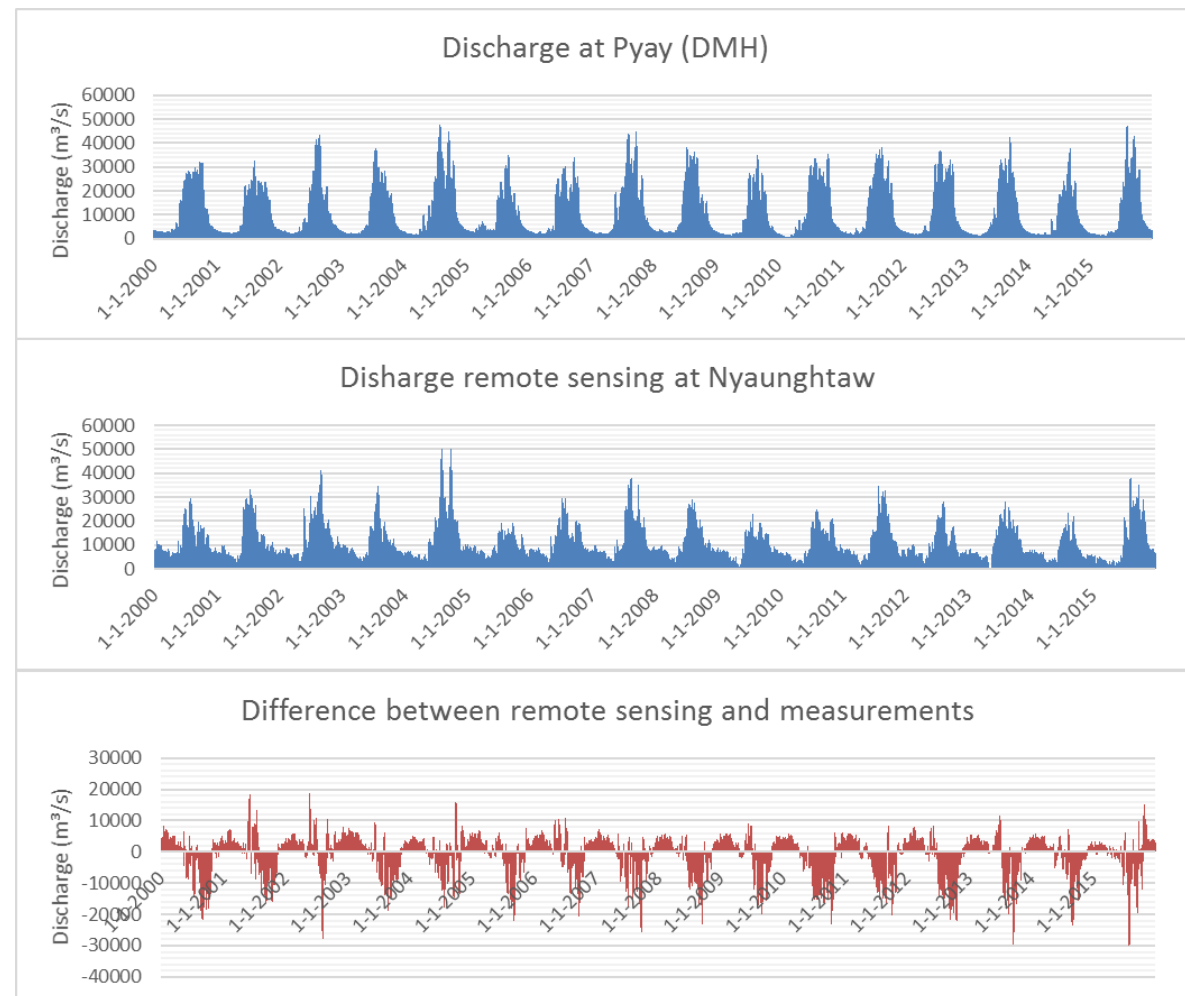


Figure 1-13 Comparison between measured discharge by DMH (2017) and the discharge measured by remote sensing (River Watch, 2017)

¹³ River Watch, Space based measurement, mapping and modelling of surface water, <http://floodobservatory.colorado.edu>

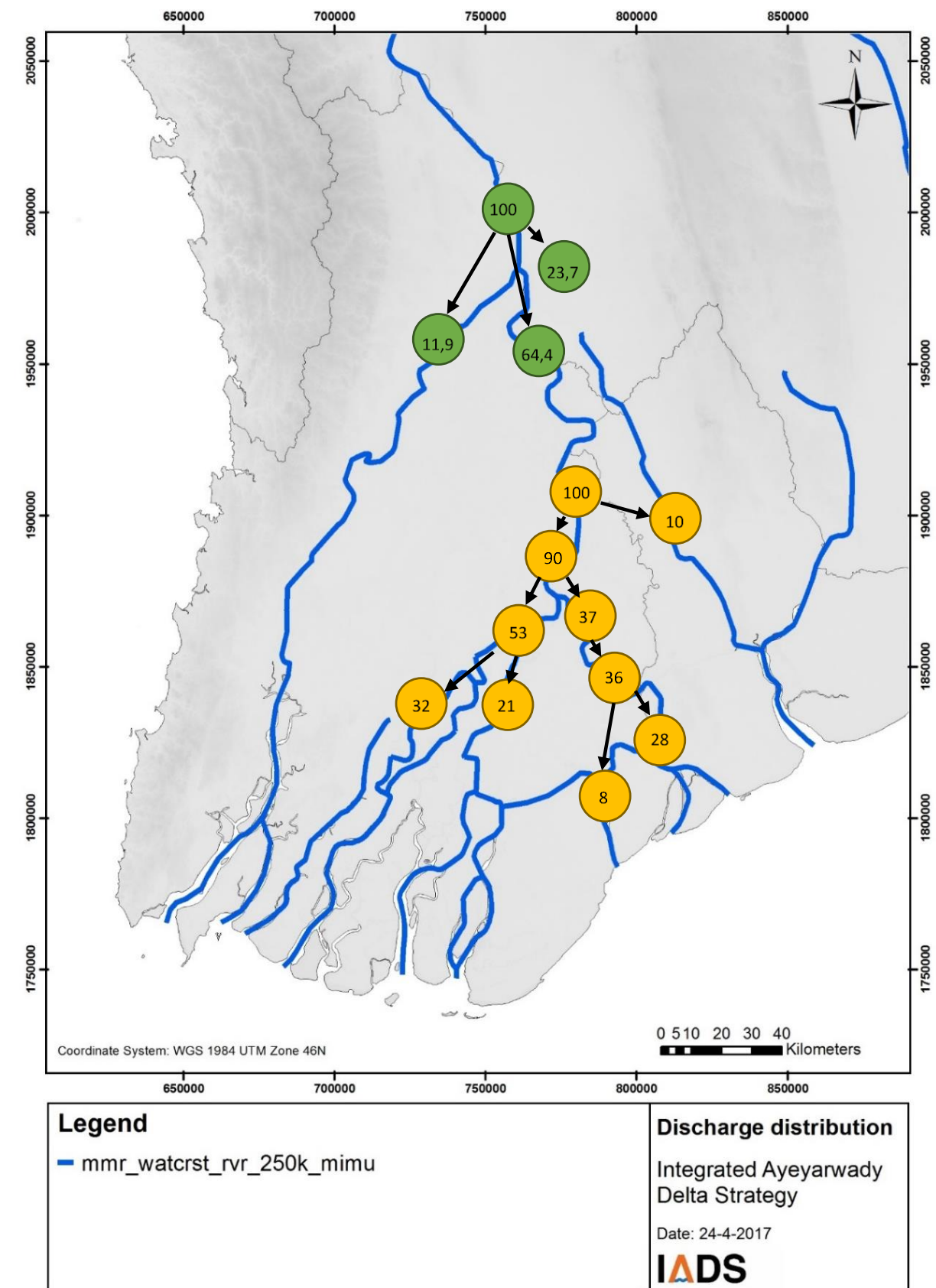


Figure 1-14 Hydrological distribution (%) during flood season based on two different sources: satellite images (orange)¹⁴ and the distribution at the apex (green in figure) is determined by Sir William Halcrow and Partners (1982) based on observations in 1979 and 1980.

¹⁴ Kravtsova, V. I., Mikhailov, V. N., & Kidyayeva, V. M. (2009). Hydrological regime, morphological features and natural territorial complexes of the Irrawaddy River Delta (Myanmar). *Water resources*, 36(3), 243.

Figure 1-14 shows the hydrological regime of the Ayeyarwady River during flood season. The distribution at the apex (green in figure) is determined by Sir William Halcrow and Partners (1982) based on observations in 1979 and 1980. The distribution of the lower part of the Ayeyarwady River (orange in figure) is determined by using remote sensing images (Kravtsoava et al. 2009). The distribution depends highly on the discharge (Q) (Table 1-1). During dry season, most of the water flows through the main channel and more water can flow in the other river branches as the discharge increases.

Table 1-1: Distribution of discharge at the apex¹⁵

	River	Q = 30,000 m³/s	Q = 40,000 m³/s	Q = 50,000 m³/s	Q = 60,000 m³/s
% Myogwin	Pathein river	9.6 %	10.6 %	11.4 %	11.9 %
% Chanthagon	Hlaing river	10.1 %	14.7 %	19.2 %	23.7 %
% Zalun	Ayeyarwady river	80.3 %	74.7 %	69.4 %	64.4 %
Total		100 %	100 %	100 %	100 %

Table 1-1 compares the discharge in the Ayeyarwady River upstream of the apex (Nyaunghtaw and Pyay) with the discharge in the Pathein River (Ngathainggyaung) for different discharge values. These values indicate approximate 10-12% of the discharge going to the Pathein River. This was validated using discharge data from DMH. The normal distribution for the past years is like shown in 2003-2004 (Figure 1-15). Values are varying annually between 10-17%. During the dry season, the percentages are slightly higher. However, analysis of 2012-2013 showed results which are deflected in 2013. During dry season percentages (distribution) of almost twice as high are shown, although discharge values are comparable (Figure 1-15, right). Reason for this is unknown, but a possible explanation could be dredging of the Pathein River, resulting in more water flowing into this branch during the dry season. The results can be seen more clearly in Figure 1-16, where the time series of 2012-2013 are compared to 3 times series of previous years. The previous times series are in line with each other, where the 2012-2013 time series clearly show a different pattern during the dry season of 2013. Additional research with measurements from 2013-2016 is necessary to understand the results and possibly find the source of change in distribution in 2013.

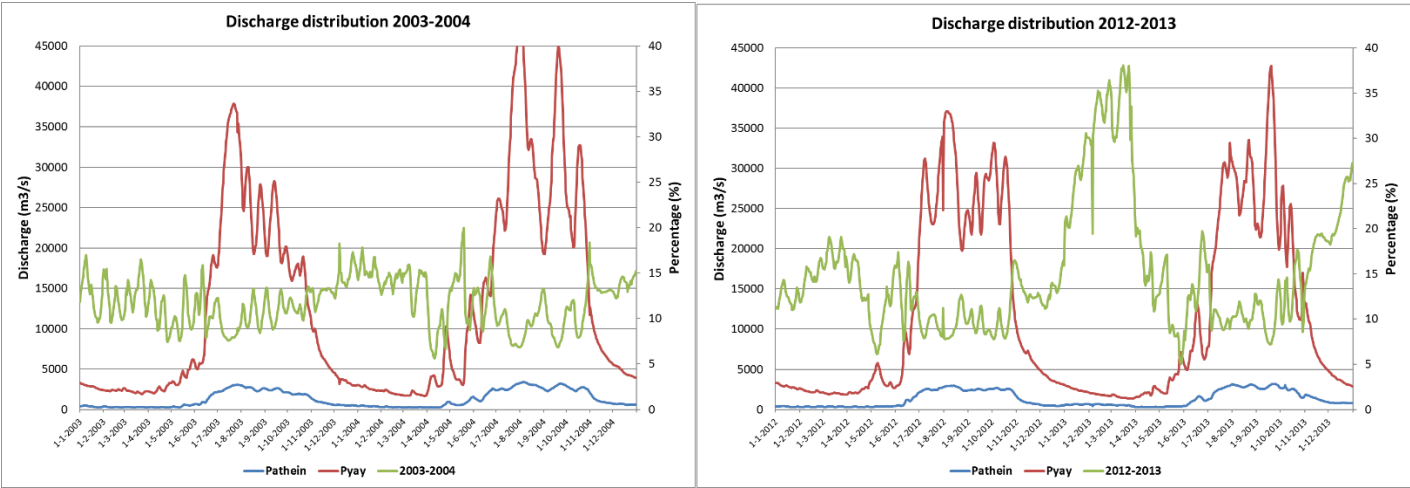


Figure 1-15 Discharge distribution Pathein River and the incoming discharge at Pyay for 2003/04 and 2012/13 (DMH, 2017)

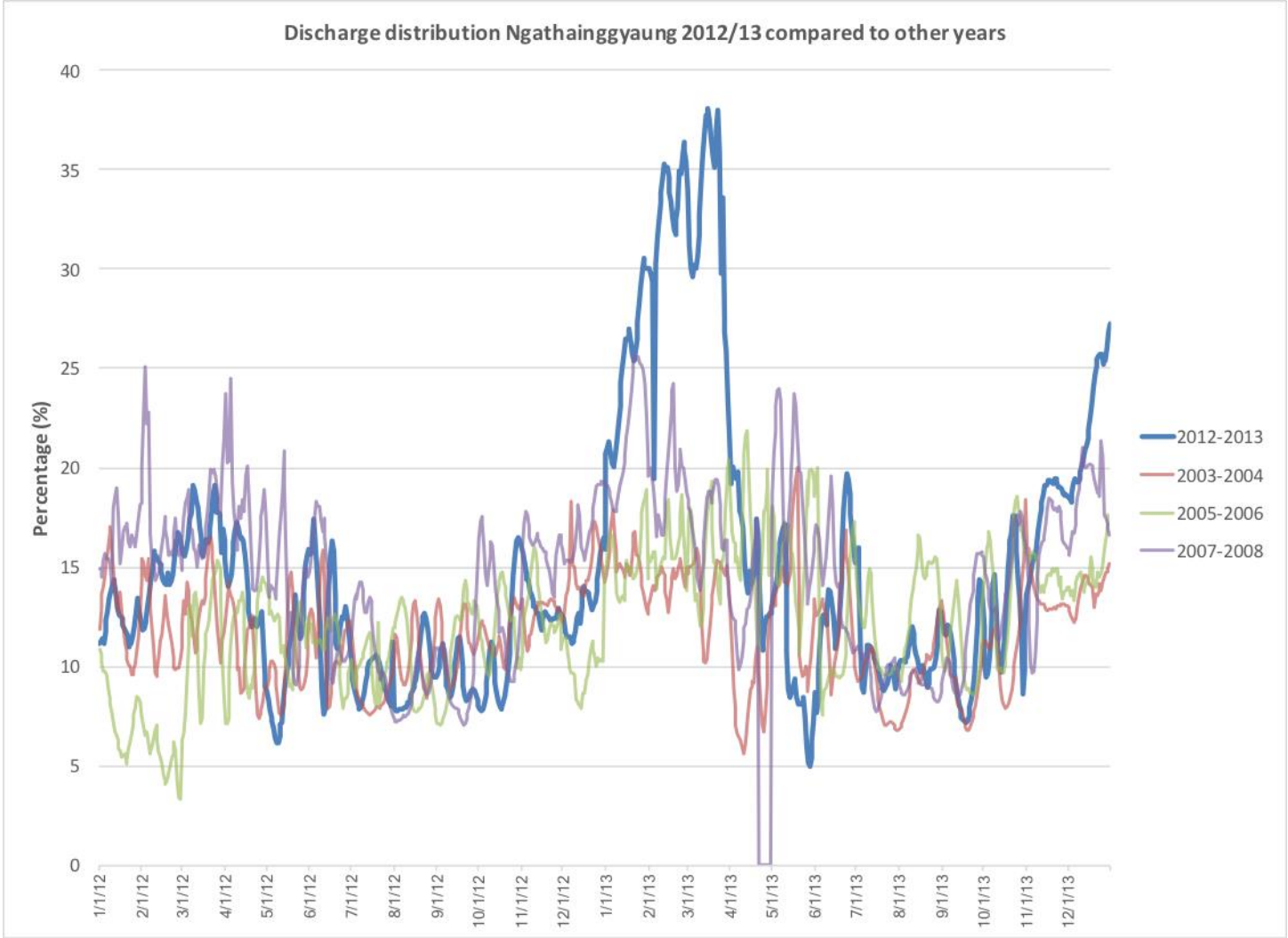


Figure 1-16 Discharge distribution between Pathein River and incoming discharge at Pyay for 2012/13 compared to other years (DMH, 2017)

¹⁵ Sir William Halcrow and Partners (1982), Irrawaddy delta hydrological investigations and delta survey (1982), volume 3

1.4.3 Water levels in the river

The Irrigation and Water Utilization Management Department (IWUMD) is measuring the water levels in the Ayeyarwady delta at 13 gauge stations. Within the Ayeyarwady and Bago Region, the Department of Meteorology and Hydrology (DMH) is measuring at 20 gauging stations in the river system. The locations of the IWUMD stations are shown in Figure 1-19. The yearly maximum water level of each gauging station is determined and added to the graph in Figure 1-17. In the past 25 years, no significant trends in maximum water level have been discovered. This could be caused by the limited height of the embankments, resulting in regular floods of the polders. The floods could have affected the measurements. Figure 1-18 shows the annual maximum at Hinthada gauging station between 1868 and 2008. Before 1920, the maximum water level varied between 41 and 44 feet above sea level. After 1920, an increase in maximum water level is visible. This is caused by the construction of dykes between 1915 and 1939.¹⁶

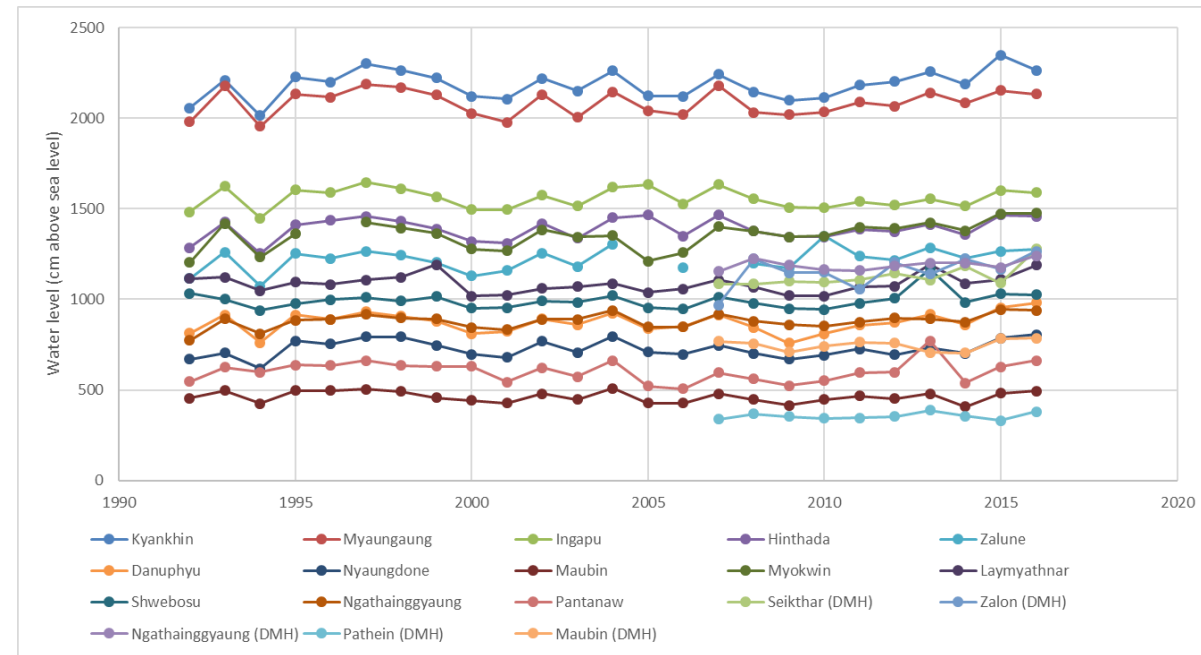


Figure 1-17 Annual maximum water level at 18 gauge station of IWUMD (2017) and DMH (2017)

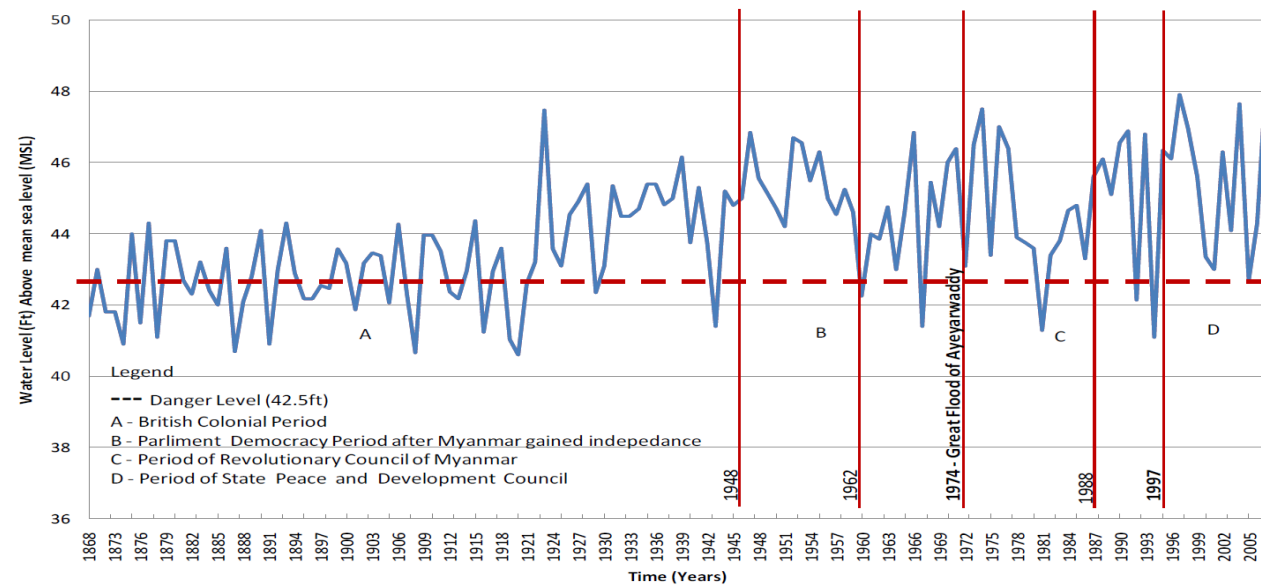


Figure 1-18 Annual maximum water levels of Ayeyarwady River at Hinthada station from 1868 to 2008¹⁷

¹⁶ Sir William Halcrow and Partners (1982), Irrawaddy delta hydrological investigations and delta survey (1982), volume 3

¹⁷ U Aye Myint (2011), Water Management Through the Ages in Ayeyarwady Delta, Powerpoint presentation, World Delta Summit

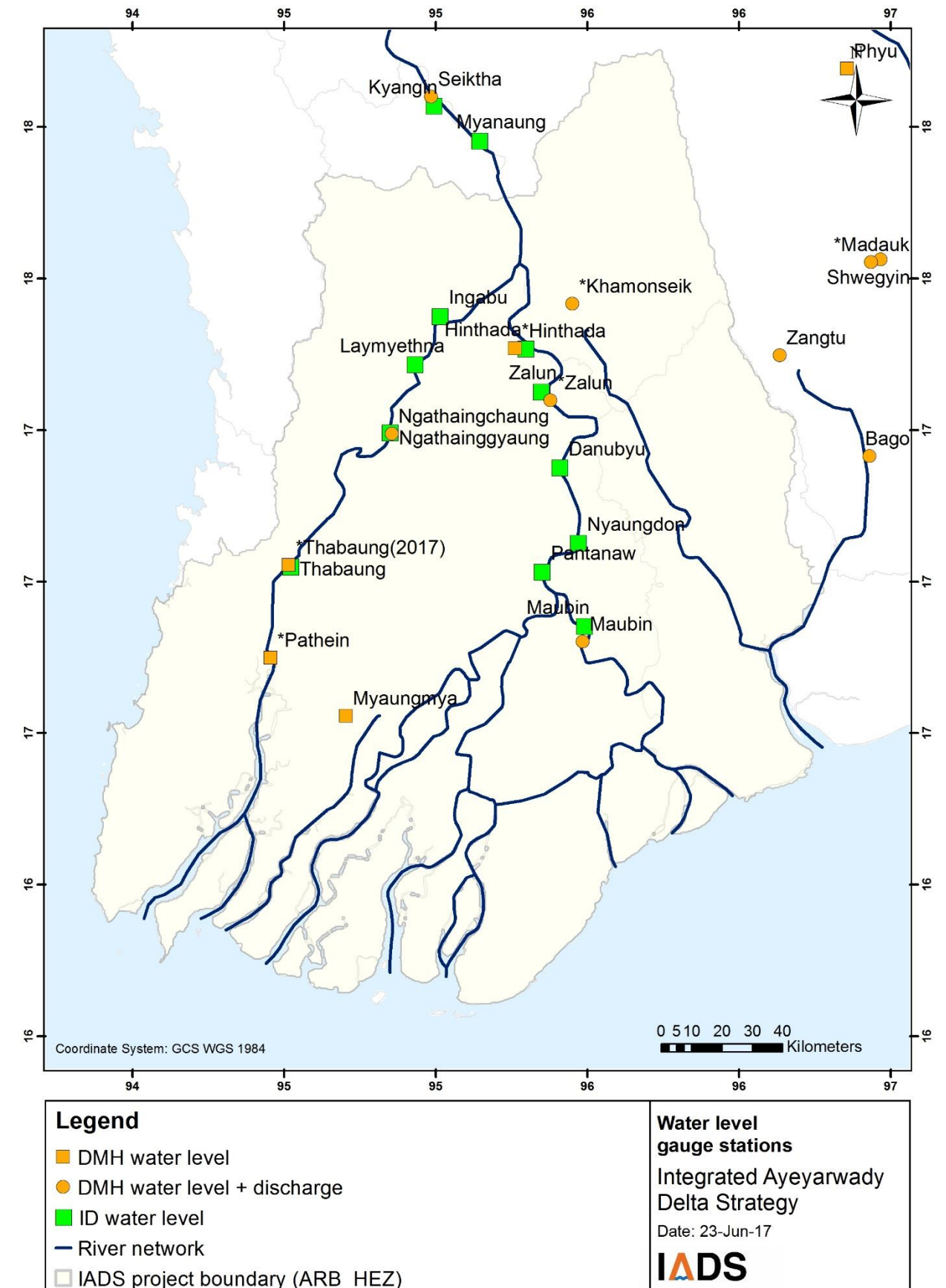


Figure 1-19 Georeferenced locations of gauging stations with water level measurements of IWUMD (2017) and DMH (2017). *indicative locations

The Irrigation and Water Utilization Management Department (IWUMD) has done a frequency analysis of the measured water levels to extrapolate water levels and assign a frequency of occurrence, or return period. Extrapolation is done by calculating the best fit distribution based on least square error¹⁸. Therefore, the type of distribution differs for every gauging station. To keep a good overview, the data are divided into three figures corresponding to station; upstream of the apex, the Patheingyi River, and further downstream the Ayeyarwady River (Figure 1-20). In Figure 1-21, the progression of the water levels is shown over the different gauging station in the Ayeyarwady branch and the Patheingyi branch, for the different extreme frequencies.

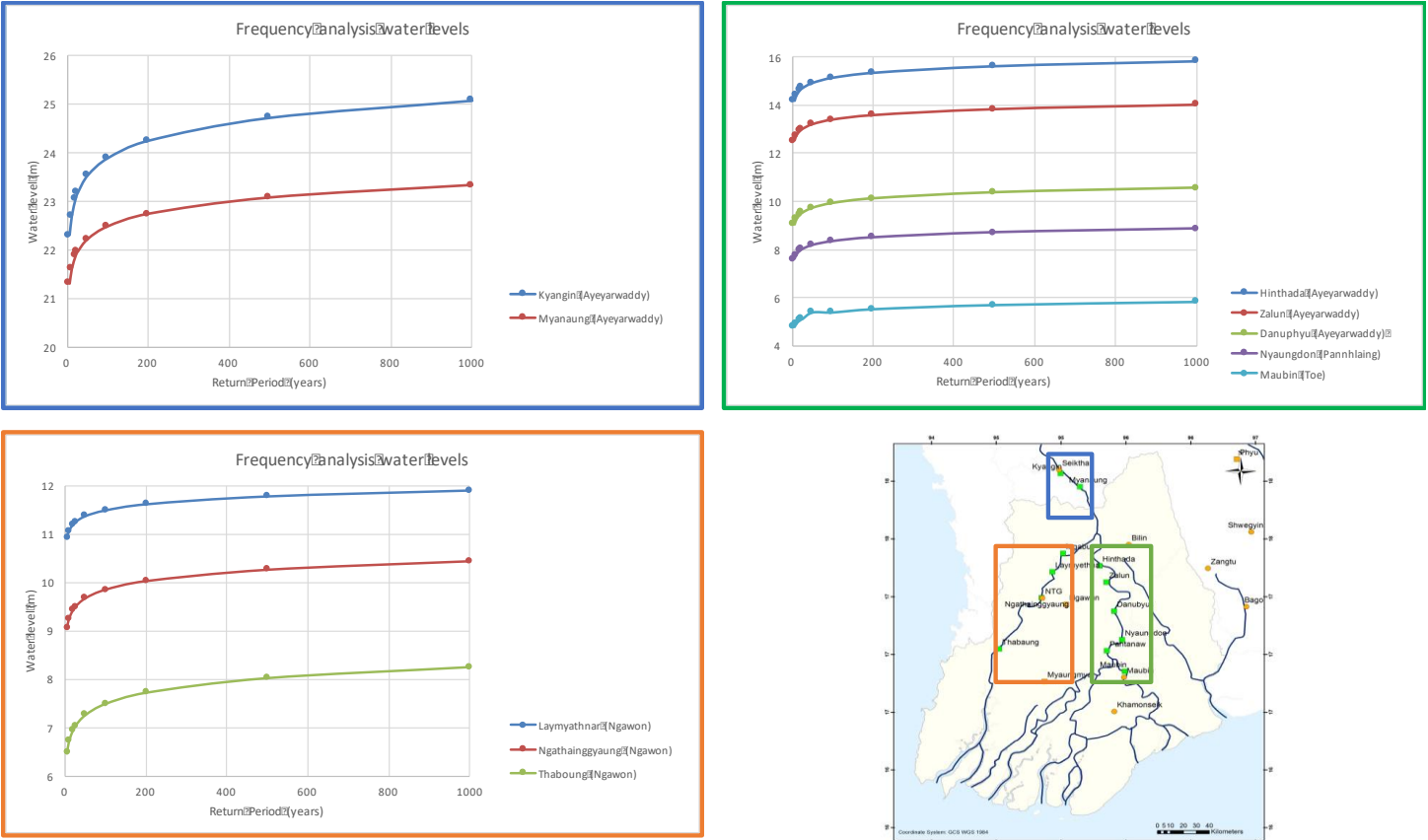


Figure 1-20 Frequency analyses by IWUMD (2017) at 10 gauging stations

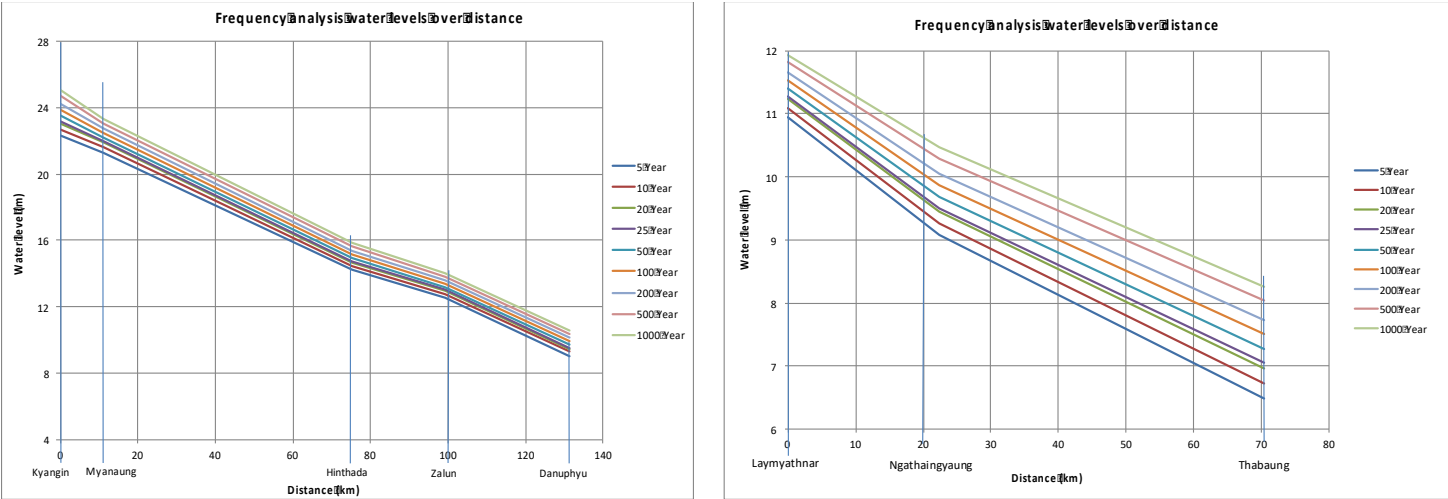


Figure 1-21 Progression of extreme water levels over gauging stations in two branches based on IWUMD (2017) data

1.4.4 Bed profiles

The discharge of rivers is usually calculated using bed profiles, water levels and the correct rating curves. Because of the dynamic behaviour of the river, the bed profile differs yearly, causing uncertainty in calculations. Figure 1-22 and Figure 1-23 show the bed profiles over one year at Pyay and Zalun. Especially at Pyay the changes are visible. The profile is eroding to the right without getting deeper. It shows the migration of the river towards the outer edge of a meander, caused by erosion. At Zalun, changes are less significant since the river consists of two deep channels and a flat and shallow plain in the middle. The two main channels are deepening, where the shallow plain is more or less constant. These figures additionally show the erosive character of the river with erosion of 100 m in flood season at Pyay. This dynamic behaviour is important to analyse when doing measurements in the river and planning water related projects.

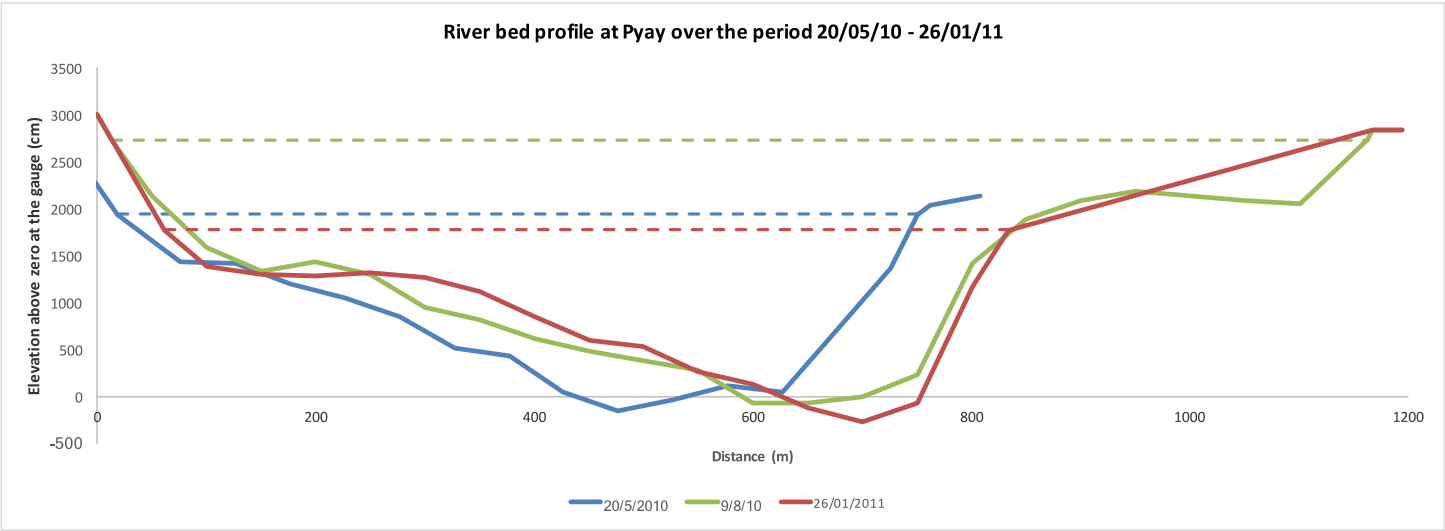


Figure 1-22 River bed profile at Pyay (DWIR, 2017)

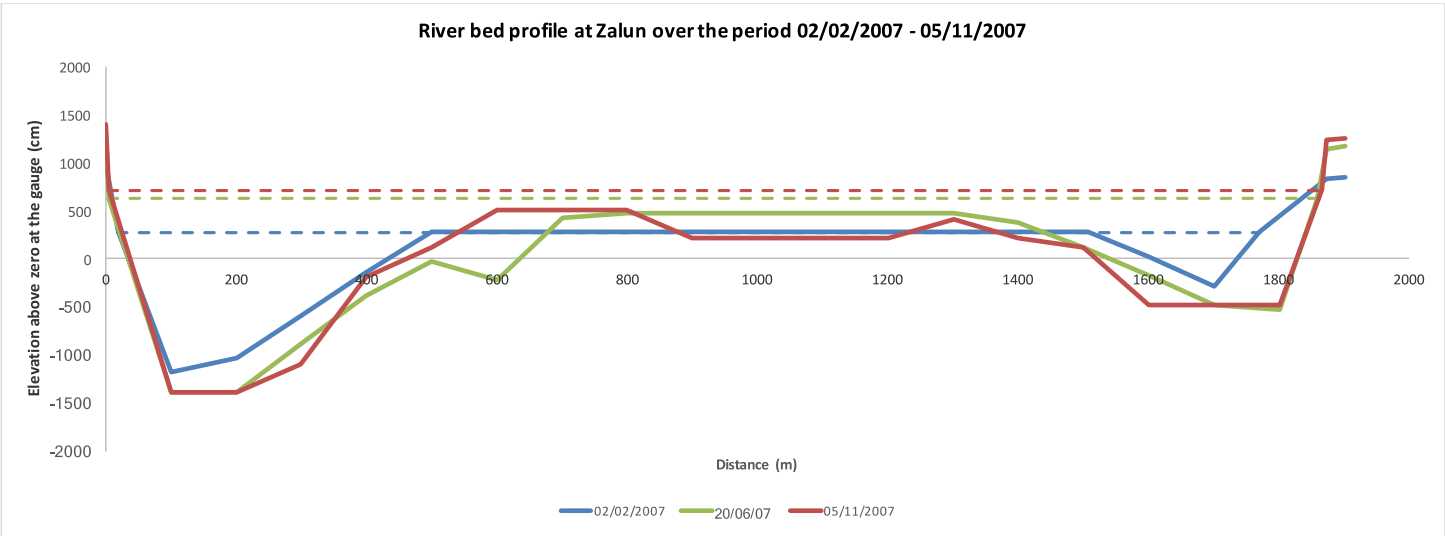


Figure 1-23 River bed profile at Zalun (DWIR, 2017)

¹⁸ Ministry of Agriculture, Livestock & Irrigation (2016), Irrigation Water Utilization & Management Department. Myanmar Irrigation Manual Volume (4), Irrigation Water Utilization & Management Department

1.4.5 Erosion and deposition

Riverbank and coastal erosion is one of the major issues in the Ayeyarwady Delta. River bank erosion takes mainly place in the Upper Delta, where the river morphology is still very dynamic. Bank erosion causes sedimentation in the river bed building up local bars that can provoke localized flooding danger. There is a lack of legislation, regulation and enforcement to avoid the settlement of mainly fishermen communities on the erosion (and flooding) sensitive coasts and river banks. Regular displacement of people and casualties are the result since villages are struck by extreme erosion problems. Figure 1-24 shows the dynamic behavior of the river. Areas in blue show the land area being transformed into river, whereas the green parts show the opposite behavior. Especially river bends are sensitive with significant changes over a period of 16 years. The picture below is the Pan Hlaing river, showing a character of extreme siltation.

Figure 1-25 shows a water transition map of the delta for the years 1984-2015 based on satellite observations.²⁰ This clearly indicates the annual and inter-annual interaction of river and land. New permanent water surfaces show the areas which were first land and made the transition into water. More interesting are the (new) seasonal changes. These areas are conversion areas from places of no water into seasonal water places. Some highlighted areas will be discussed into more detail in the section about river flooding. The highly dynamic river profile is also shown here near Nyaungdon, where the river is changing its profile over the years.

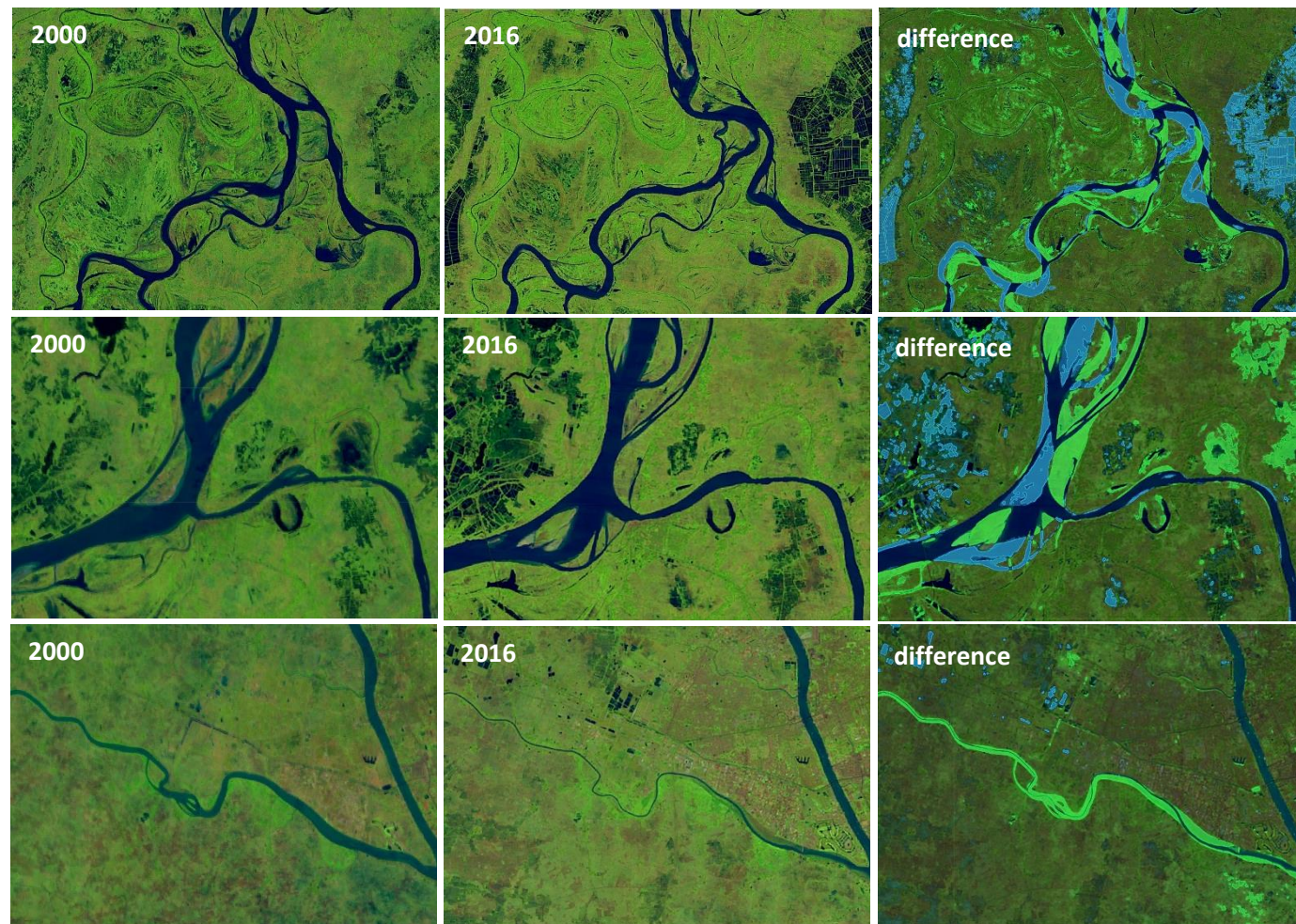


Figure 1-24 Bifurcation of the Ayeyarwady River with the Toe River (top), Nyaungdon (middle) and the Pan Hlaing river (bottom)¹⁹

¹⁹ Aqua Monitor, Surface water changes (1985-2016), <https://aqua-monitor.appspot.com>

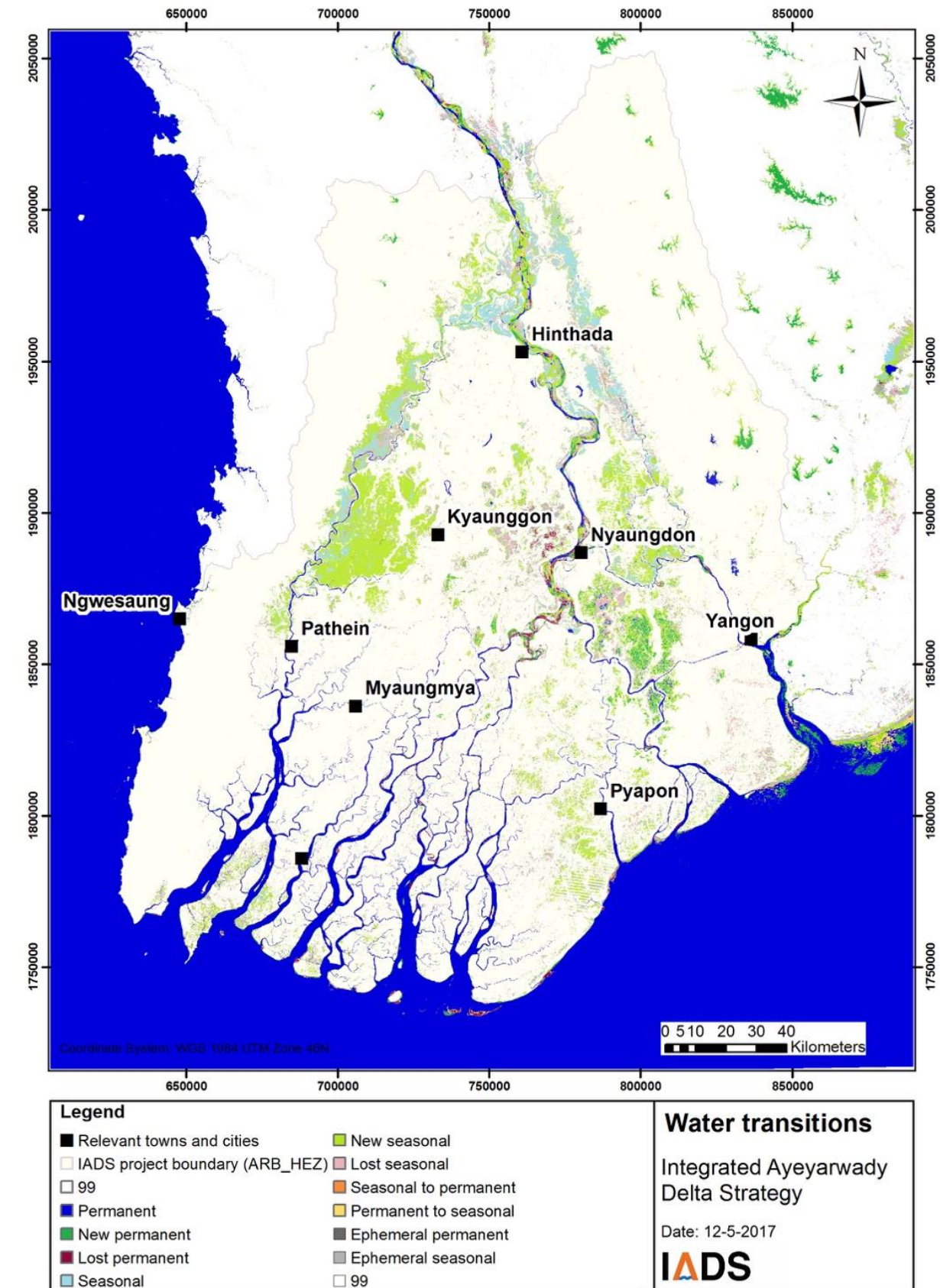


Figure 1-25: Water transition over the period 1984-2015²⁰

²⁰ Pekel, J.F., Cottam, A., Gorelick, N. & Belward, A.S. (2016), High-resolution mapping of global surface water and its long-term changes, Nature, 540, 428-422, doi:10.1038/nature20584

1.4.6 Sediment transport

The Ayeyarwady River and its branches deliver large amounts of sediments into the Bay of Bengal during the monsoon season (Figure 1-26). Data collected between 1969 and 1996 at Pyay (Prome) are analyzed to provide the best available modern estimate of discharge ($379 \pm 47 \times 10^9 \text{ m}^3/\text{year}$) and suspended sediment load ($325 \pm 57 \times 10^6 \text{ t/year}$) for the river upstream of the delta head.²² A statistical comparison with data collected in the nineteenth century (1871 to 1879) shows that the discharge has significantly decreased in the last ~100 years for the peak month of August. Regression and correlation analyses between discharge in the modern period and indices of El Nino–Southern Oscillation (ENSO) show a relationship.²¹ Figure 1-27 shows the sediment load over the years at Pyay. As was already shown in discharge data, there is a strong seasonal variability of the discharge and consequently the sediment load. More than 90% of the annual sediment load is delivered during the monsoon season, between mid-May and mid-November. The right figure shows the correlation of measured discharge and sediment load at Pyay. For the determination of the sediment load simply a conversion factor with the discharge is used ($L = 0.00127Q^{1.4264}$). Therefore, a 1:1 similarity is shown between discharge and sediment load. Analysis of the sediment load is therefore impossible.

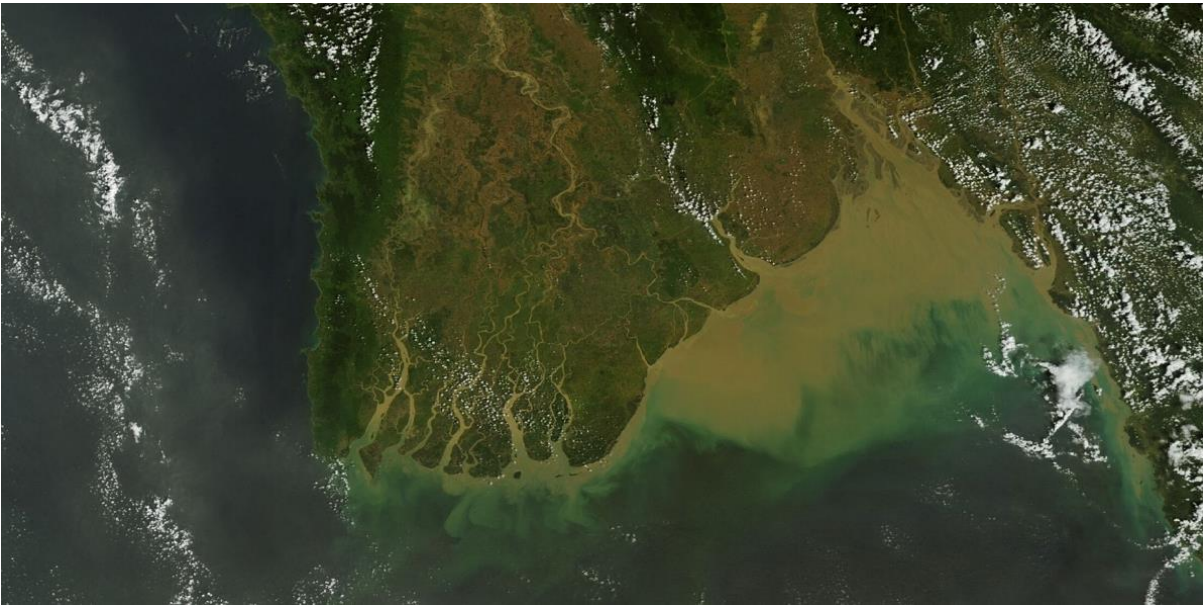


Figure 1-26: Image showing sediment plumes along the southern Myanmar coastline ²²

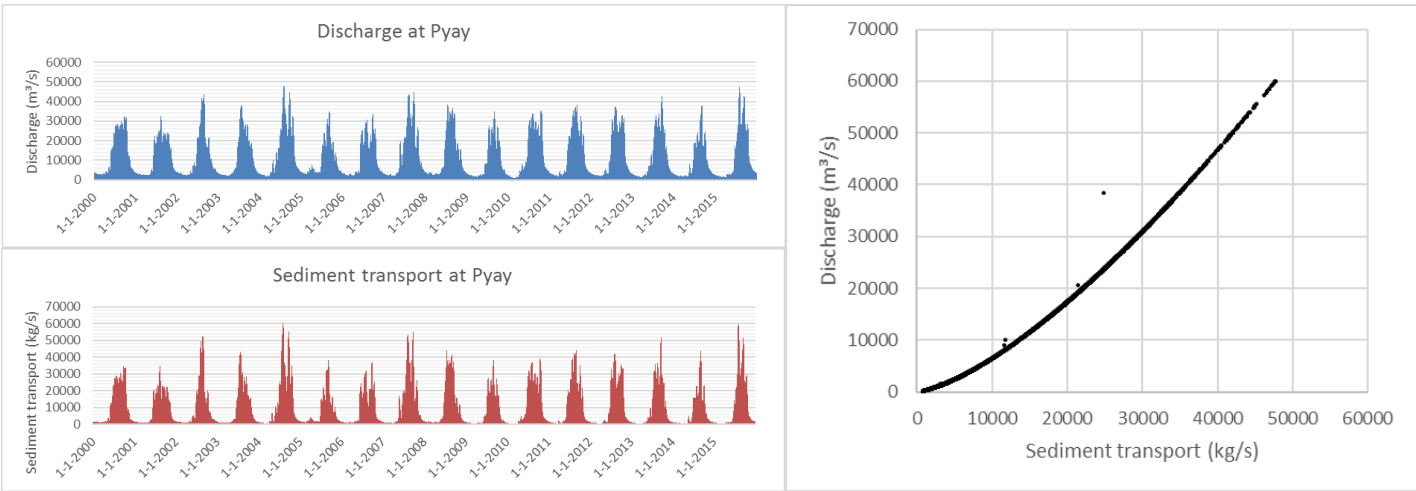


Figure 1-27 Left: discharge and sediment transport at gauging station Pyay (DMH, 2017). Right: the relation between discharge and sediment transport data shows that the sediment transport is a calculated value based on discharge

1.4.7 Water levels in the coastal zone

11 gauging stations are set up at the coastal site of the delta. Some of these stations are located at the coast, whereas some are in the (tidal) river branches. These stations are used for the tidal data along the coast and tidal propagation in the rivers. However, at some stations the data are only measured three times a day; 6:00 AM, and two varying times where the maximum and minimum water level occurred. Because of this, it is hard to make a tidal analysis, since the frequency of the measurements is too coarse. A Delft-3D model is made which validates the measurements at a few of these points.²³ The results for the month of March are shown in Figure 1-28, where the three tidal gauging stations are displayed together with the modelled and measured data at three locations. The tidal range is largest at the Amar station with spring tide of approximately 3 meters. The Amar station is located closest to the coastal zone, which shows a maximum tidal range of approximately 2.7 meters and a minimum tidal range of approximately 1.0 meter. The tidal ranges are higher at the east side of the delta compared with the west side. The tidal variation shows a distinct pattern of spring and neap tides. The tidal influence enters deep into the delta, which offers opportunities for tidal irrigation by boosting the fresh water. Especially during the dry season, when the river discharges are very low, the tidal influence into the delta is large.

The tidal regime along the coast of the delta is mainly semi-diurnal in character, but with significant contributing diurnal components. The 12 ocean outfalls of the delta are spread along some 250 km of coastline. The spring tide range varies from a minimum of 1.5 meter at the Pyapon River entrance to a maximum of 5 meters at the entrance to the Yangon River. This is probably caused by the tidal motion that resonates in the shallow tidal inlet. The phase of the main M₂ tidal constituent at the mouth of the Yangon River is about 6 hours later than at the Patheingyi River entrance. This means that high water occurs at the east end of the delta at the same time as low water occurs at the west end of the delta. Large phase differences in the tide along the coast of the delta influence the tidal motion within the delta, especially in the zone where the two tides meet which is approximately along the line of the Chana Bakir River.²⁴ This can be shown in more detail with the tidal analysis of Sir Halcrow and Partners Figure 1-28. Based on a 29 day measurements series in 1979, for 5 places along the coast, the 6 most contributing tidal components are shown, with the main contribution of the M₂ tide together with the S₂ tide. Next to that, the diurnal components K₁, O₁ and the over-tide M₄ are influencing the tide. Between the M₂ tide in the east and the west side, a phase difference can be recognized of 200 degrees or more, meaning that this component is working out of phase at both sides of the delta.

The M₂ component is a semi-diurnal component caused by the movement of the moon, while S₂ is a semi-diurnal component caused by the movement (and attraction forces) of the sun. K₁ and O₁ are diurnal components, while M₄ is a combination component. The phases of the tides are expressed in degrees, that can be converted in time using the rotational speed of the component. Semi-diurnal components have a period of 12 hours (sun) or 12 hours and 50 minutes (moon), where the diurnal components have a period of 24 hours (sun) or about 25 hours and 40 minutes (moon).

²¹ Furuichi, T., Win, Z., & Wasson, R. J. (2009). Discharge and suspended sediment transport in the Ayeyarwady River, Myanmar: centennial and decadal changes. *Hydrological processes*, 23(11), 1631-1641.

²² Sediments in Irrawaddy River Delta and Gulf of Martaban, <http://www.eosnap.com/tag/irrawaddy-river/>

²³ Hendriks, E. (2016), Development of a Delft3D model for the Ayeyarwady delta (2016), Delft University of Technology and Deltares

²⁴ Hydraulics Research Station Wallingford(1982), A one-dimensional analysis of the tidal hydraulics of deltas

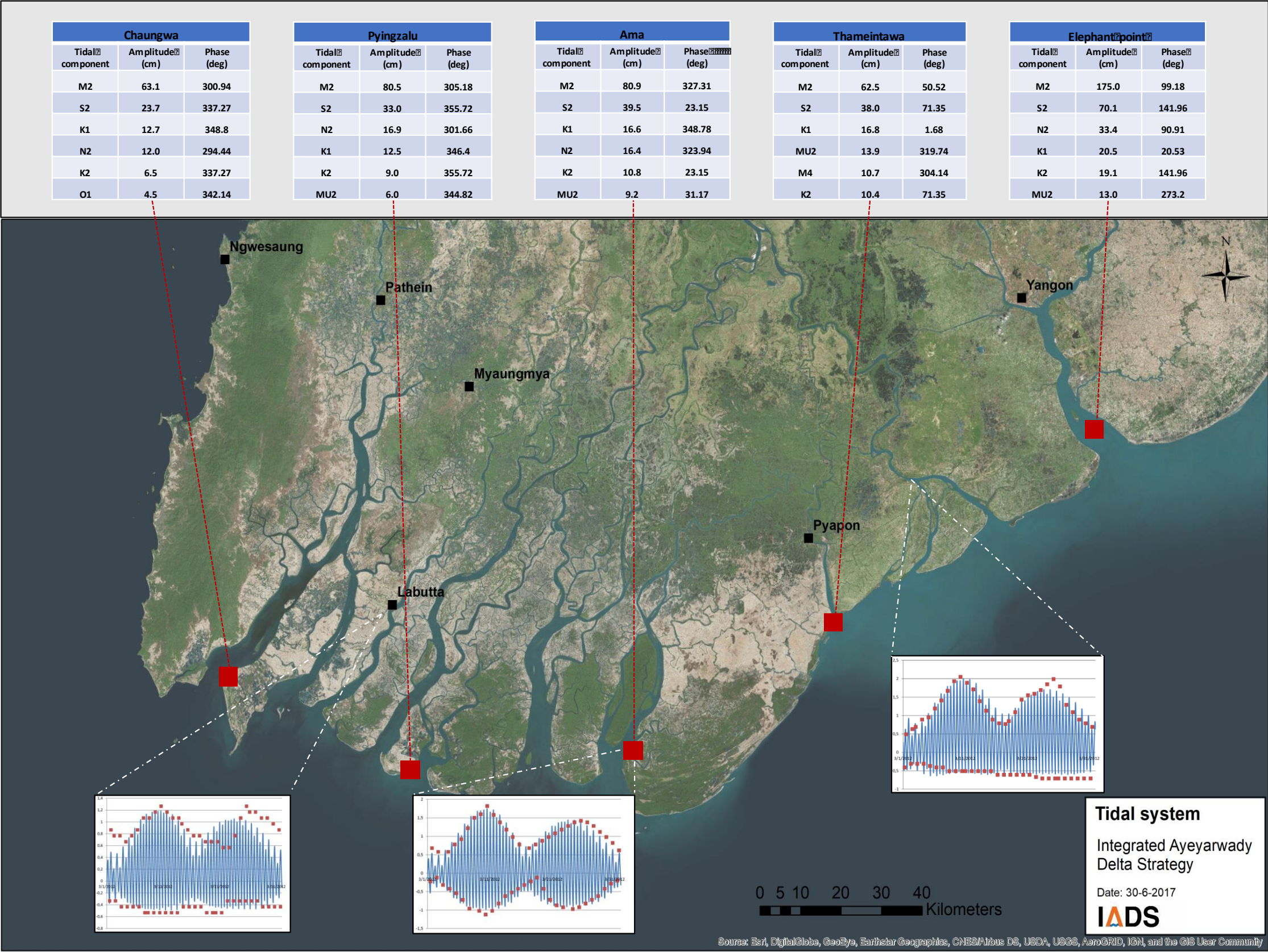


Figure 1-28: Overview of the tidal system with main tidal components based on Halcrow and Partners (1982²⁵) and measured and observed water levels at three tidal station (DMH) along the coast in Delft-3D (Hendriks, 2016)²⁶

²⁵ Sir William Halcrow and Partners (1982), Irrawaddy Delta, Hydrological Investigation and Delta Survey, Volume 3- Analysis

²⁶ Hendriks, E. (2016), Development of a Delft3D model for the Ayeyarwady Delta, Myanmar, Delft University of Technology

1.4.8 Salt intrusion

Because of the large tidal propagation inside the delta, a salinity front moves far inland with the tide. The counteracting force of this intrusion is the discharge of the river, so a combination of both determines the salinity front together with river geometry. During low discharge and spring tide, the salinity front can move deeper into the delta. This can be seen from Figure 1-30, where the salinity front is moving deeper in March than in November. However, this 1ppt measurement is usually taken at a water depth of 1m from the surface, because this part of the profile is most relevant for irrigation purpose. Since saline water with a higher density than fresh water is usually found at the deeper water profile, the salt intrusion is expected to move even further inside the delta over the whole cross profile. On the map salinity measurements are shown during the March spring tide measurements at different stations. In total, seven branches are measured every year by IWUMD. In the Pathein river and Yangon river, the salinity front is moving very deep into the river channel due to the significant amplification of the tide. In the Pathein river, it almost reaches the city of the Pathein, which may affect the surface water reservoirs of the city. Looking at differences between measurements over the years no significant trend is visible. The year 2015 showed a peak for salt intrusion, but other years show no uniformity between the river branches indicating the complex system of the river and tidal interaction in the delta.

In the figure below the interaction of saline water from the sea and the fresh groundwater reservoirs below land is shown. Sea level rise does not only affect the intrusion into the river branches, but also potentially affect the intrusion into groundwater with the consequence of pumping saline water from wells in the lower Delta instead of fresh water. Therefore, not only measurements of the surface area are necessary, but also measurements of the subsurface.

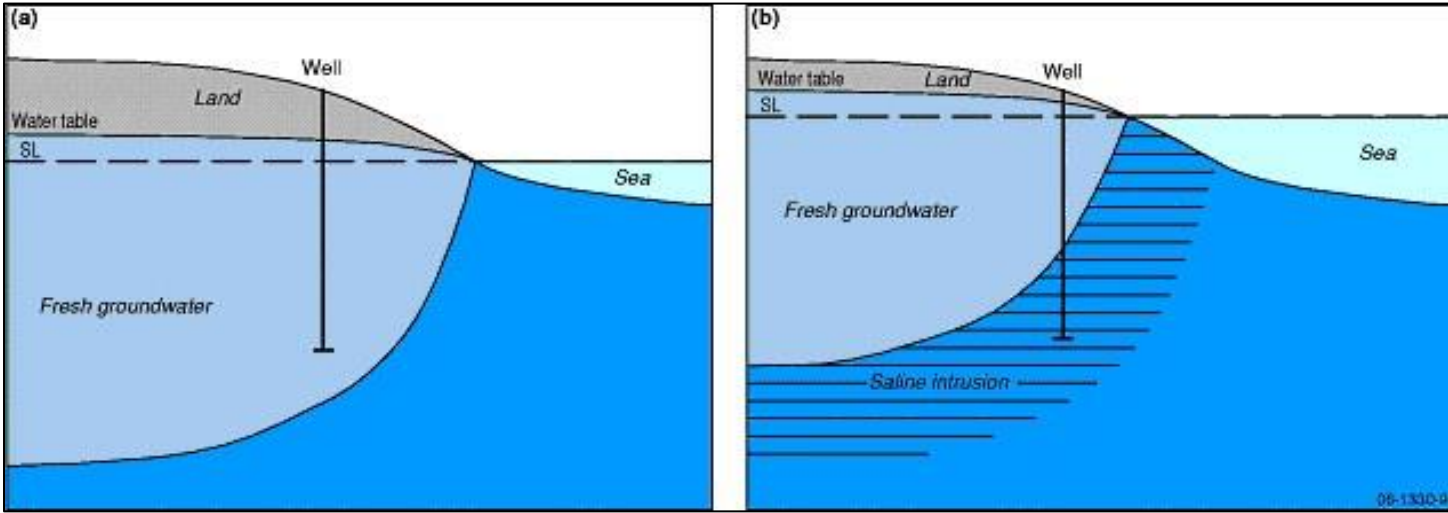


Figure 1-29: Schematic overview of fresh groundwater and saline water interaction and the consequence of sea level (SL) rise²⁷

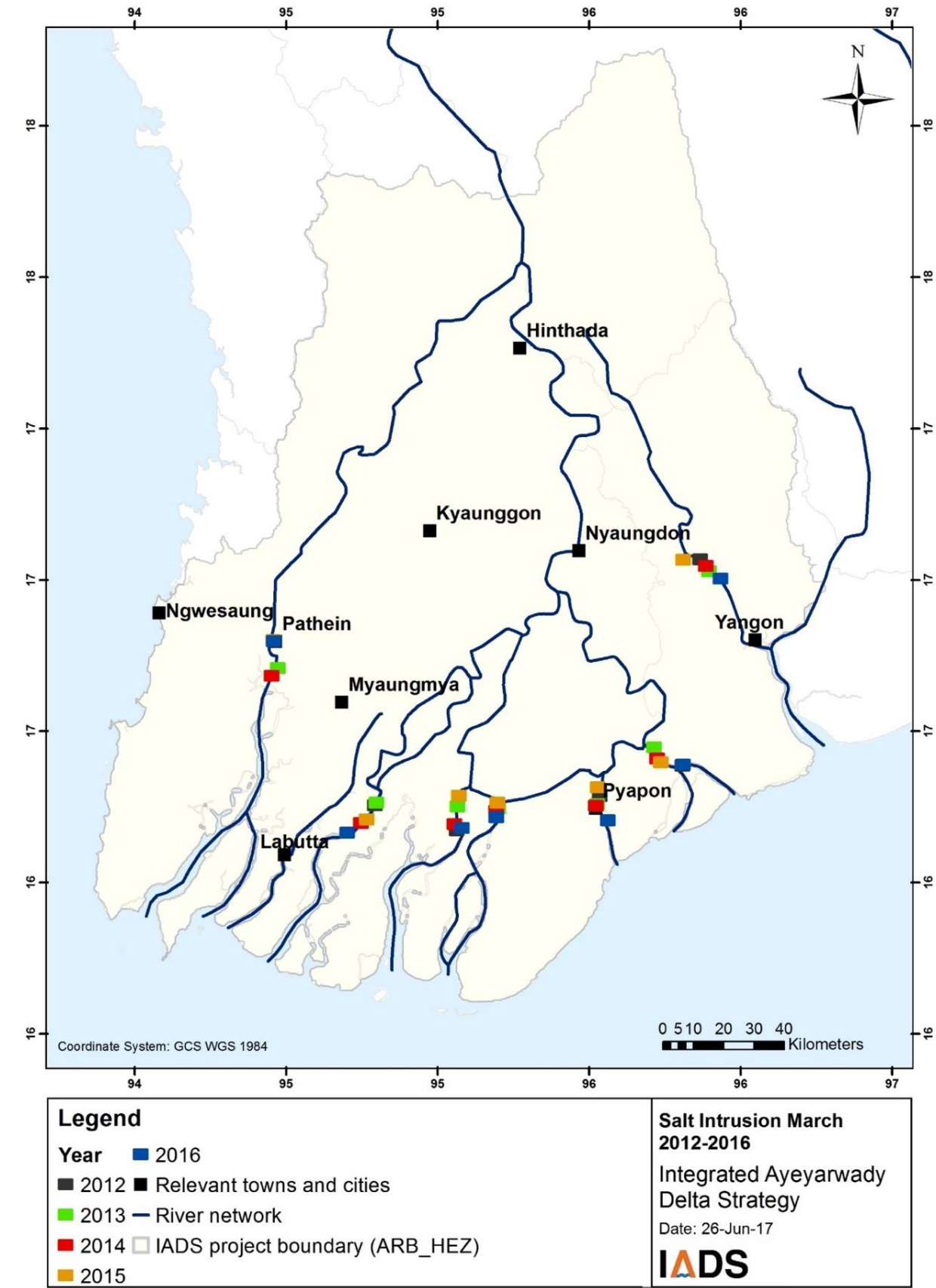


Figure 1-30: Average salinity intrusion in the Ayeyarwady Delta for years 2012 – 2016 from IWUMD (2017)²⁸

²⁷ OZCoasts, Saline Intrusion, Accessed: June 26, 2017, http://www.ozcoasts.gov.au/indicators/saline_intrusion.jsp

²⁸ Irrigation Water Utilization & Management Department (IWUMD) (2017), Ministry of Agriculture, Livestock & Irrigation (MOALI). Data on water levels, frequency analysis and salinity of different locations and years

1.4.9 Wave climate

Little information is available about the wave climate along the coast of the Ayeyarwady delta. Therefore, data were obtained from remote sensing analysis (BMT Argoss).²⁹ Because satellite data were not available in front of the coast, data from a wave-model were used in the study of Kroon and Rip (2015). As can be seen in Figure 1-31 (right), most waves are entering from the south-west, with little deviation to the south and west. The mean wave height varies from 0.5 meter during the dry season, increasing during the monsoon season towards a mean value of 1.8 meter. The thin red line shows the seasonal variation and the orange area the inter-annual variation. There is quite some scatter and occasionally mean wave heights of 3 meter or more may occur in the monsoon period.

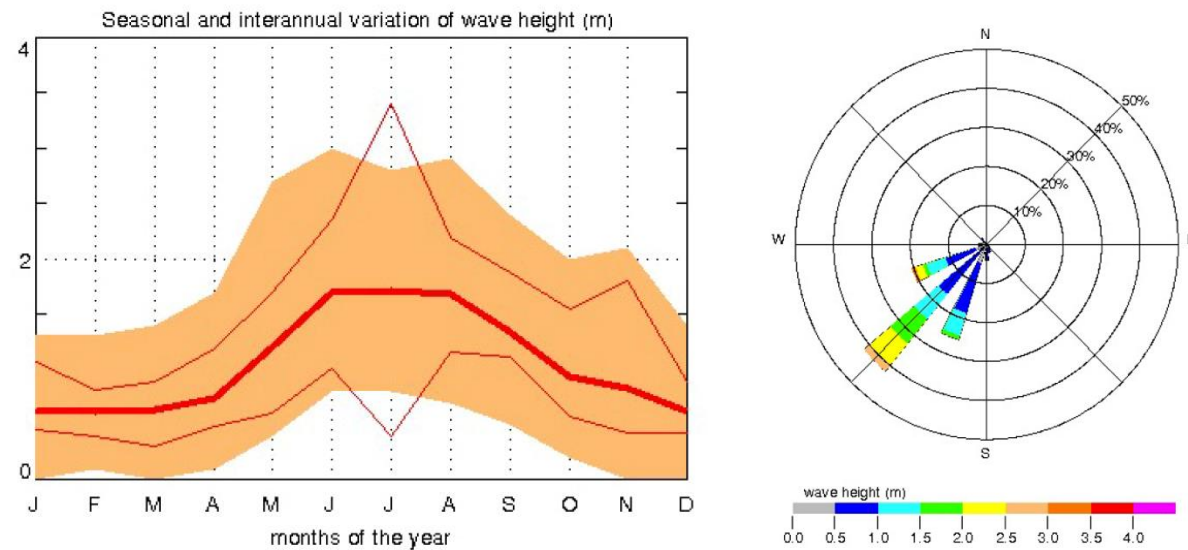


Figure 1-31 Argoss results of the Ayeyarwady coast showing wave heights (left) and direction (right)²⁹

1.4.10 Coastal sediment dynamics

The Ayeyarwady delta is a disproportional large delta relative to its catchment size compared to other deltas in the world. It can be characterized as a tide dominated delta system. The monsoon wave climate with predominantly south-westerly waves cause an alongshore sediment transport along the delta coast enhanced by tidal and wind generated waves. The coastal waters are highly turbid and essentially muddy, although getting sandier towards the west. Important is the mud-trapping in the Gulf of Martaban in the east. There has been a net delta advance of 7.8 m/y between 1974 and 2015, but a strong longshore variability was observed. 50% of the delta experienced erosion.³¹ The largest advance was observed near the mouth of the Yangon river where a major mud bank developed. During the cyclone Nargis in 2008, the delta shoreline was retreated with 157m/week on average. However, the weeks after the event, the shoreline was recovered again, showing the feedback of the delta.

Potential cause of the shoreline erosion is most probably the constructing of dams in the river basins cutting off the existing sediment supply with 30%. Moreover, construction of river embankments, mangrove removal and natural subsidence are identified as possible causes of coastal erosion. Figure 1-32 shows the sediment transport along the coast in more detail. In the left picture, the transport during the south-west monsoon is shown, including higher river discharges. The transport is moved to the east by the currents and is bulked up in the Martaban Sea. Part of the mud belt is transported into the Martaban canyon. During the north-eastern monsoon, the surface current flow reverse and sediment moves to the west. These currents may push some of the suspended sediments westwards into the eastern Bay of Bengal and some of its moves further northwards.

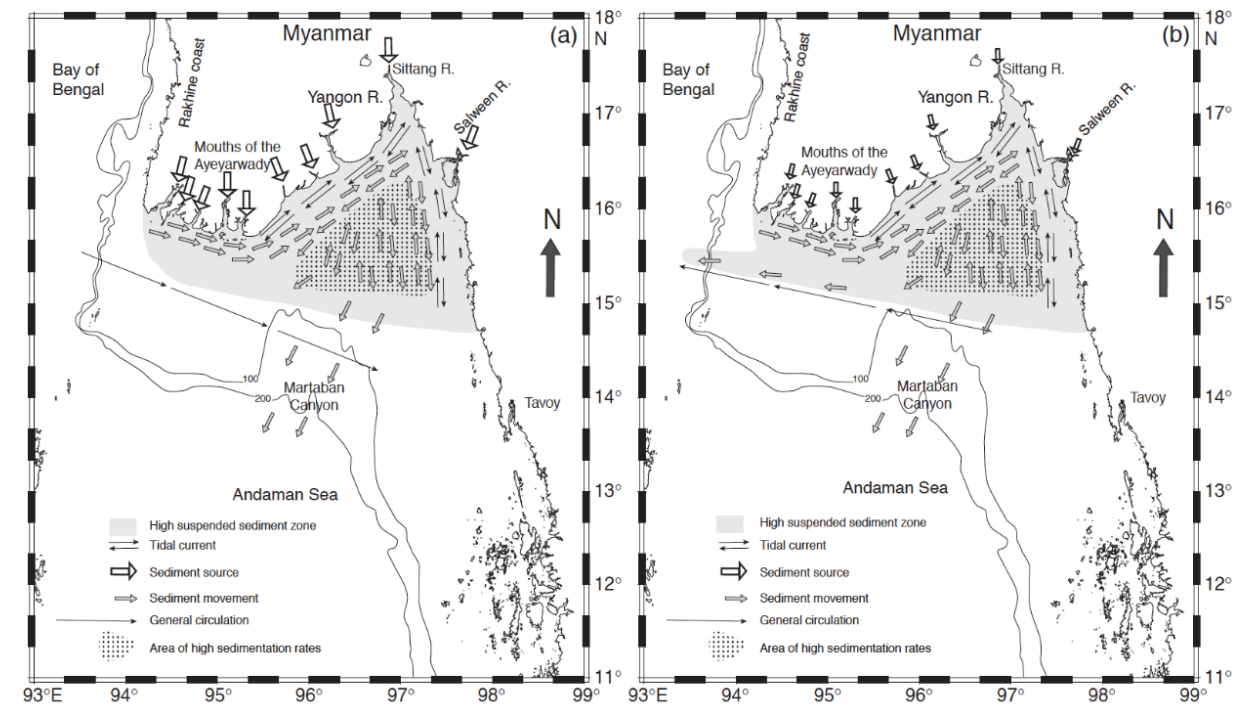


Figure 1-32 Schematic diagram showing sediment sources, transport pathways and depositional areas on the Ayeyarwady shelf. (left) during SW monsoon (right) during NE monsoon³⁰

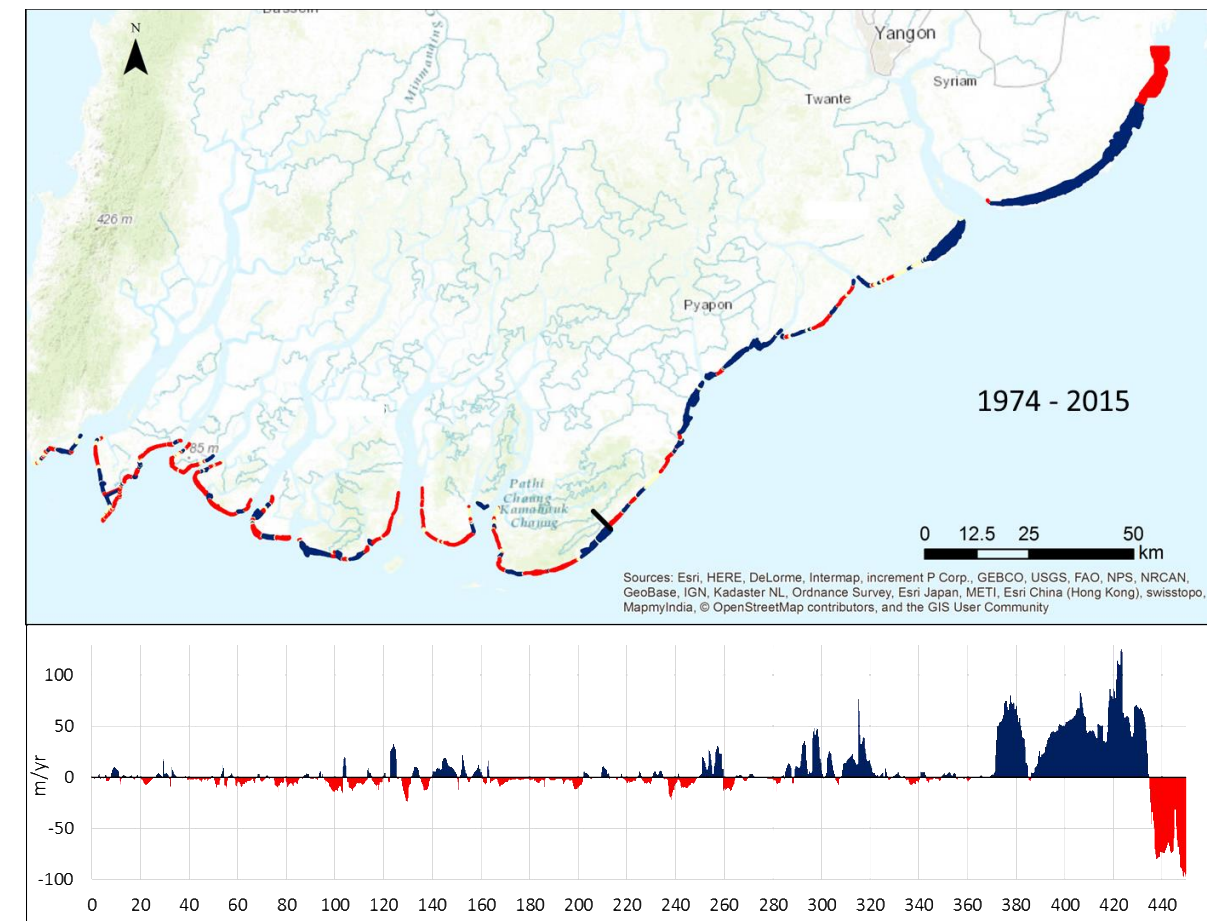


Figure 1-33: Areas of coastal accretion (blue) and coastal erosion (red) for the period 1974 and 2015³¹

²⁹ Kroon, M.E.N., and Rip, J. (2015), Scoping Study of Coastal Squeeze Phenomenon in the Ayeyarwady Delta (2015), Delft University of Technology

³⁰ Rao, P.S., Ramaswamy, V. & Swe Thwin, Sediment texture, distribution and transport on the Ayeyarwady continental shelf, Andaman Sea (2005), Marine Geology, 216, 239-247

1.5 Oil and gas

Myanmar is one of the oldest oil producing countries in the world from its hand-dug wells in the center of the country. Offshore oil and gas is discovered in 2000 and especially the gas production of the country has grown enormously since then.³² The Ayeyarwady delta consists of deep wells of potential gas of Miocene geological age (Figure 1-34), as well as a small storage of oil. The reservoirs are located on depths of 4,000-12,000 ft. (1.2-3.6 km). So far only three reservoirs are discovered, although 37 reservoirs were identified. The three gas reservoirs Apyauk, Nyaungdon and Maubin are in production since 1991, 1999 and 2006 respectively. The cumulative produced gas in the delta until May 2015 was approximately 650,000 billion cubic feet, which is 41% of the total gas production of Myanmar³³. Although the exact hydrocarbon potential is largely unknown, there is a large likelihood that Myanmar has hydrocarbon potential. However, other sources state that the gas reserves in the Ayeyarwady Delta are already exploited. Just offshore of the Delta, the Yadana gas field is one of the biggest contributors to the current gas production of the country. From 2014 on, gas and oil fields in the sea were up for tender by oil and gas companies. A gas pipeline is constructed offshore and over land from Yadana to Yangon and Dawei.

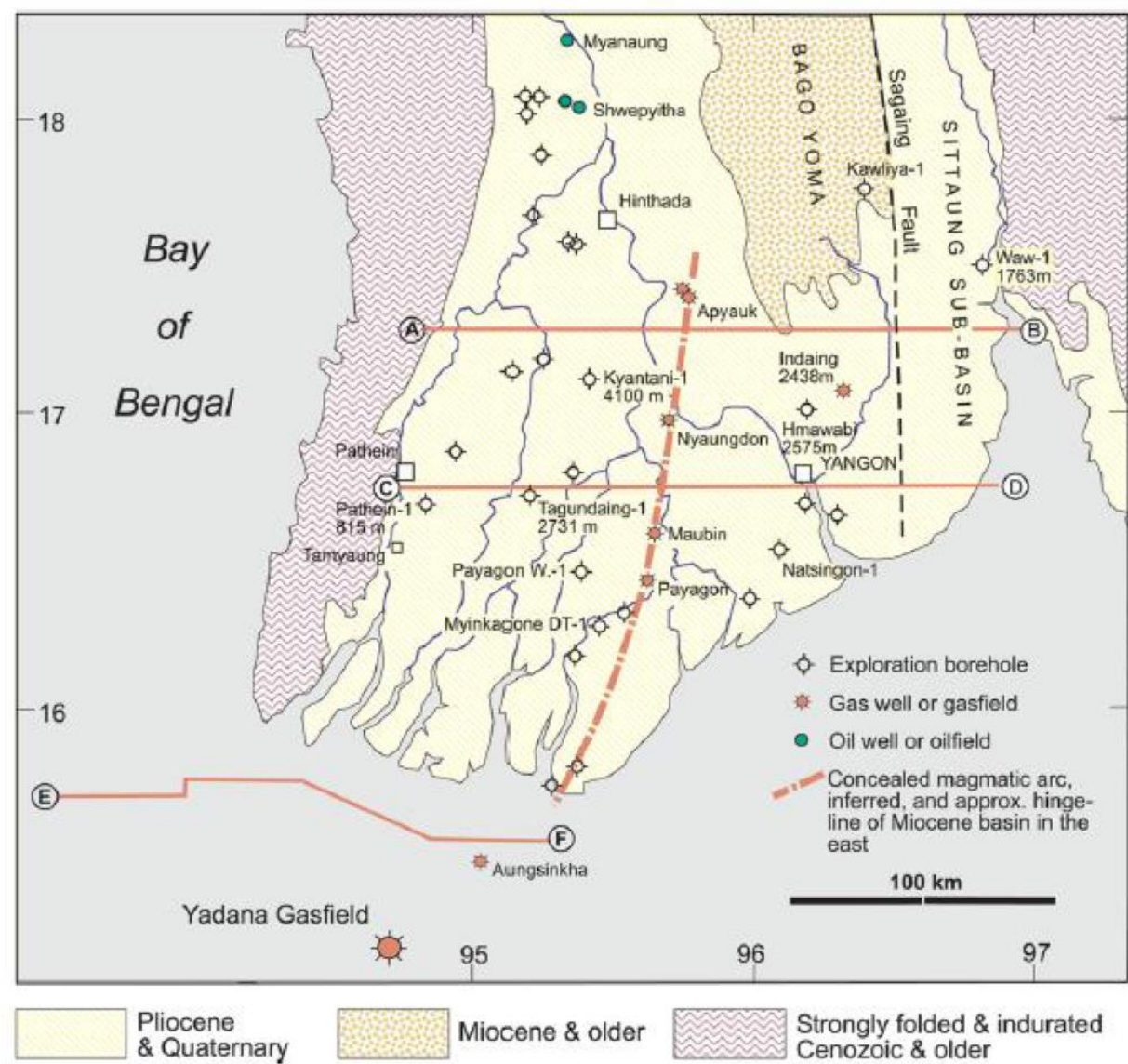


Figure 1-34 Location of boreholes and exploration boreholes in the delta³²

In Place Proved Oil and Gas Reserves of Discoveries, Onshore Myanmar

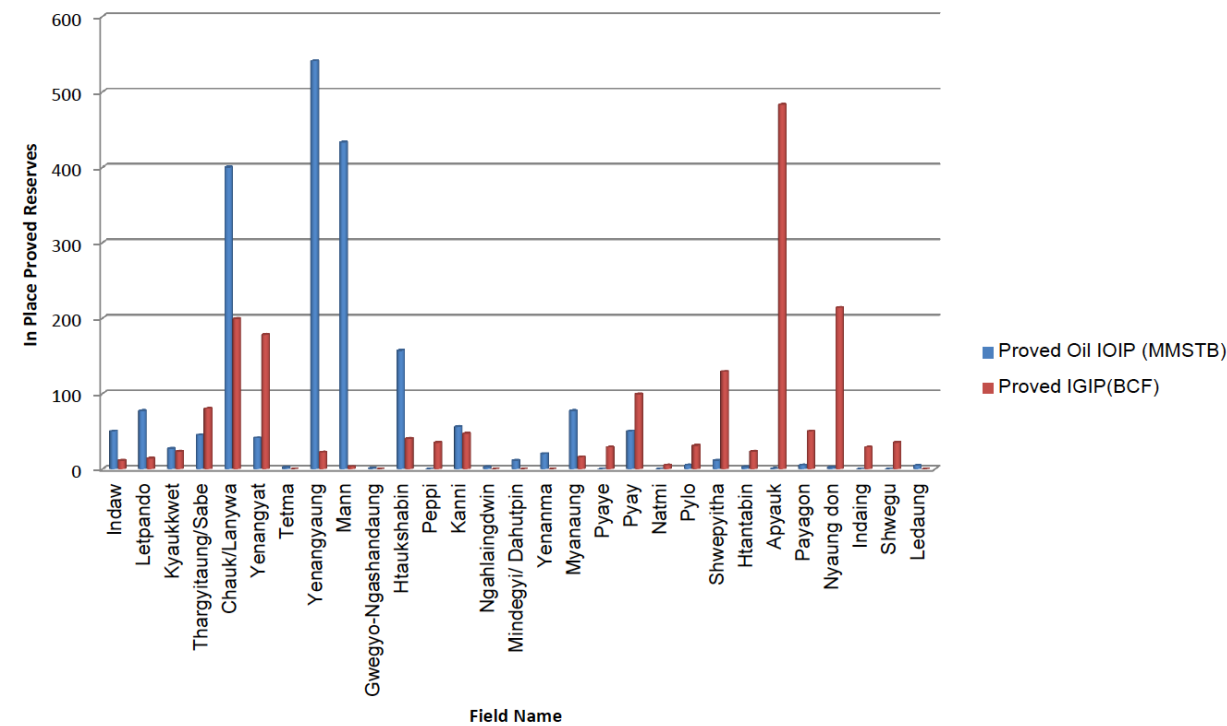


Figure 1-35 Proved oil and gas reserves, with Apyauk and Nyaungdon fields in the Ayeyarwady³³

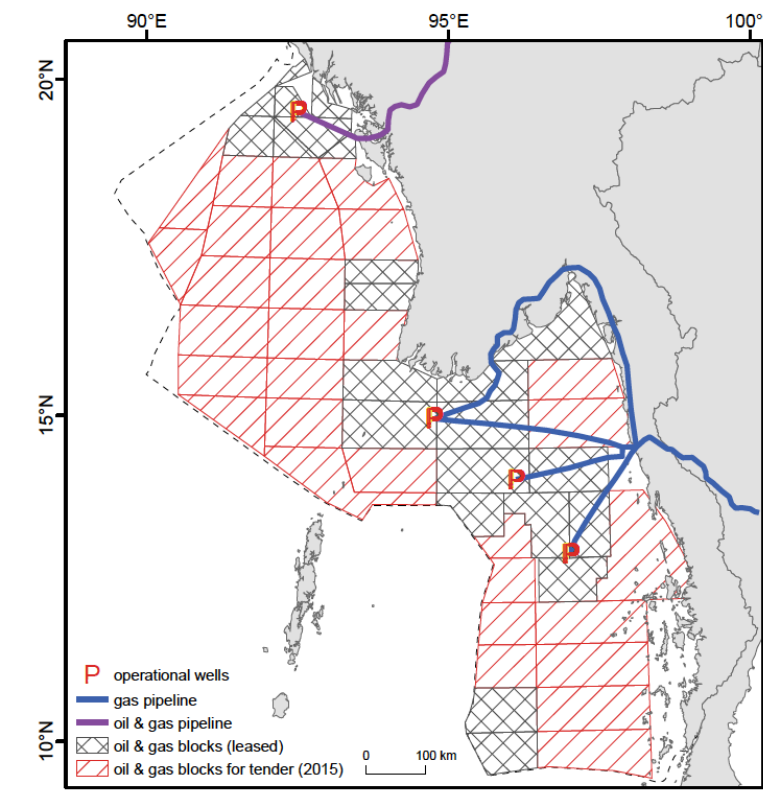


Figure 1-36: Gas and oil pipelines offshore gas fields³⁴

³¹ Anthony, E.J., Besset, M. and Dussouillez, P. (2017), Recent shoreline changes and morpho-sedimentary dynamics of the Ayeyarwady River Delta, Aix Marseille Universite & WWF
³² Ridd, M.F., & Racey, A. (2015), Introduction to the Petroleum Geology of Myanmar, Geological Society, Chapter 1
³³ Duane Morris , Discussion on Realistic Oil and Gas Potential of Onshore Myanmar

³⁴ Birch, F.C.H., et al. (2016), Myanmar Marine Biodiversity Atlas, University of Exeter, UK, 79p

1.6 Environment

1.6.1 Mangroves

The natural vegetation of the lower delta is mangrove forest where many different species of mangrove can be found dependent on their location in the tidal system. Today, 46 percent of the total area of mangroves in Myanmar is found in the Ayeyarwady Delta, where the total mangrove population in Myanmar is 8.8% of the total mangrove forests area in South East Asia³⁵. However, this mangrove area has been heavily exploited and is largely in a degraded state due to human activities such as wood harvesting and coastal development. Very little of its forest area is protected, only 6.3% according to World Bank data. Most of the remaining forest is in various stages of regrowth. Mangroves appear to be classified as primary or secondary areas. Primary areas are protected under jurisdiction of the Ministry of Natural Resources and Environmental Conservation (MONREC); they are not available for aquaculture and are essentially forest reserves. Significant jurisdiction of the secondary areas seems to be devolved to the Department of Fisheries for availability to conversion to aquaculture. The delineation of primary and secondary areas does not appear to be very clear and even primary forests are exploited by the local communities.³⁵ The mangroves of the Ayeyarwady Delta have been seriously degraded over time due to overexploitation of the resource and to the conversion of land for rice fields and shrimp (and fish) ponds, an activity promoted by the government to ensure self-sufficiency in food production. Next to this, the current policy developments favor export-orientated agriculture and this will affect the mangroves. As shown in Table 1-2, the area covered by mangroves has decreased from 274,324 ha to 44,973 ha in the period between 1980 to 2013. This number is supported by Webb et al. (2014)³⁶, who stated that the area of mangroves is decreased from 262,300 ha in 1978 to around 100,000 ha in 2011. Figure 1-37 shows the mangrove decline in a span of 80 years. In addition, the Forest Department reported a decrease from 295,940 ha in 1980 to 78,750 ha in 2015, a decrease of 73%.³⁷ Even though the historical number is quite different, the more recent mangrove area data are more or less similar. It suggests that during the past 33 years about 60-84% of the mangroves in the Ayeyarwady Delta have been lost, and this trend will most likely continue in the future. Figure 1-38 shows where most of the mangroves are declined. The trend moves from inland to the coast. The only completely preserved area is the protected Meinmahla Kyun Wildlife Sanctuary. Interesting to note is that mangroves were still able to resist the forces of cyclone Nargis and no significant loss was recorded. Only some species on already degraded area were unable to recover from the cyclone. Six of the main species in the Ayeyarwady delta are shown in Figure 1-38. Especially the *A. officinalis* and the *E.agallocha* showed the least disturbance and fastest recovery by the cyclone, whereas the *R.apiculata* was most susceptible for cyclone impact.

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Table 1-2: Conversion of mangroves in to agricultural fields and shrimp ponds between 1980 and 2013 (Maung, 2013)

Division / state	Total mangrove 1980 (ha)	Other land use (ha)			Current mangrove 2013 (ha)	Loss %
		Agriculture	Shrimp pond and other	Total		
Ayeyarwady	274,323.7	107,430.5	121,920.7	229,351.2	44,972.5	84

Table 1-3: Mangrove cover change between 1980 and 2015³⁷

	1980 cover (ha)	2015 cover (ha)	Loss (ha)	Loss %
Ayeyarwady	295,939.7	78,749.7	217,188.8	73

³⁵ Wim Maung (2013), Status of Mangrove Forest in Myanmar and Coastal Livelihood and Environmental Assets Restoration in Rakhine Project Power Point presentation

³⁶ Webb, E.L., Jachowski, N.R.A., Phelps, J., Friess, D.A., Than, M.M. & Ziegler, A.D. (2014), Deforestation in the Ayeyarwady Delta and the conservation implications of an internationally-engaged Myanmar, Global Environmental Change, 24, 321-333

³⁷ Forest Department (2017), Mangrove Data, Ministry of Natural Resources and Environmental Conservation, Republic of the Union of Myanmar

³⁸ Toe Toe Aung, Yukira Mochida, & Maung Maung Than (2013), Prediction of recovery pathways of cyclone-disturbed mangroves in the mega delta of Myanmar, Forest Ecology and Management, 293, 103-113

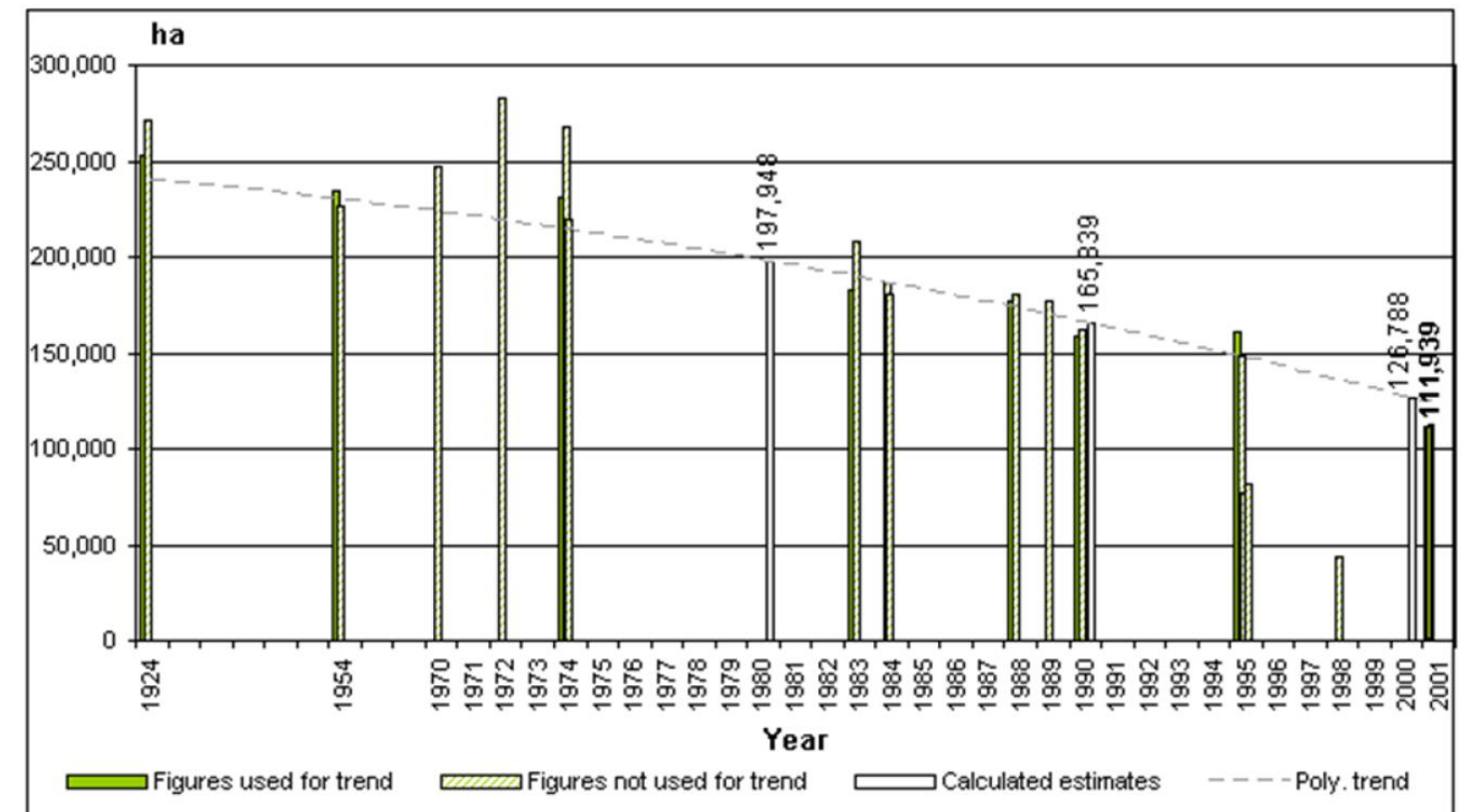


Figure 1-37 Left: mangroves decline in a span of 80 years in the Ayeyarwady delta from FAO,2007³⁹

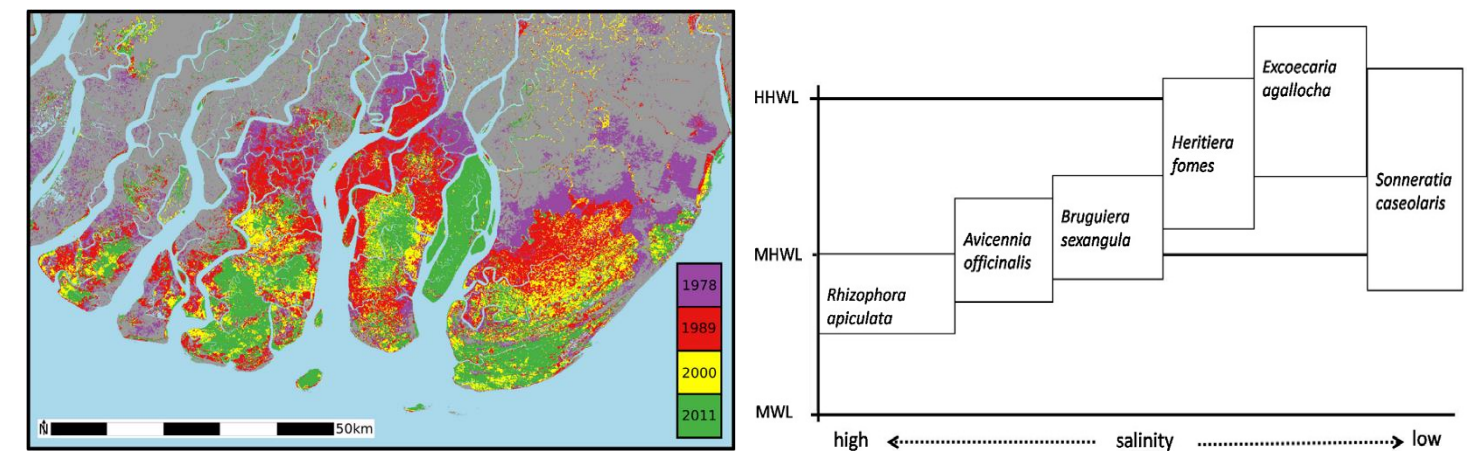


Figure 1-38: Mangrove land cover over the years 1978 to 2011 (left)³⁶ and Six mangrove types and their location in estuaries (right)³⁸

³⁹ Myanmar Integrated Water Resources Management: Strategic Report (2014)

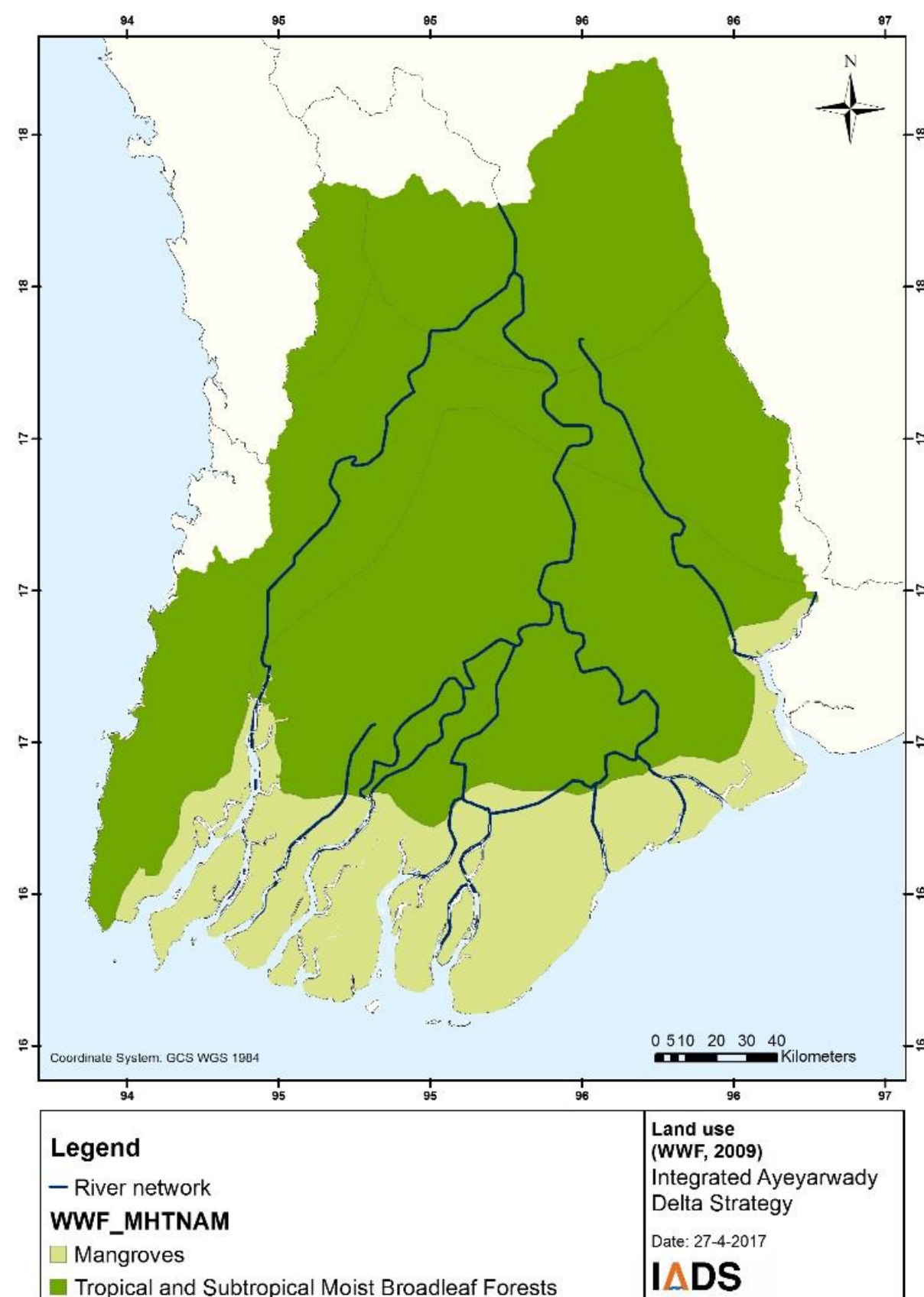


Figure 1-39: WWF Global Ecoregions, Major Habitat Types, Biogeographical Realms and The Nature Conservancy Terrestrial Assessment Units as of December 14, 2009.

1.6.2 Forests

Next to mangroves, forest covers a large part of the rest of the country. However, this is also in decline, which may result in faster run-off to the rivers from the land. Also, other forest areas are not much protected and they are in degraded state. Figure 1-39 presents the ecoregions that were originally present in the delta next to the current use of land.

The forest industry is another big industry in Myanmar due to large forest areas and the good quality wood covering the country. As already mentioned before, Myanmar is the world largest exporting country in teak logs. However, the increasing importance of the sector has its drawbacks as it encourages fast deforestation of the country's mainly unprotected forest reservoirs. At current deforestation rates, the remaining forest is predicted to have vanished by 2035 due to agricultural expansion and logging. Analysis by Wang (2016)⁴⁰ suggests deforestation rates being highest in the Ayeyarwady Region of all Regions with rates of 2.62% between 2001 and 2010 (compared to national average of 0.81%). Moreover, the same research indicates annual carbon flux rates of 2.38%.

To unleash the potential of forests in terms of both ensuring local incomes to reduce poverty and manage and restore forest, establishment of community forest (CF) enterprises in the Ayeyarwady Delta is essential. Analysis showed⁴¹ that in the Delta, bamboo is the highest priority product followed by timber and charcoal. In 2009-2010, the forestry industry had a value of 79,063 million Myanmar Khat. Wood is predominantly used for cooking in the rural villages of the delta. Enterprise-oriented community forest offers a potential opportunity to achieve income generation and sustainable forest management, but adaptation is slowly. In 2012, only 134 CF certificates were handed out compromising 7,500 acres (half plantation, half natural forest). Bamboo is in highest demand in local communities for housing and making bamboo-based handicrafts. Although charcoal production is officially illegal in the Ayeyarwady Region, it is still the number three marketed wood showing the bad regulations and control of forestry. The Forest Master Plan of the Myanmar Government aims at having 918,000 ha of protected forest by 2030 meaning that almost 14% of the total Ayeyarwady forest area should be protected CF area at that time.

⁴⁰ Wang, C. & Myint, S.W. (2016), Environmental Concerns of deforestation in Myanmar 2001-2010, Remote Sensing, 8, 728, doi10.3390/rs8090728

⁴¹ Kyaw Tint, et al. (2014), Unleashing the potential of community forest enterprises in Myanmar, ECCDI, UEA and IIED, London, UK

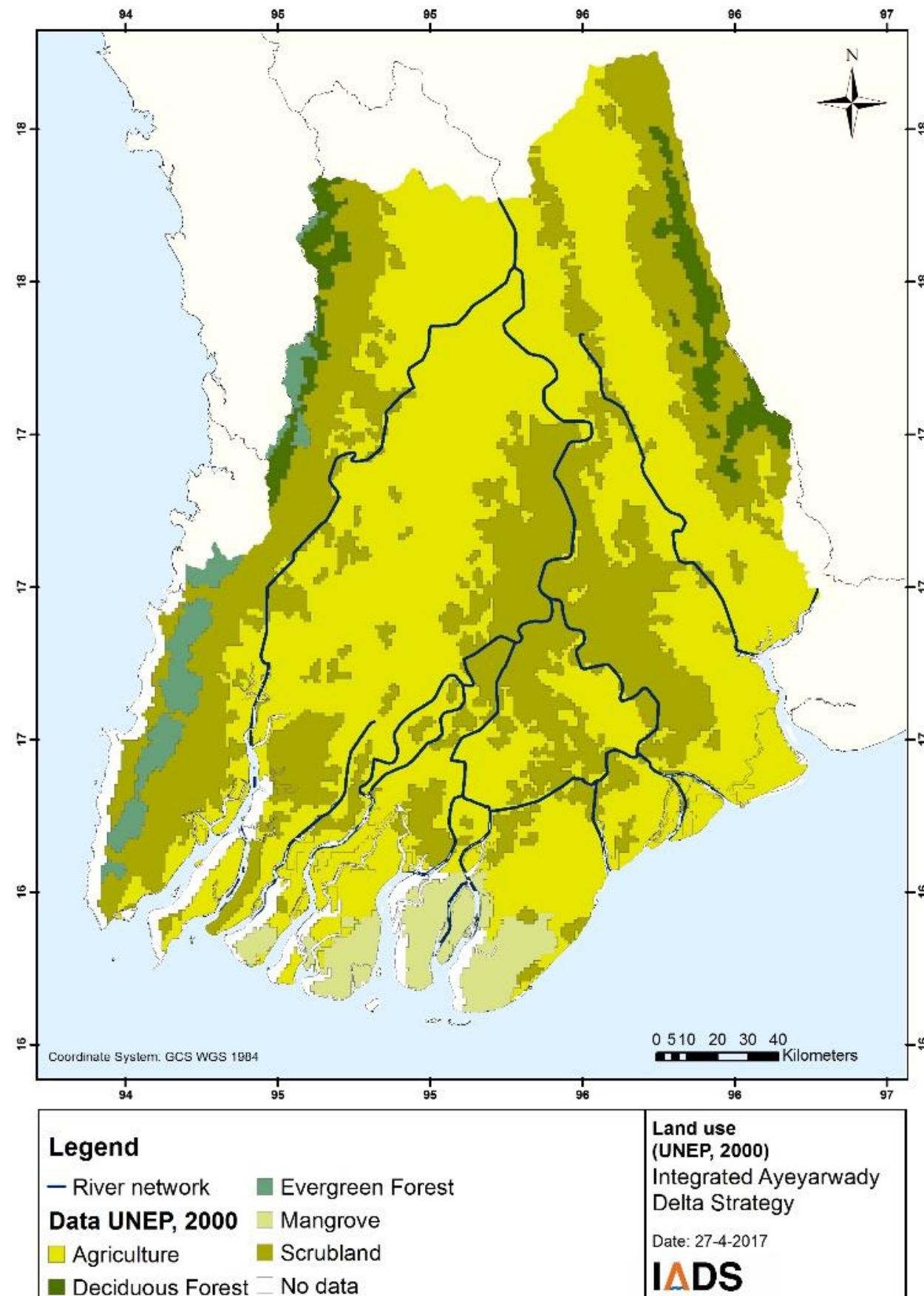


Figure 1-40: Myanmar land use map WWF (2009)

1.6.3 Biodiversity

Myanmar holds an incredible rich biodiversity and habitats that have escaped the path of over-exploitation compared with its neighbouring countries. A study by the Wildlife Conservation Society identified all species of conservation concern found in the country assessed by the Red List of globally endangered and critically endangered species.⁴² Over 100 species of this list were found in the country, although more are expected to be present. Based on this, 132 key biodiversity areas are identified throughout the country holding significant populations of species of high conservation concerns. Only 25% of these areas are legally protected and the rest of the areas are therefore the main concern. The same as the past development in neighbouring countries, the rich biodiversity is under increasing threat. They are endangered by human encroachment, commercial over-exploitation of animals and fish, agricultural expansion and logging. Some interesting endangered mammals for the Ayeyarwady Delta are the marine turtles, crocodiles and the Ayeyarwady Dolphin.

Several turtles and tortoises inhabit Myanmar and especially the southern region of the country. Large concentrations of marine turtles are nesting along the coast. Nesting beaches are usually not protected and conservation action is needed. Two large estuarine turtles occur. The population has declined due to a combination of egg-collecting, harvesting adults, and destruction of nesting habitat. The amounts of nests have seen an exponential decline from around 8000 in 1900 to no evidence of continued survival in 2000.⁴³

Several crocodile species were found in Myanmar, mostly concentrated in the lower Ayeyarwady Delta. Nowadays only one specie survived, the *Crocodylus porosus*, with the only viable population confined in the Meinmahla Kyun Wildlife Sanctuary.⁴⁴ Historically, the estuarine crocodile was widely distributed and abundant in the coastal region and major rivers.

Elephant conservation is another major concern in the Ayeyarwady and the rest of the country. Most elephants in the Ayeyarwady live in the Rakhine Yoma Elephant Range, which is mainly located in the Rakhine State with overlap in the Ayeyarwady. Illegal killing happens for a variety of reasons, including trafficking of ivory or other elephant body parts including skin, and as revenge killings motivated by human-elephant conflict. A trend in elephant killing can be observed in the Ayeyarwady Division, where elephant killings have increased from 2012 to 2015 by ten-fold (23 in total in 2015).⁴⁵

Another endangered species are the Sarus cranes with two kinds of cranes occurring in Myanmar; the red-head and the blackhead crane. The country has a moderate population of cranes, which is a native bird of Myanmar. Conservation of these cranes is essential to prevent extinction, especially in the Ayeyarwady Delta.⁴⁶ They live in mainly wetlands such as canals, ponds and marshes, but they can also be found in cultivated area such as paddy fields crossing path with humans.

The designation of Meinmahla Kyun which is a wildlife sanctuary situated in Bogela Township, Ayeyarwady Region as a Ramsar Site marks the Myanmar government's commitment to the protection of coastal ecosystems, including mangroves, mudflats and turtle nesting beaches. Located in brackish water conditions, Meinmahla Kyun hosts the world's largest population of the critically endangered mangrove plant species *Sonneratia griffithii*, and more than 30 species of threatened fauna found on the IUCN red list, including the critically endangered mangrove terrapin (*Batagur baska*), endangered wild dog (*Cuon alpinus*), vulnerable Ayeyarwady dolphin (*Orcaella brevirostris*) and lesser adjutant stork (*Leptoptilos javanicus*). Threatened migratory bird species found in the area include the critically endangered

⁴² Wildlife Conservation Society (2013), Myanmar Biodiversity Conservation Investment Vision, Yangon, Myanmar

⁴³ Thorbjarnarson, J. and Platt, S.G. and Kiang, S.T. (2000), Conservation status of freshwater turtles in Meinmahla Kyun Wildlife Sanctuary and vicinity, Myanmar. Natural History Bulletin of Siam Society, 48, 185-191

⁴⁴ Thorbjarnarson, J., et al. (2006), Herpetological Natural History, 10(1), 67-79

⁴⁵ MECAP (2017), Myanmar Elephant Conservation Action Plan (MECAP) 2017- 2026

⁴⁶ Sarus crane conservation continues in Ayeyarwady Delta, accessed: 21/06/2017, http://www.shwemyanmar.info/news_detail_m.php?id=4377&type=3

spoon-billed sandpiper (*Calidris pygmaea*) and the endangered Nordmann’ greenshank (*Tringa guttifer*) and great knot (*Calidris tenuirostris*), which makes the Ramsar Site important for shorebird conservation along the Australasian flyway. Furthermore, it is home to 50 vascular plants and is recognized as the most threatened mangrove habitat in the world. During the Nargis Cyclone storm surge, 50% of all trees on the island were destroyed. However, instead of strengthening the protection of the ecosystem, the people who lost their homes were allowed to extract timber form the wildlife sanctuary to rebuild their houses for a four-months period. Every year, around hundred tourists visit the wildlife sanctuary with opportunities for ecotourism in the future. However, this might be hampered due to bad access during rainy season and difficulties of spotting wildlife on the island. With more than 30 villages living in poverty surrounding the Meinmahla Kyun estuary, the Forest Department and Fauna & Flora International hope that international recognition as Ramsar Site will attract additional funding to alleviate poverty while protecting and restoring the mangrove forest with its unique biodiversity values.



Figure 1-41: Location of the Meinmahly Kyun Wildlife Sanctuary. Image: FAO (2002)

In Figure 1-42, the main corridor areas near and in the delta are shown. It includes the Terrestrial Corridor, River Corridor and Marine Corridor. These corridors serve as bundle of biodiversity habitats. On the left side, the Terrestrial and marine corridor is also one of the Priority Corridors of the National Biodiversity and Action Plan⁴⁷; the Rakhine Yoma Range. The mountains of the Rakhine Yoma Range support a large, contiguous block of semi-evergreen, evergreen and mixed forest. It also includes a large stretch of coastline with extensive areas of intertidal mudflats and mangroves being the livelihood of marine inhabitants. The other two corridors are shaped around the main river branches and the forest area north of Yangon. Figure 1-43 shows the map of key identified biodiversity areas in the country. Some high priority and medium priority are identified in the delta area, especially in the lower delta near the coast. These include already protected area in orange and the key biodiversity areas, which are in need for status of protection. These areas are forest areas, mangroves, wetlands and the island south of the Delta with the Thamihla Kyun Wildlife Sanctuary on it.

⁴⁷ Ministry of Environmental Conservation and Forestry (2011), National Biodiversity Strategy and Action Plan Myanmar, Ministry of Environmental Conservation and Forestry and UNEP and GEF, Republic of the Union of Myanmar

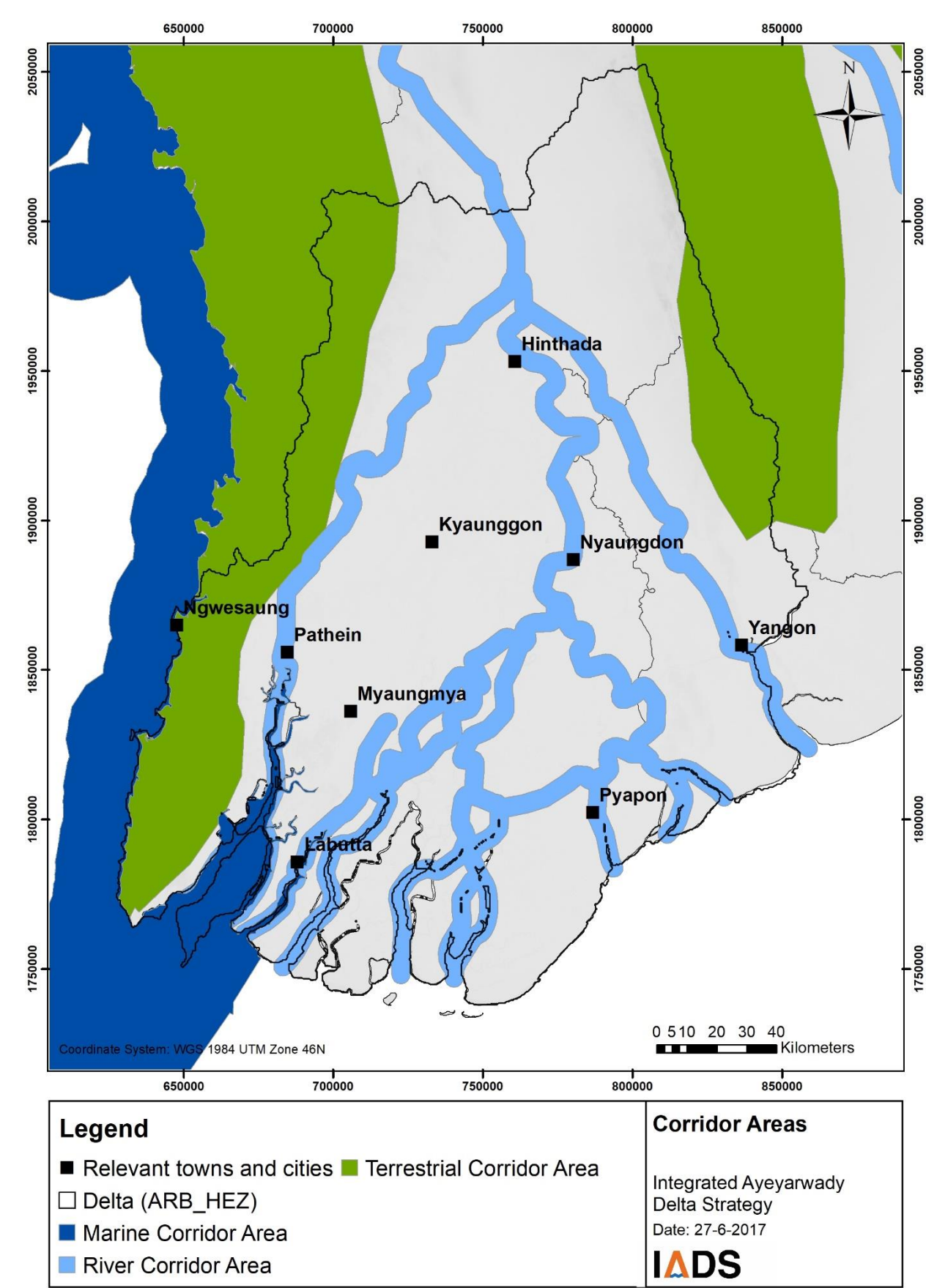


Figure 1-42: Marine, River and Terrestrial Corridors in the Ayeyarwady Delta⁴²

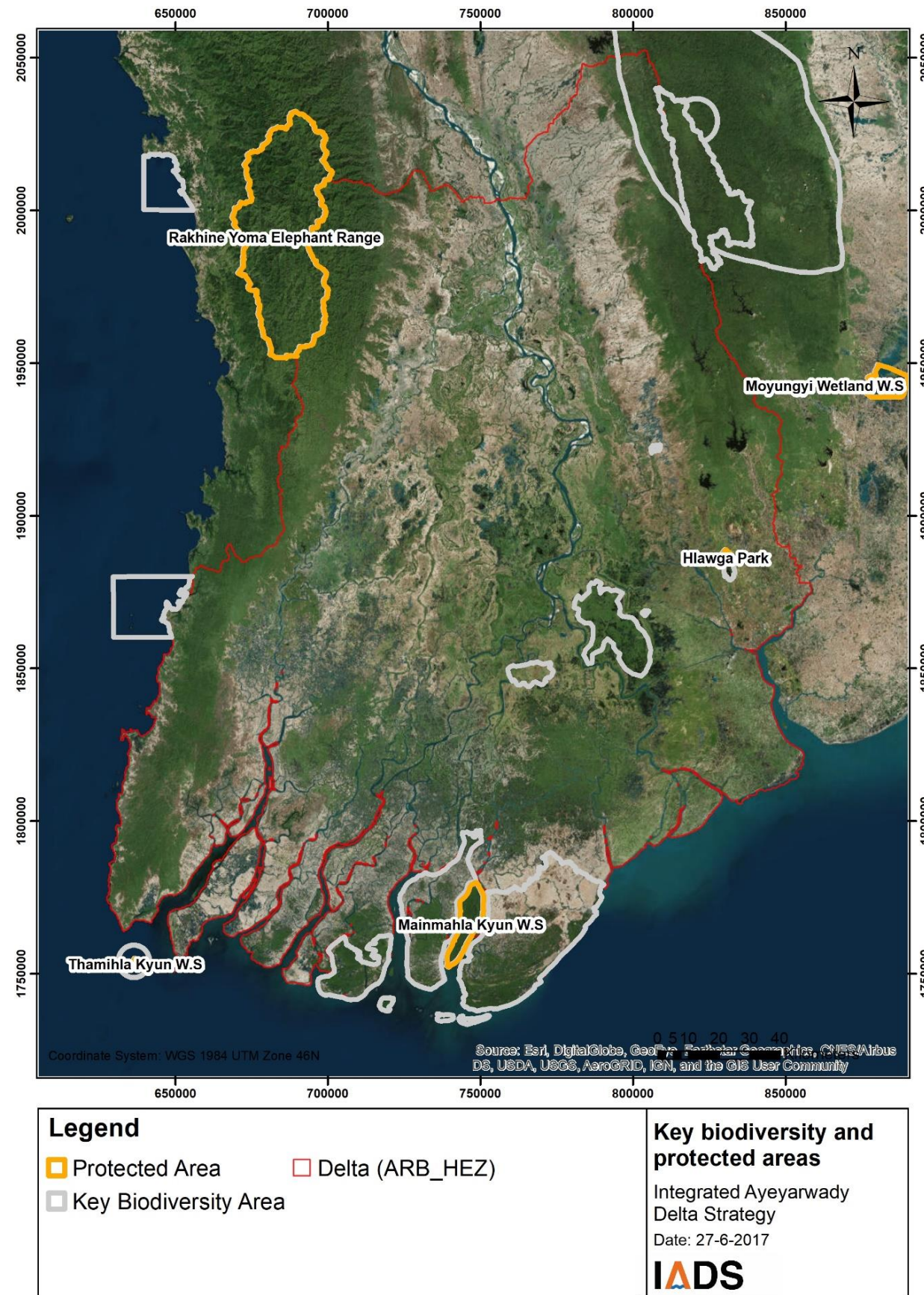


Figure 1-43: Already Protected and Key Biodiversity areas redrawn from MBCIV (Wildlife Conservation Society, 2013)⁴²

1.7 Water quality

Little is known about the water quality in the delta, but recent developments in agriculture, industry and urbanization are increasingly threatening the water quality of the delta. Water quality concerns are being raised with regard to mining activities and the growth of cities and industrial zones. The disposal of untreated domestic wastewater will lead to increased oxygen demand and deteriorating hygienic conditions of the surface waters and the increase in industrial and mining activities will further affect the water quality in the delta with a range of additional parameters (heavy metals, organic micro-pollutants and oils). Also, the use of the chemical fertilizers and pesticides are becoming more important in agricultural practices and this will affect the water quality as contaminated water will drain off the fields. Moreover, utilization rates of chemical fertilizers in the delta happen to be the highest among the agricultural regions in Myanmar.⁴⁸

One of the few studies on water quality in the delta showed that phosphate concentrations (PO_4) are very high in the deltaic water most probably because of lack of wastewater treatment. Also, high NO_3 concentrations were found near settlements indicating that decomposition of home waste disposals has already affected shallow water aquifers near settlements.⁴⁹ Table 1-4 shows indicative values for water quality for irrigation.

DWIR is annually monitoring the water quality at 10 different locations during the dry season (Table 1-5). The table shows the measurements since 2011. No water quality acts or guidelines are available to determine the water quality.

Table 1-4: Indicative guideline values for irrigation water quality, based on ⁵⁰, ⁵¹ and ⁵²

Parameter	Unit	Guideline value	Information Source / Note
pH		<7	To limit fouling potential on irrigation infrastructure
Temp (oC)	oC	-	
DO	mg/L	-	Depends on destination, but generally no worry for irrigation
Iron	mg/L	<0.1	
Chloride	mg/L	350 - 700	350 corresponds to low risk of increasing crop cadmium concentration, whereas 700 corresponds to high risk
Chlorine	mg/L	-	
Alkalinity	mg/L	<40	
Hardness	mg/L	>350 mg/L as $CaCO_3$	Limit fouling potential
Ammonia	mg/L	-	Heavily dependent on pH
Nitrite	mg/L	-	heavily dependent on pH
Nitrate	mg/L	<10	
Fluoride	mg/L	2	
Turbidity	NTU	5	Indication for turbidity in drinking water
Thermotolerant Coliforms	cfu	(a) <10 cfu/100 ML	(a) Raw human food crops in direct contact with irrigation water (irrigation of salad vegetables)
		(b) < 1,000 cfu/100 ML	(b) For crops that are processed before sold to consumers or sold, pasture, irrigation for animals
Salinity	EC (dS/m)	3	Average value for paddy/rice crops. Depending on soil (sand 4.8 –clay 1.6)

⁴⁸ Zaw Lwin Tun & Hla Oo New (2010), Flood Management at the national level, Myanmar

⁴⁹ Hliang, K.T., Haruyama, S., Hide, M., & Aye, M.M. (2013), Water Quality of the Ayeyarwady Delta, Myanmar using GIS-based Mapping and Analysis

⁵⁰ Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand (2000), Australian and New Zealand guidelines for fresh and marine water quality, Volume 1.

⁵¹ Department of Primary Industries (2014), Farm water quality and treatment, Agriculture NSW Water Unit, Australia

⁵² Agriculture Victoria (2013), Water Quality for farm water supplies, Victoria, Australia

Table 1-5 Water quality measurements between 2011 and 2015 at 10 locations by DWIR (2017)

Location	Year	Month	PH	Temp (°C)	D.O (mg/L)	Iron (mg/L)	Chloride (mg/L)	Chlorine (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	Ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Fluoride (mg/L)	Turbidity (NTU)
Act*			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kyankhinn	2011	March	7.2	27.7	4.6	0.015	58	0.04	135	42	0.91	5	0.32	1.25	30
	2012	March	6.81	28.7	6.81	0.645	166	0.29	197	90	0.59	35	>1.0	0.2	140
	2013		7.4	17.3	16.81	0.66	180	0.21	197	95	0.95		1	0.25	120
	2014		5.8			0.805	380	0.14	202	115	0.1		0.33	1.55	95
	2015	March	7.4	17.3	16.81	0.66	180		197		0.95		1	0.25	120
Myanaung	2011	March	7.28	32.4	3.99	0.23	315	0.04	130	65	0.07	10	0.4	0.2	10
	2012		8.68	27.3	6.57	0.515	232	0.23	197	102	>1.0	40	1	1.3	145
	2013		7.3	27	16.7	0.95	500	0.13	214	110	1		0.12	1.5	100
	2014		6.5			0.165	94		135	95	0.07		0.37	0.05	58
	2015	March	7.3	27	16.7	0.95	500		214		1		0.12	1.5	100
Hinthada	2011	March	7.18	32	5.22	0.12	211	0.04	150	65	>1.0	5	0.7	>1.5	25
	2012		8.23	28.8	6.75	0.59	>500	0.13	214	122	>1.0	40	0.9	1.2	150
	2013		8	26.8	6.9	0.9	500	0.52	145	85	0.45		0.15	1.5	55
	2014		4.4			0.685	205	0.19	150	108	0		0.26	1.2	70
	2015	March	8	26.8	6.9	0.9	500		145		0.45		0.15	1.5	55
Zalun	2011	March	7.18	32.3	6.08	0.15	355	0.04	145	65	0.11	5	0.8	>1.5	38
	2012		8.07	28.3	5.66	0.375	335	0.14	180	108	0.74	20	0.65	0.1	95
	2013		8	27	7.7	0.185	240	0.49	165	108	0.02		0.26	0.4	55
	2014		5.9			0.025	410	0.74	120	95	0.01		0.37	1.55	13
	2015	March	8	27	7.7	0.185	240		165		0.02		0.26	0.4	55
Aphauk	2011	March	7.21	30.4	5.67	0.155	410	0.05	155	56	0.47	5	0.1	1.1	20
	2012		8.07	29.1	6.6	0.33	>500	0.05	165	47	>1.0	20	0.47	0.35	140
Zakargyi	2012	March	8.16	28.9	6.4	0.15	100	0.18	145	0	>1.0	10	0.42	0.55	58
Danuphyu	2011	March	7.15	31.5	5.7	0.12	260	0.18	155	60	0.96	5	0.8	1.35	15
	2012		7.91	28.4	6.83	0.365	112	0.11	170	56	0.16	10	0.42	1.3	25
	2013		7.8	29.6	8	0.31	120	0.14	160	85	0.23		0.24	1.5	20
	2014		6.2			0.02	285	0.18	135	80	0		0.23	1.06	13
	2015		7.8	29.6	8	0.31	120		160		0.23		0.24	1.5	20
Nyaungdone	2011	March	7.25	29.9	5.71	0.165	270	0.04	160	70	0.77	5	0.24	>1.5	22
	2012		8.89	28.4	12.99	0.95	182	0.19	208	70	0.16	15	1	1.4	65
	2013		8.3	28	10.33	0.12	500	0.13	160	115	0.26		0.35	1.45	35
	2014		8.4			0.025	335	0.05	160	130	0		0	1.4	35
	2015		8.2	28	10.33	0.12	500		160		0.26		0.35	1.45	35
Maubin	2012	March	8.38	28.3	9.78	0.385	211	0.19	130	35	0.13	10	>1.0	1.1	45
	2013		8.5	28.5	13.35	0.39	120	0.02	150	80	0.03		1	1.4	30
	2014		8.9			0.35	150	0.12	150	100	0.05		0.35	1.3	70
	2015		8.5	28.5	13.35	0.39	120		150		0.03		1	1.4	30
Twantee	2012	March	7.95	26.6	12.85	1.895	206	0.11	352	355	>1.0	115	0.43	1.1	200
	2013			27.5	16.12	1.92	200	0.12	250	300	1		0.42	1.2	120
	2014		8.5			1.85	230	0.16	250	370	1.8		0.45	1.5	170
	2015			27.5	16.12	1.92	200		250		1		0.42	1.2	120
*ND = No data															

1.8 Natural hazards

1.8.1 River flooding

Flooding has always been one of the major hazards in Myanmar. The threat of flooding usually occurs between June and October with the highest risk in August around the peak monsoon rains. The Chindwin River is the largest tributary of the Ayeyarwady River. The Chindwin River has floods several times in a year from the onset of the rainy season to the end of the monsoon. Most of the floods in the lower Ayeyarwady and the delta area are due to the Chindwin River and when it coincides with upper Ayeyarwady floods, severe flooding occurs in the delta area. The largest tidal range along the Ayeyarwady coastline can enhance the occurrence of flood events. Especially during high tide, increase of water level makes the hinterland more vulnerable for flooding. Figure 1-44 shows that spring tidal ranges can create dangerous water levels up until Nyaungdone. A look at Figure 1-45 shows that almost all townships in the delta were affected at least once in the last 5 years. Especially the upper parts of the delta are flooded more often since the highest discharges occur there. In the coastal regions, river flooding occurs in combination with the earlier mentioned tidal influence.

An example of a township which is flooded almost annually is Kyaunggon. In July and August 2016, Kyaunggon was flooded for 1.5 month. A similar situation happened in 2015. According to the representative of the regional parliament the intensity of the floods increased since 2015. Before 2015, no such intense floods happened in the township. The disaster risk committee from the township only applied responsive management (food and medical supply). There is no disaster risk management able to prevent the township from flooding.

Figure 1-46 shows the surface water that occurred between 1984 and 2015 indicating the percentage of time that water was present in a certain area. Darker blue corresponds to a higher percentage of occurrence. These maps are created from satellite observations over time, showing the frequency of water measurements.⁵³ These images clearly show the frequently flood inundated areas. A large area is visible in the west near Kyaunggon, famous for its recurring flood events. As was already mentioned before, flood events occur in the northern part of the delta before the Ayeyarwady River distributes its water over the many branches. In addition, areas near Nyaungdone also pop up as flood hotspots, which can be explained by the influences of tide, still occurring in this area.

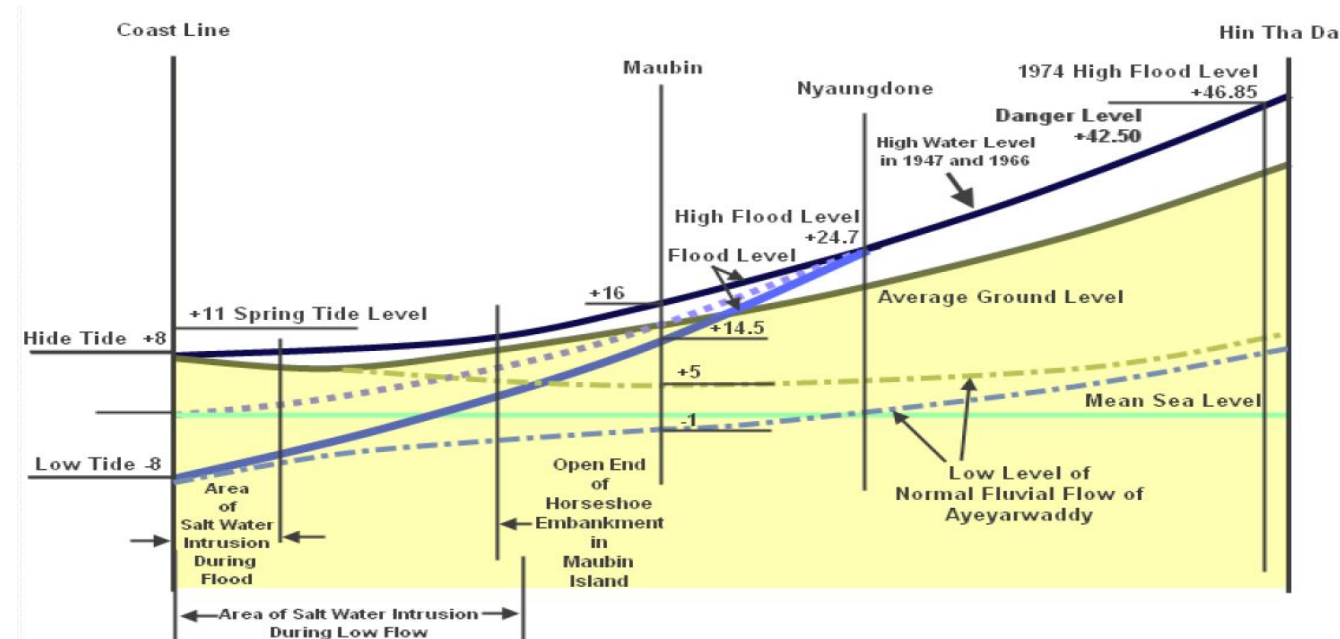


Figure 1-44 Cross section of Ayeyarwady delta showing fluctuation of tide during flood⁵⁴

⁵³ Pekel, J.F., Cottam, A., Gorelick, N. & Belward, A.S. (2016), High-resolution mapping of global surface water and its long-term changes, Nature, 540, 428-422, doi:10.1038/nature20584

⁵⁴ U Aye Myint (2011), Water Management Through the Ages in Ayeyarwady Delta, Powerpoint presentation, World Delta Summit

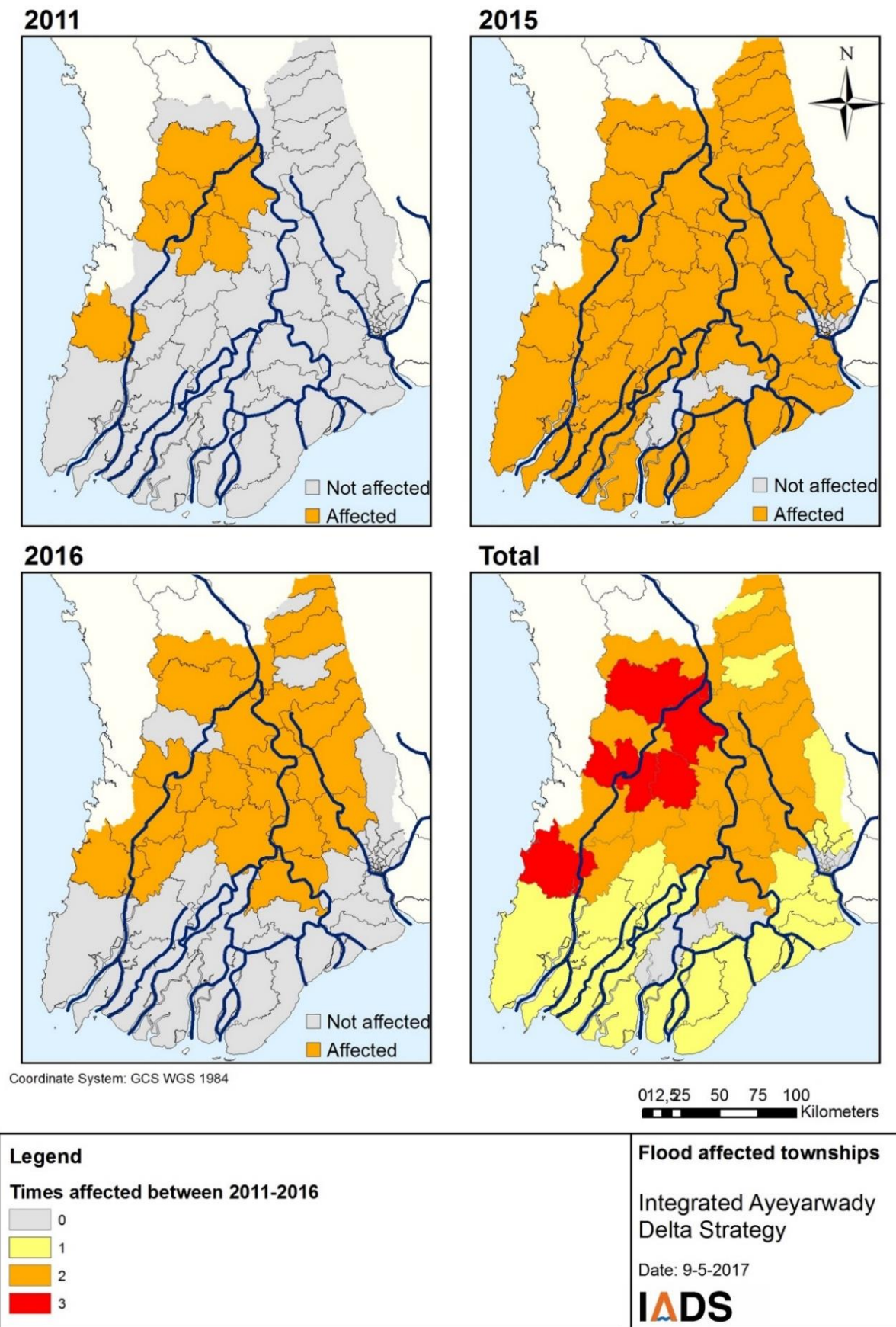


Figure 1-45 Flood affected townships in 2011, 2015, 2016 and the total of these years (MIMU, 2017).



Figure 1-46: Water occurrence over the period 1984-2015 with colour indication showing the time water was present (Pekel et al. 2016)⁵³

1.8.2 Cyclones

The coastal region of Myanmar is prone to cyclones and accompanying storm surges. April, May (pre-monsoon) and October to December (post-monsoon) are considered to be the cyclone months as per last 100-year record. Cyclone Nargis in 2008 is by far the most devastating natural disaster in the country's history. It directly showed the extreme vulnerability, in particular of the country's coastal regions and delta areas, to such low-frequency high-impact natural hazards. The category three Cyclone Nargis struck Myanmar on the 2nd and 3rd of May 2008, making landfall in the Ayeyarwady Region, approximately 250 km south-west of Yangon, and affecting more than 50 townships, mainly in Yangon and Ayeyarwady Regions, including Yangon itself (Figure 1-47). The affected townships are shown in Figure 1-48. Cyclone Nargis was characterized by wind speeds of up to 200 km/hr accompanied by heavy rain. According to the record of the cyclonic storm, the maximum storm surge height was 23 ft (7.02 m) in Pyinsalu Township, Ayeyarwady Region. The Cyclone Nargis was the worst natural disaster in the history of Myanmar, and the most devastating cyclone to strike Asia since 1991. As of the 24th of June 2008, the official death toll stood at 84,537 with 53,836 still missing, and 19,359 injured. Assessment data show that some 2.4 million people were severely affected by the cyclone out of an estimated 7.35 million people living in the affected townships.⁵⁵ The cyclone did not only affect humans, but also the ecosystem was severely affected. Enormous coastal erosion was measured and mangroves suffered from the event as well, making the area even more vulnerable after the event. Most of the cyclones arrive from the south west direction. There is no distinct pattern of the path cyclones follow, and this makes them highly uncertain in terms of potentially vulnerable area (Figure 1-49).



Figure 1-47: Satellite images on April 15, 2008 (left) and May 5, 2008 (right).

Table 1-6: Cyclones that hit the Myanmar coastline⁵⁶

Year	Region/state	Name	Affected	Dead
1968	Rakhine State			837
2004	Rakhine State		14,000	220
2006	Rakhine State	Mala		2
2007	Rakhine State	Akash		14
2008	Ayeyarwady	Nargis	2,400,000	138,000
2010	Rakhine State	Giri	70,000	157
2013	Rakhine State	Mahasan		0

⁵⁵ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

⁵⁶ Cyclones and Floods in Myanmar, http://factsanddetails.com/southeast-asia/Myanmar/sub5_5h/entry-3138.html

On a Saffir-Simpson scale, the exposure of the delta can be divided into four regions (Figure 1-48). This scale links hurricane wind speeds to expected damage. Category 5 is the highest class with wind speeds of 252km/h or higher causing catastrophic damage to houses, infrastructure and power outages. Affected areas will be uninhabitable for weeks to months. The lowest class, class 1, occurs at wind speeds of 118-153 km/h. These winds will produce some damage with possible power outages that could last for several days to weeks. The other categories are wind speeds in between these extreme classes, which is the case for the major part of the Ayeyarwady Delta.

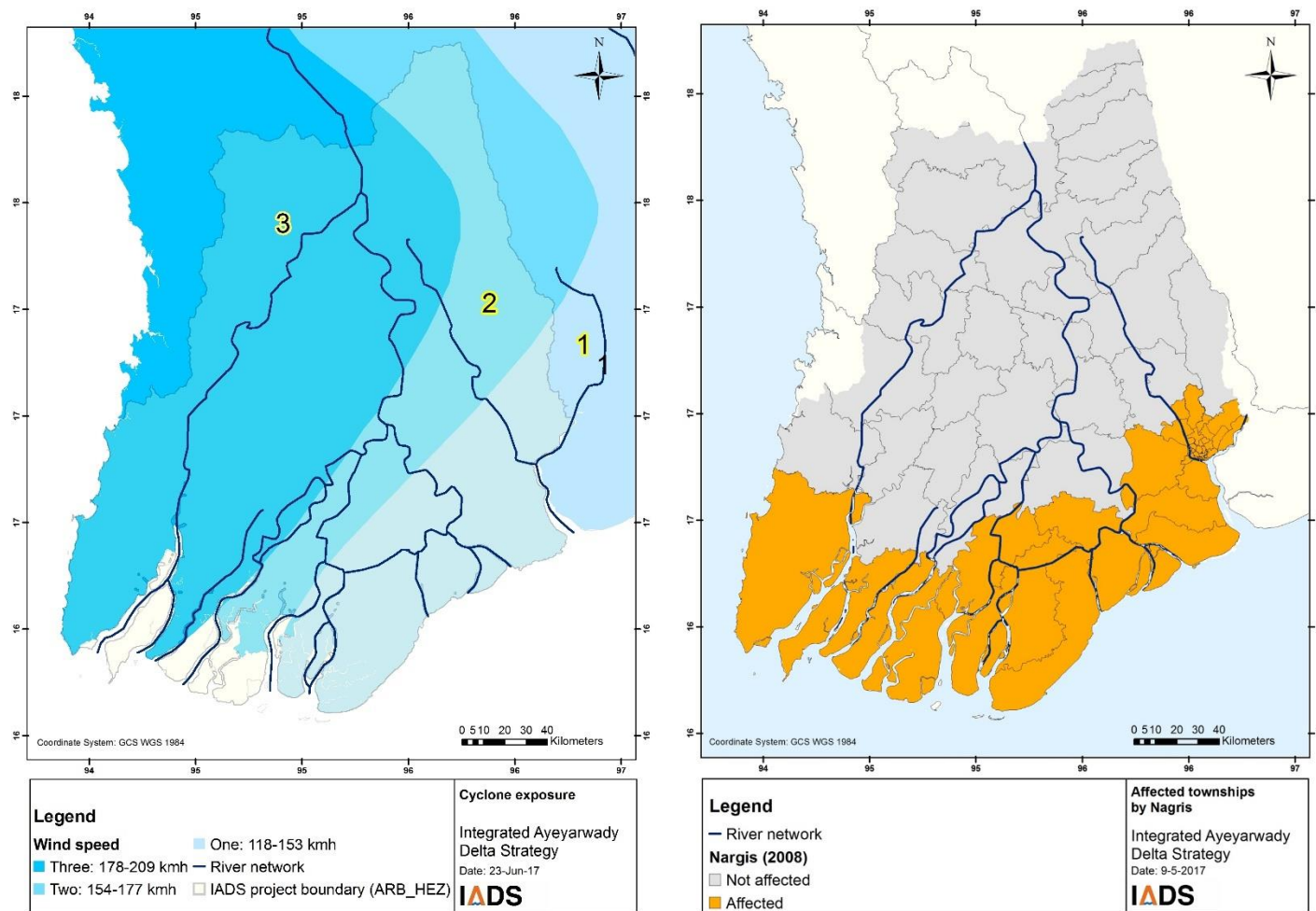


Figure 1-48 Cyclone exposure (left)⁵⁷ and affected townships by cyclone Nargis (right) (MIMU, 2017)

⁵⁷ OCHA Regional Office for Asia Pacific (2011). Myanmar: Natural Hazard Risks, <http://img.static.reliefweb.int/sites/reliefweb.int/files/styles/attachment-large/public/resources-pdf-previews/101638-map.png?itok=QrYqDlVv> (visited on 29-5-2017)

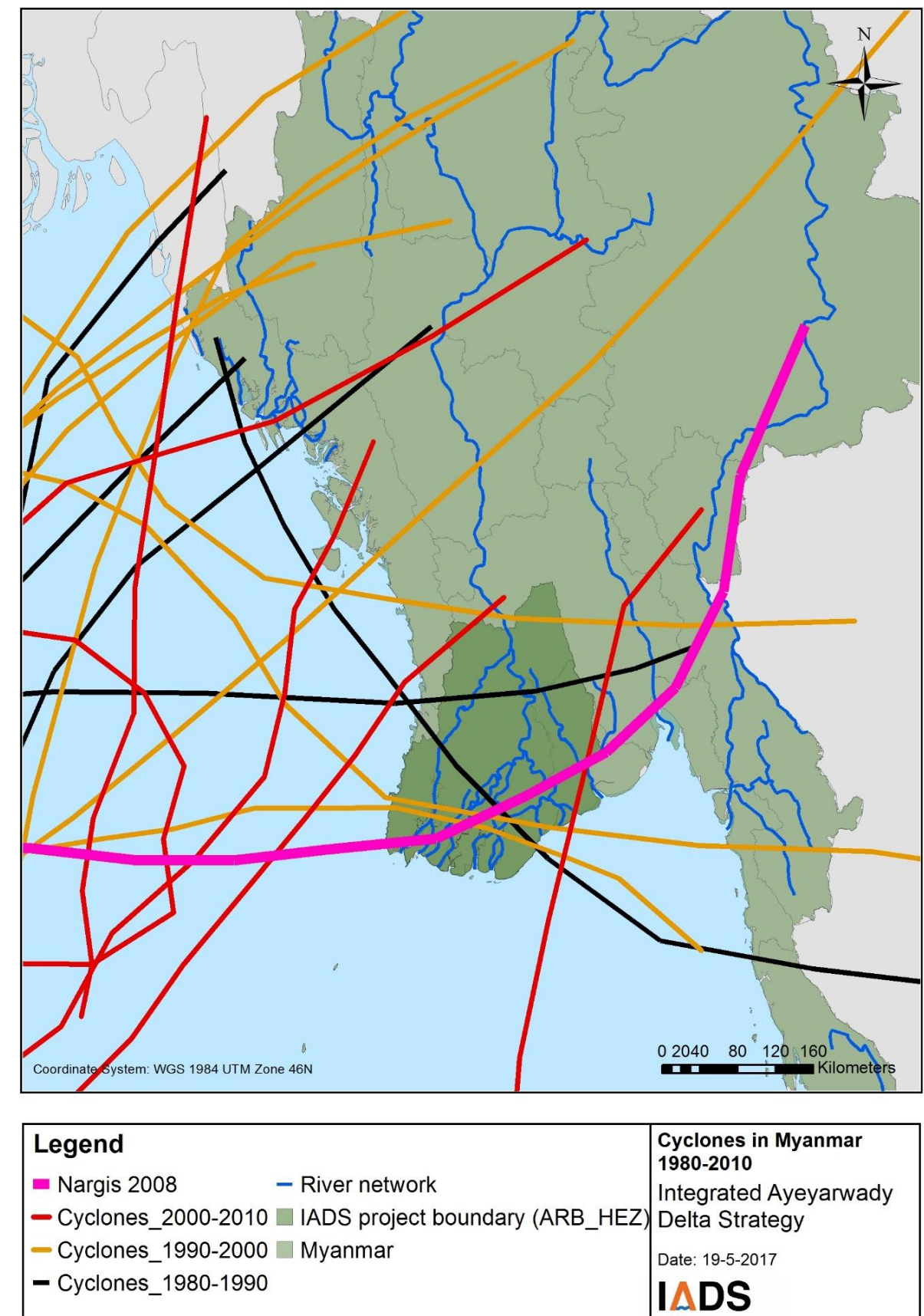


Figure 1-49 Observed cyclone paths between 1980 and 2010⁵⁸

⁵⁸ Naval research Lab, Monterey and JWC http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/best_tracks/iodindex.php

1.8.3 Droughts

The same as in many arid or semi-arid countries in the world, Myanmar faces some increasing problems with droughts under increasing pressures on water resources and water scarcity. Particularly the central dry zone north of the delta has experienced several droughts over the years, because this part of Myanmar gets less precipitation compared to other regions. Several drought events in the years 1997, 1998, 2010 and 2014 led to crop failure and water shortage. Also, the dry zone area as well as the Ayeyarwady delta have been affected by El Nino impact since 2015 with drier than average conditions. This can cause fire hazards, drought, disease and food insecurity. Moreover, it may hamper the navigational opportunities for the people in the delta, who are sometimes dependent on this.⁵⁹

1.8.4 Earthquakes and tsunamis

As is discussed in 1.2.1, the active Sagaing Fault crosses the country from north to south. Although the fault is located very close to Yangon, the largest risks for a significant earthquake are in the north and eastern parts of the country. Figure 1-50 shows the biggest earthquakes in Myanmar and the Andaman Sea. Large inland earthquakes are reported in the Bago and Mandalay regions. The low laying Ayeyarwady Delta could be threatened by earthquake-induced tsunami waves from the Andaman sea. The disastrous earthquake in 2004 affected 1,130 people and killing 25 people in the Ayeyarwady region. According to the records of DMH, the number of deaths was a little higher: 31 people. This is relatively low compared to other neighboring countries.⁶⁰

The tsunami heights from the 2004 Sumatra-Andaman earthquake were between 0.4 and 2.9 m along the Myanmar coast, according to a post tsunami survey at 22 sites in Ayeyarwady Delta and the Taninthayi coast (Figure 1-51). Interviews to coastal residents indicate that the tsunami heights were lower than high tide level in the rainy season, probably by storm surge.⁶⁰

The intensity of tsunami’s in terms of round-up and the extent of inundation in the Ayeyarwady Delta, as indicated by computed tsunami amplitudes, was comparatively lower than in other countries in the region during the 2004 Indian Ocean Tsunami. In other coastal areas in Myanmar (North and South) the amplitudes are slightly larger than in the Ayeyarwady Delta, because the shallow delta extending offshore caused an increment of the tsunami wave amplitude.⁶⁰

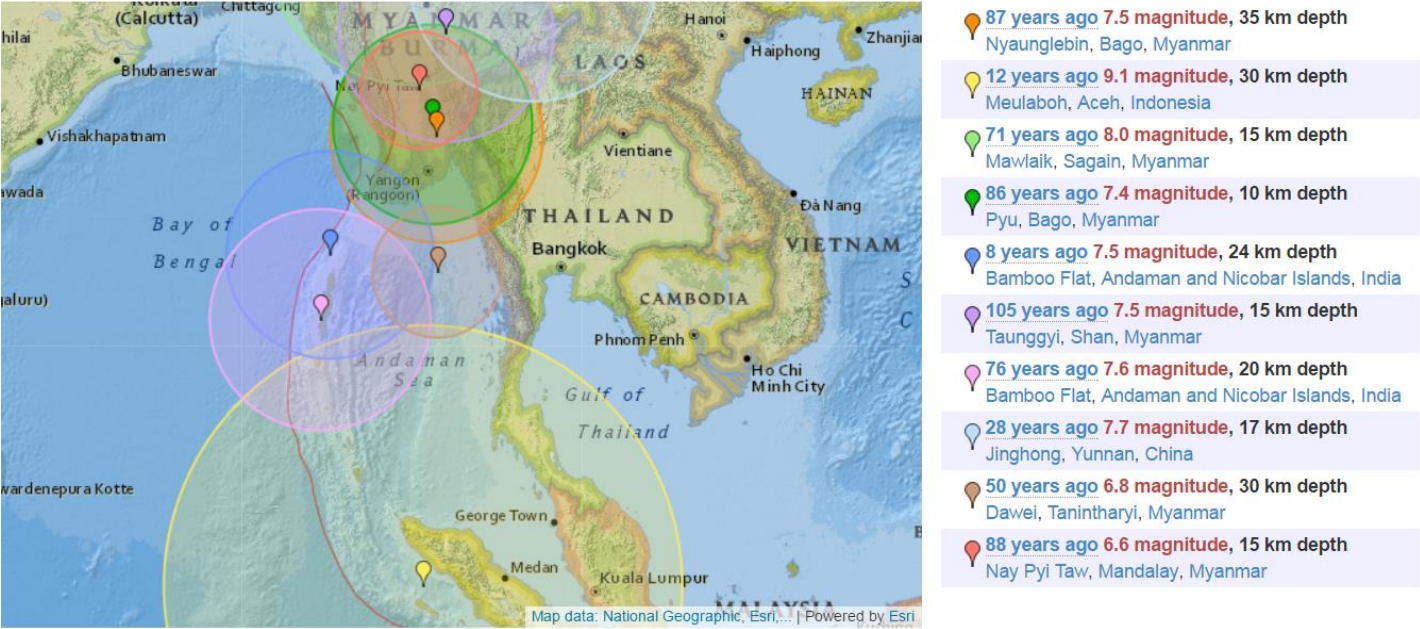


Figure 1-50: List of biggest earthquakes in Myanmar and the Andaman Sea, date of reference March 2017⁶¹

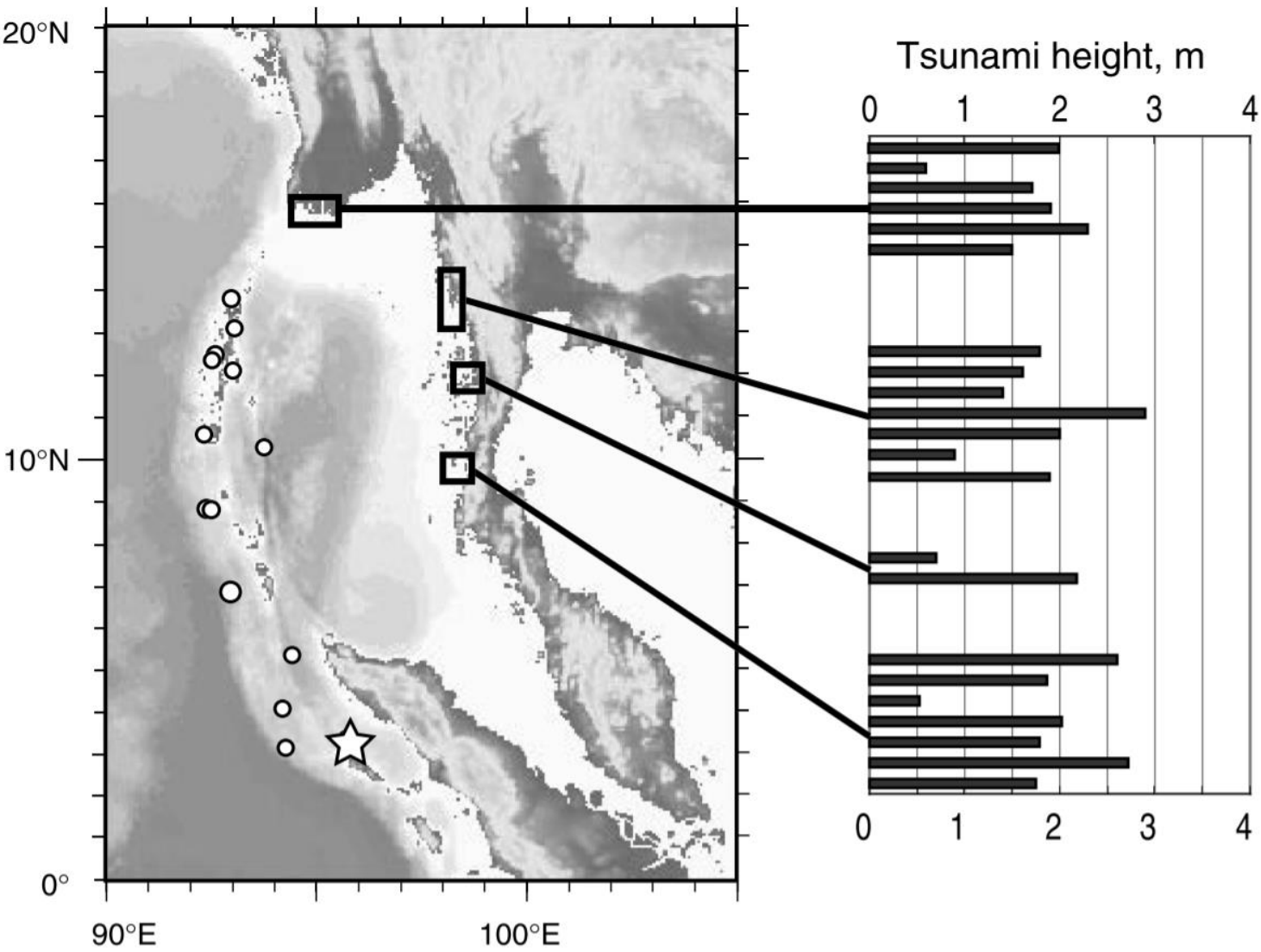


Figure 1-51 The left map shows the epicenter of the main shock (star) and 1-day aftershocks (circles) according to U.S.G.S. The right panel shows the corrected tsunami heights at various locations along the coastline.⁶⁰

⁵⁹ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME
⁶⁰ Satake, K., Aung, T. T., Sawai, Y., Okamura, Y., Win, K. S., Swe, W., & Oo, T. Z. (2006). Tsunami heights and damage along the Myanmar coast from the December 2004 Sumatra-Andaman earthquake. Earth, planets and space, 58(2), 243-252.
⁶¹ <http://earthquaketrack.com/mm-17-yangon/biggest>

1.9 Climate change

Climate change is, like it is for most countries, one of the pressures for the future. In 2015, the country was ranked as the world's second-most vulnerable country to extreme weather events. The most productive agricultural zones of Myanmar's agriculture are in the areas most vulnerable to climate change. The main paddy producing region is the coastal and delta zone, particularly the Ayeyarwady basin, while the intensive mixed upland crop area is in the central dry zone. On the one hand, the farms depend on frequent river flood events, because the river provides fertile alluvial soils. On the other hand, they suffer from water-related extreme events such as floods and droughts. It is expected that these extreme events will increase in frequency and magnitude in the future because of climate change. The observed changes in Myanmar according to the MCCSAP⁶² in the last six decades are:

- Mean temperature has risen by around 0.08 degree Celsius each decade;
- There is late onset and early termination of southwest monsoon;
- There are more extreme weather events;
- Sea levels are rising.

Based on these observation and global projects, climate change projections for Myanmar are derived by DMH. These included expected maximum and minimum temperature increase and the expected rainfall departure. Additional to this, sea level rise is one of the main concerns for the coastal area of the Ayeyarwady delta, which results in increased salinity, coastal erosion and inundation. If the sea level rises by 0.5 meter, an expected shoreline change of 10 kilometres inland will occur. This is likely to occur in 2080 according to the sea level rise projections shown in Table 1-7, showing the direct impact on the delta region because of the predicted climate change. Although droughts are not considered to have large direct impacts on the delta, the increase of drought events will increase utilization pressures on ground water for expanding irrigated agriculture in the delta. Indirectly the climate change impact will affect the economic development of the country. For example, 85% of the rural population relies on climate-sensitive sector for their livelihoods. Therefore, these already vulnerable communities will feel the impact of climate change first.

Table 1-7 Projected sea level rise for Myanmar.⁶²

Timeline	Middle range of projected sea level rise (cm)
2020	5-13
2050	21-41
2080	37-83

Table 1-8 Climate change projections for Myanmar, based on RCP4.5⁶²

	Annual maximum temperature increases (°C)				Annual minimum temperature increases (°C)				Rainfall departure (%)			
	2021-2040	2041-2060	2061-2080	2081-2100	2021-2040	2041-2060	2061-2080	2081-2100	2021-2040	2041-2060	2061-2080	2081-2100
Ayeyarwady	0.8-1.1	1.2-1.8	1.5-2.2	1.8-2.5	0.7-1.2	1.3-1.8	1.6-2.3	1.9-2.4	3-14	5-15	12-30	25-40
Bago	0.8-1.3	1.3-2.0	1.9-2.9	2.3-3.8	0.8-1.2	1.4-1.9	1.8-2.4	2.1-2.6	3-14	5-15	12-30	25-40
Yangon	0.8-1.2	1.3-2.0	1.8-2.9	2.3-3.8	0.8-1.2	1.4-1.9	1.8-2.3	2.0-2.5	3-14	5-15	12-30	25-40

Table 1-9 Climate change projections for Myanmar, based on RCP8.5⁶²

	Annual maximum temperature increases (°C)				Annual minimum temperature increases (°C)				Rainfall departure (%)			
	2021-2040	2041-2060	2061-2080	2081-2100	2021-2040	2041-2060	2061-2080	2081-2100	2021-2040	2041-2060	2061-2080	2081-2100
Ayeyarwady	0.9-1.2	1.6-2.1	2.3-3.0	3.2-4.0	0.8-1.3	1.7-2.3	2.2-3.2	3.1-4.1	6-13	14-25	12-44	10-31
Bago	0.9-1.2	1.6-2.1	2.4-3.1	3.3-4.1	0.9-1.4	1.8-2.4	2.5-3.4	3.4-4.4	6-13	14-25	12-44	10-31
Yangon	1.0-1.3	1.6-2.1	2.4-3.1	3.3-4.1	0.9-1.4	1.8-2.4	2.5-3.4	3.4-4.3	6-13	14-25	12-44	10-31

⁶² MonREC (2017), Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016-2030, Ministry of Natural Resources and Environmental Conservation, the Republic of the Union of Myanmar

Table 1-10 Projected change in precipitation (%) in the 2011-2040 period compared to 1980-2005 average⁶³

Location	Annual		Hot season (March-May)		Wet season (June – Oct)		Cool season (Nov to Feb)	
	Low	High	Low	High	Low	High	Low	High
Ayeyarwady Delta	-1%	11%	-13%	18%	0%	10%	-27%	13%
Yangon Deltaic	0%	12%	-12%	19%	1%	11%	-29%	14%

Table 1-11 Projected change in precipitation (%) in the 2041-2070 period compared to 1980-2005 average⁶³

Location	Annual		Hot season (March-May)		Wet season (June – Oct)		Cool season (Nov to Feb)	
	Low	High	Low	High	Low	High	Low	High
Ayeyarwady Delta	3%	23%	-7%	19%	3%	25%	-9%	15%
Yangon Deltaic	5%	24%	-4%	17%	5%	26%	-5%	15%

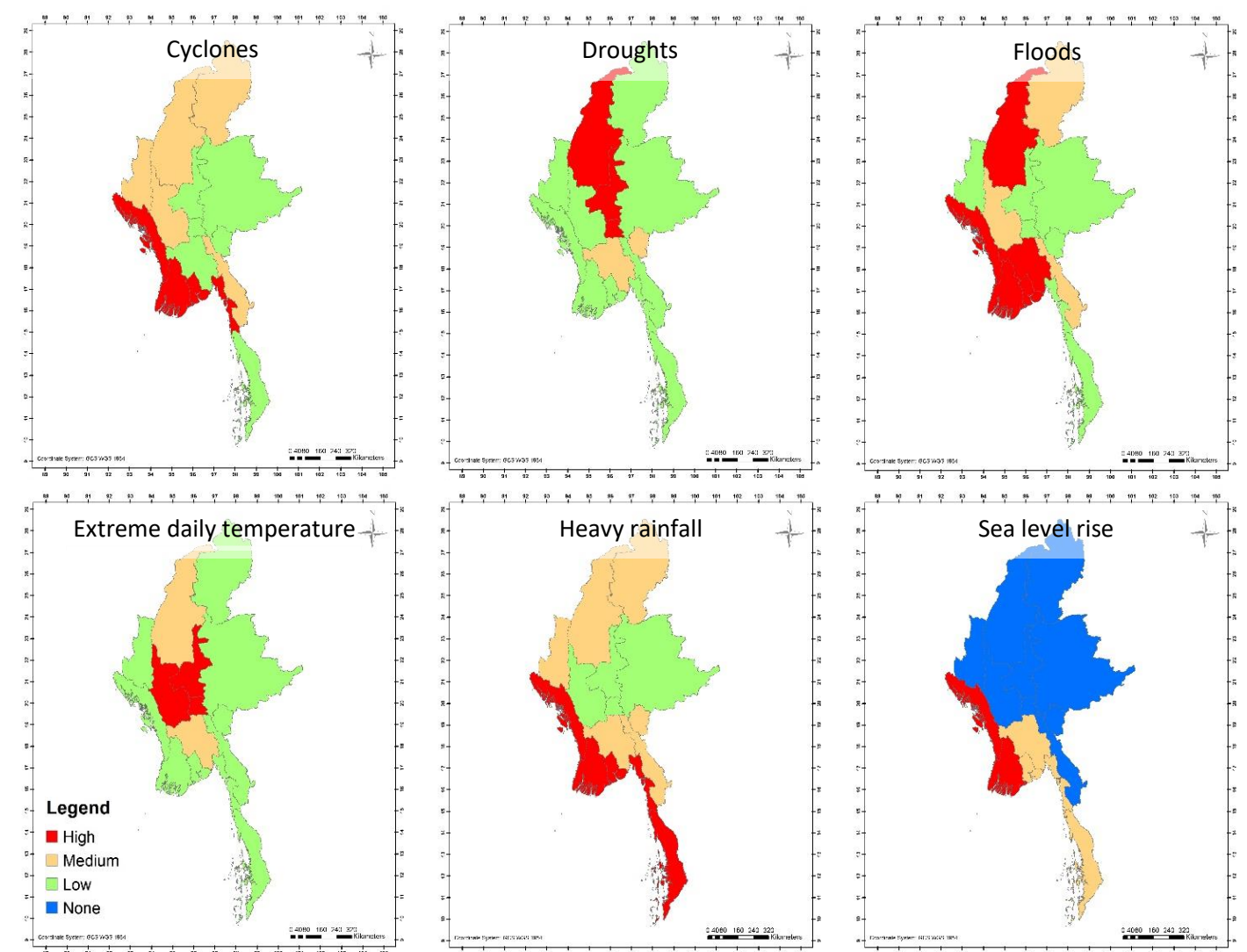


Figure 1-52 Projected risk to different climate hazards from left to right (Cyclone, Drought, Flood, Extreme Daily Temperature, Heavy Rainfall and Sea Level Rise Risk). Source: Redrawn from the Ministry of Environment and Conservation 2010⁶⁴

⁶³ Horton, et al. (2016) Assessing Climate Risk in Myanmar, Center for Climate Systems Research at Colombia University, New York

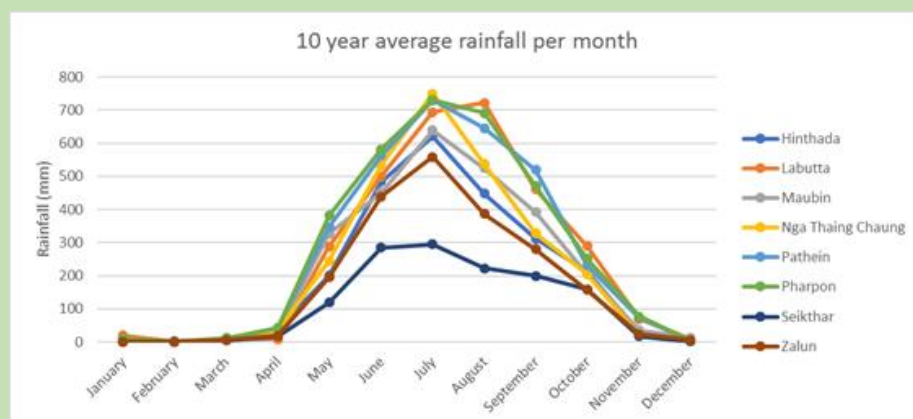
⁶⁴ Raitzer et al. (2015), Myanmar's agriculture sector: unlocking the potential for inclusive growth, p23

1.10 Trends in Baseline

Climate and climate change

Observed changes in the climate in Myanmar are in line with the changes for Southeast Asia. Based on data from the last six decades following climate trends are observed:

- Mean temperature has risen by around 0.08 degree Celsius each decade.
- The average annual rainfall in the delta is 1,500-2,000 mm in the north, increasing to 2,500 mm in the southeast and 3,500 mm in the southwest. Over 90 percent of the rain falls in the monsoon season (see figure below), which starts mid-May and ends mid-November. This is also the period of high flows in the rivers.



The observed trend is a late onset and early termination of the southwest monsoon. The average annual duration was 144 days in the period of 1961-1990, which has decreased to an average duration of 121 days over the 30-year period 1981-2010. This implies higher average rainfall intensities during the shorter monsoon period. In addition, rainfall is becoming more variable in time in the rainy season.

In the coastal zone, the total annual precipitation increased by 157 mm/decade between 1981 and 2010 (Horton et al. 2016). Inland the increase in the same period was 37 mm/decade.

Although these increases (of total rainfall and intensity) will result in higher flooding risks (requiring action to fulfil development objective 1: ensuring safety from floods and climate change related disasters), more water will be available on an annual basis. As droughts are expected to be more frequent and prolonged, the question is whether this (small) increase in annual rainfall will be beneficial for the water availability.

- MCCSAP (2017) states that the increase in both mean temperature and more hot days, shortening of the rainy season and likelihood of intensified rain during the wet season could result in heightened intensity of tropical storms and cyclones, and increased likelihood of floods (endangering development objective 1: ensuring safety from floods and climate change related disasters).

Note: At this moment, no statistical proof is available that the frequency and strength of cyclones and related floods is on the rise.

- The rising temperatures and shorter monsoon period will result in more frequent and severe droughts. This will have impacts on water availability for agriculture and drinking water (affecting development objective 2: enhance water security and efficiency of water usages).
- Sea levels are currently rising by 3 mm/year (Vulnerability and Resilience Assessment of the Ayeyarwady Delta, 2014). This sea level rise will have impact on agriculture (increased salinization, endangering development objective 4: Ensure sustainable and integrated river systems and estuaries management and use) and flood safety (increased inundation risk, endangering development objective 1: ensuring safety from floods and climate change related disasters).

The Myanmar Climate Change Strategy and Action Plan (MCCSAP, 2017) 2016-2030 provides the following scenarios for sea level rise.

Timeline	Middle range of projected sea level rise (cm)
2020	5-13
2050	21-41
2080	37-83

- With respect to hydrology no reliable long-term time series exist. Measured trends can thus not be assessed accurately. However, there is a general consensus on an expected increase in frequency and magnitude of extreme events (floods, droughts) in the future.
- Concerning the distribution of river discharges over the different branches, only scarce data sources are available (Sir William Halcrow and Partners (1982) based on observations in 1979 and 1980). Roughly, it can be assumed that of the Ayeyarwady river discharge 10% (low flows) to 12% (during floods) flows to Patheingyi River. The Hlaing River conveys approximately 10% (low flows) to 24% (during floods) of the total discharge.
- A change in the tidal regime may have an impact on the discharge distribution in the delta. However, such alterations in tidal regime and thus of discharge distribution cannot be supported by measurements. The wave climate is dominated by winds and cyclones. As intensity of cyclones is expected to increase in the future, also the wave heights and thus wave attack is expected to increase. In combination with reducing mangrove coverage (see below) the coastal erosion and flooding risks may increase (important for development objectives 3 (Conserve and restore wetlands and ecosystems and promote their wise use) and 4 (Ensure sustainable and integrated river systems and estuaries management and land use)).
- Salinity intrusion depends on river geometry, sea level and river discharges. Rising sea-levels will lead to salinity intrusion deeper into the delta and salinization of the groundwater. When flows during the dry season decrease in the future, the salt water will move further upstream in the delta.

Table 1-12 Climate change impacts⁶²

Risk	Direct impacts on the delta region
Cyclone	• Crop, land and infrastructure damage • Damage to coastal ecosystem and ecosystem services • Loss of lives and livelihoods • Saline intrusion in agriculture fields
Intense rains	• Flash floods • Intense surface runoff and soil erosion • Crop damage • Enhanced problems during La Niña due to excessive water levels
Flood	• River floods; flash floods; urban flooding • Damage to coastal ecosystem and ecosystem services • Severe inundation of land • Damage of crop, land and infrastructure
Sea level rise	• Cultivated lands and villages inundated with seawater • Loss of land, infrastructure and coastal habitats • Saltwater intrusion and coastal erosion

Subsidence

So far, only remote sensing data for the Yangon city region have been analysed, showing evidence of subsidence. Subsidence rates up to 9 mm/year (not validated by ground data yet) are thought to be caused by groundwater extraction. Plans exist to increase the volume of surface water sources in the future. This should slow down the subsidence rates in the future.

No data on subsidence rates in the Ayeyarwady Delta are available. However, subsidence is expected to be an important threat for the delta, especially when groundwater extraction or oil and gas production would increase. Syvitski et al (2009) estimated a Relative Sea Level Rise (= Sea level rise plus compaction/subsidence minus delta aggradation through sedimentation) of 3.4 – 6 mm/year, and categorised herewith the Ayeyarwady Delta as a delta in peril.

In order to value the importance of subsidence a monitoring system (including remote sensing techniques) and more research are needed. For this also the expected change in sediment loads, due to dam construction and deforestation, should be accounted for.

Morphology

The coastline of the delta grew by on average of 8.7 km²/year in the period 1925 - 1989. This period of aggradation was followed by a period of net erosion at a rate of 13 km²/year until 2006. Causes of erosion are thought to be the reduced sediment loads of the rivers due to dam construction, construction of river bank protection, declining mangrove coverage and subsidence. Based on information of coastal morphology, this moderate coastal erosion continued over the last decades, although erosion is not found along the whole coastline (approx. 53% of coastline). The rivers in Myanmar are, to a large extent, natural. The character of the rivers in the delta varies between meandering (one channel) and anastomosing (composed of two or more interconnected channels). The natural character allows for horizontal and vertical erosion and sedimentation processes along long stretches of the rivers. During floods, the river banks may erode over tens of meters. Reduced sediment loads in the river due to dam construction may induce erosion of the river bed and suppressing horizontal erosion in the future. On the other hand, wrong land use practices may increase sediment loads to the rivers. Therefore, no firm projection of future trends on river dynamics can be given. However, it can be concluded that horizontal erosion processes (and consequent sedimentation at the opposite bank) will continue to take place and may affect infrastructure and flood protection works.

In the dry season fishermen built local ridges in the rivers to create fish ponds (personal communication Irrigation Department). These ridges are in general not removed prior to the flood season, in this way causing increased flood risks. When these practices continue this endangers development objective 1 (ensuring safety from floods and climate change related disasters).

Environment

The mangroves of the Ayeyarwady Delta have been seriously degraded over time due to overexploitation of the resource and to the conversion of land to rice fields and shrimp (and fish) ponds. During the past 33 years 60 to 84% of the mangroves in the Ayeyarwady Delta have been lost (cutting started in the north), and this trend will most likely move on in the future. Forests cover a large part of Myanmar. Like mangroves, forests are also in decline, which may result in faster run-off to the rivers and increased sediment loads in the rivers. These processes endanger both development objective 1 (ensuring safety from floods and climate change related disasters) and development objective 4 (Ensure sustainable and integrated river systems and estuaries management and land use).

Not much information is available on water quality trends in the delta. One of the few studies on water quality in the delta showed that phosphate concentrations (PO₄) are very high in the deltaic water, most probably because of lack of domestic wastewater treatment. Also, high NO₃ concentrations were found near settlements indicating that decomposition of home waste disposals have already affected shallow water aquifers near settlements. Population growth and the increase in agricultural, industrial and mining activities will further affect the water quality in the delta with a range of additional parameters (heavy metals, organic micro-pollutants and oils). A possible way to assess the change in water quality is to collect and analyse data on sales of fertilizers over the last years.. Increasing sales may be an indicator for increased nutrient levels and as such deteriorating water quality.

Water quality

Network Layer



2 Network layer

2.1 Cities

The delta of Myanmar holds many villages and cities, with high concentrations of people in large cities like Yangon. All the people living here are connected in different ways through multiple networks. The ADB⁶⁵ stated that investing in Myanmar's infrastructure is key in developing access to economic opportunities, reducing transport costs, promoting trade, and attracting private investment. According to the ADB⁶⁵ news release, Myanmar is one of the least-connected countries in the world in terms of telecommunication, transportation, and logistics. By improving transportation and other networks in the delta further economic development is possible. The townships with their road and water network in the delta are shown in Figure 2-1.

2.2 Road transport

The Ministry of Construction and the Ministry of Transport and Communication are responsible for maintaining and constructing roads. Many villages and cities are only accessible by land. Three main highways run through Myanmar, in order of traffic quantity: (1) Yangon – Mandalay, (2) Yangon – Pyay and Western Union Highway, (3) Patheingyi – Monywa Highway. The last highway (3) connects cities on the east side of the Ayeyarwady River. The road network in the delta region is underdeveloped, partly because of the costs involved in construction and maintenance of roads in the delta. These high costs are due to the many bridges that need to be built in order to span the great number of rivers and creeks.⁶⁶ This is also visible in Figure 2-1, especially in the southern parts of the delta it is very difficult to travel east-west. Another issue is that many roads are of bad quality, as can be observed from Table 2-1 indicating the large length of earthen roads.

Table 2-2 shows the bridges in Hinthada, Labutta, Maubin and Myaungmya districts in the Ayeyarwady Region.

Table 2-1: Overview of types of road and length in Ayeyarwady region⁶⁷

Road type	2012	2013	2014	2016 ⁶⁸
	Length (km)			
bituminous road	1312	1592	1857	1946
metaled road	216	159	58	58
surface road	612	488	399	500
earth road	436	362	364	315
total road	2593	2620	2704	2818

Table 2-2 Bridges in the Ayeyarwady Region⁶⁸

District	180 ft. & above			180 ft. - 100 ft.			100 ft. - 50 ft.			Below 50 ft.			Pipe	Culvert	Total
	RC	Coars way	Timber	RC	Bailey	Timber	RC	Coars way	Timber	RC	Bailey	Timber			
Hinthada	8	2	3	3		5	7	1	5	302	4	30	80		450
Labutta	5	2	1	4		2	3		1	11			16		45
Maubin	7			8			10			57			9	10	101
Myaungmya	12			7		3	3		5	35		1	82		148
Total															744

⁶⁵ ADB (2014), <https://www.adb.org/countries/myanmar/main>

⁶⁶ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

⁶⁷ MIMU Ayeyarwady dataset, Rows 663 - 667

⁶⁸ Ministry of Construction (2016), Crushed rock road and gravel road added into surface road category

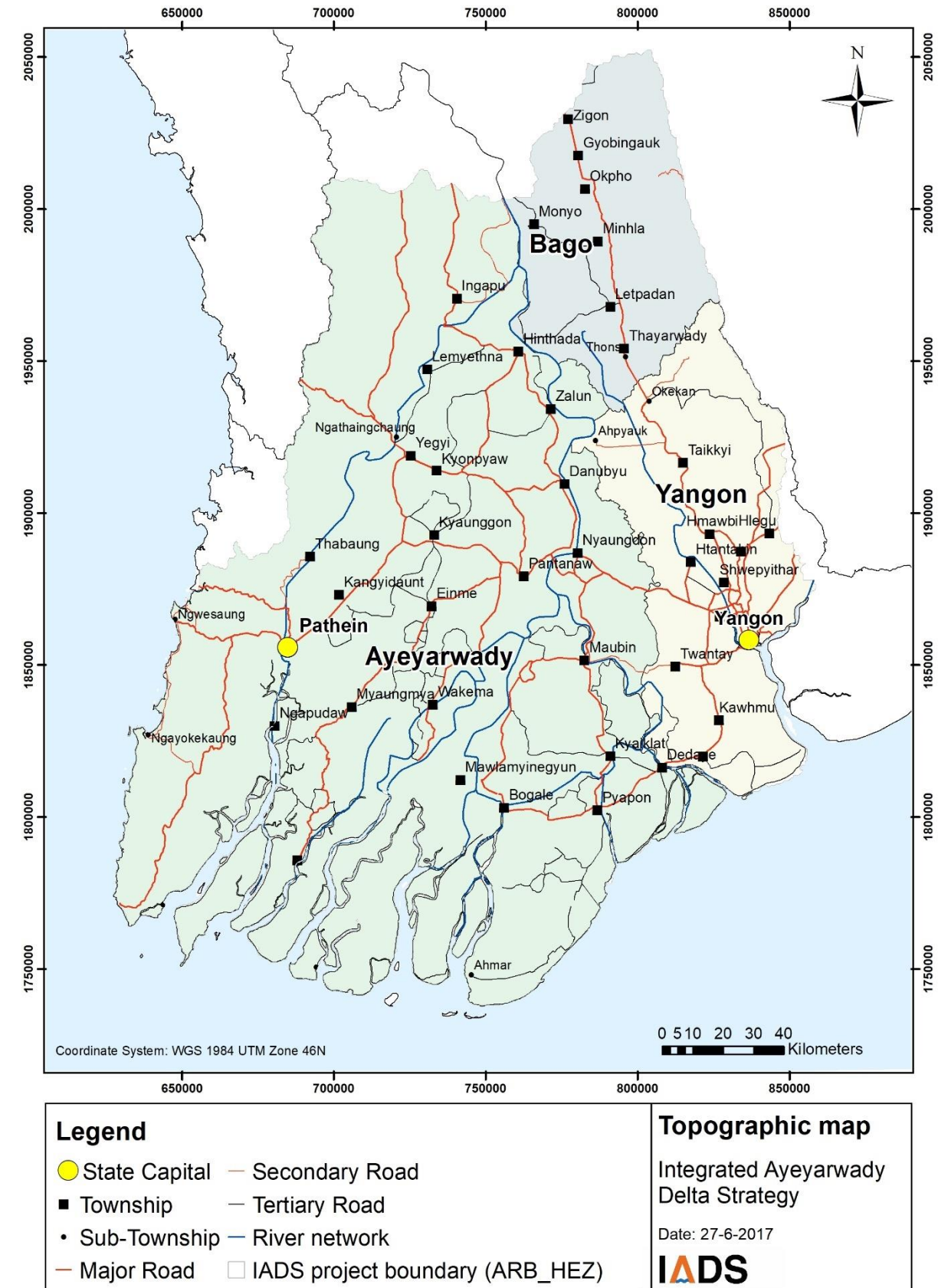


Figure 2-1: Major townships and road transport in the delta (MIMU, 2017)

2.3 Rail and air transportation

The Ministry of Rail Transportation is in charge of railway and rail transport. Myanmar has a total of 5,099 km of railway. However, only a few towns and cities are connected by railway lines. The railways in the delta are mainly positioned north-south (Figure 2-2). The railway network connects the city of Yangon with the North of Myanmar and through Hinthada all the way to Pathein. The lines are characterised by the great number of stations and bridges. There are currently no railway links to adjacent countries.⁶⁹ The railway transport services are state-owned by Myanmar Railways, being in charge of both freight and passenger transportation by rail.

The Department of Civil Aviation and Myanma Airways are involved in air transportation; both are departments under the Ministry of Transport. Three airports are located within the Ayeyarwady and Yangon region (Figure 2-2). Yangon airport is the largest and is the main international airport of the country. Between 2013 and 2016, the airport was expanded to increase the capacity of passengers from 2.7 million to 3.8 million per year. Since March 2016, 26 airlines operate to/from 21 international destinations while 10 airlines operate on 25 domestic routes.⁶⁹ Pathein airport is the largest in the Ayeyarwady region, where flights mainly leave for Yangon and Thandwe. Myanmar National Airlines is a state-owned airline, serving flights to: Hong Kong, India, Singapore and Thailand. Domestically it serves 27 airports. Myanmar Airways International is a privately-owned airline. It mainly serves international airports in: China, India, Japan, Malaysia, Myanmar, Singapore, South Korea, Taiwan and Thailand.

Table 2-3: Railway stations and lengths⁷⁰

Region	No. of Stations	Rail length (km)
Ayeyarwady Region	65	418
Bago Region	116	742
Yangon Region	76	273

Table 2-4: Main railway lines with mileage, stations and bridges⁷⁰

Line	Division	Mileage	Stations	Bridges
Yangon-Mandalay	6	328	91	994
Yangon Central	7	156	75	448
Pathein – Hinthada - Kyangin	9	147	42	236

⁶⁹ <http://yangonairport.aero/about-the-airport/>
⁷⁰ Website Myanmar Railways: <http://www.myanmarrailways1877.com/eng/>

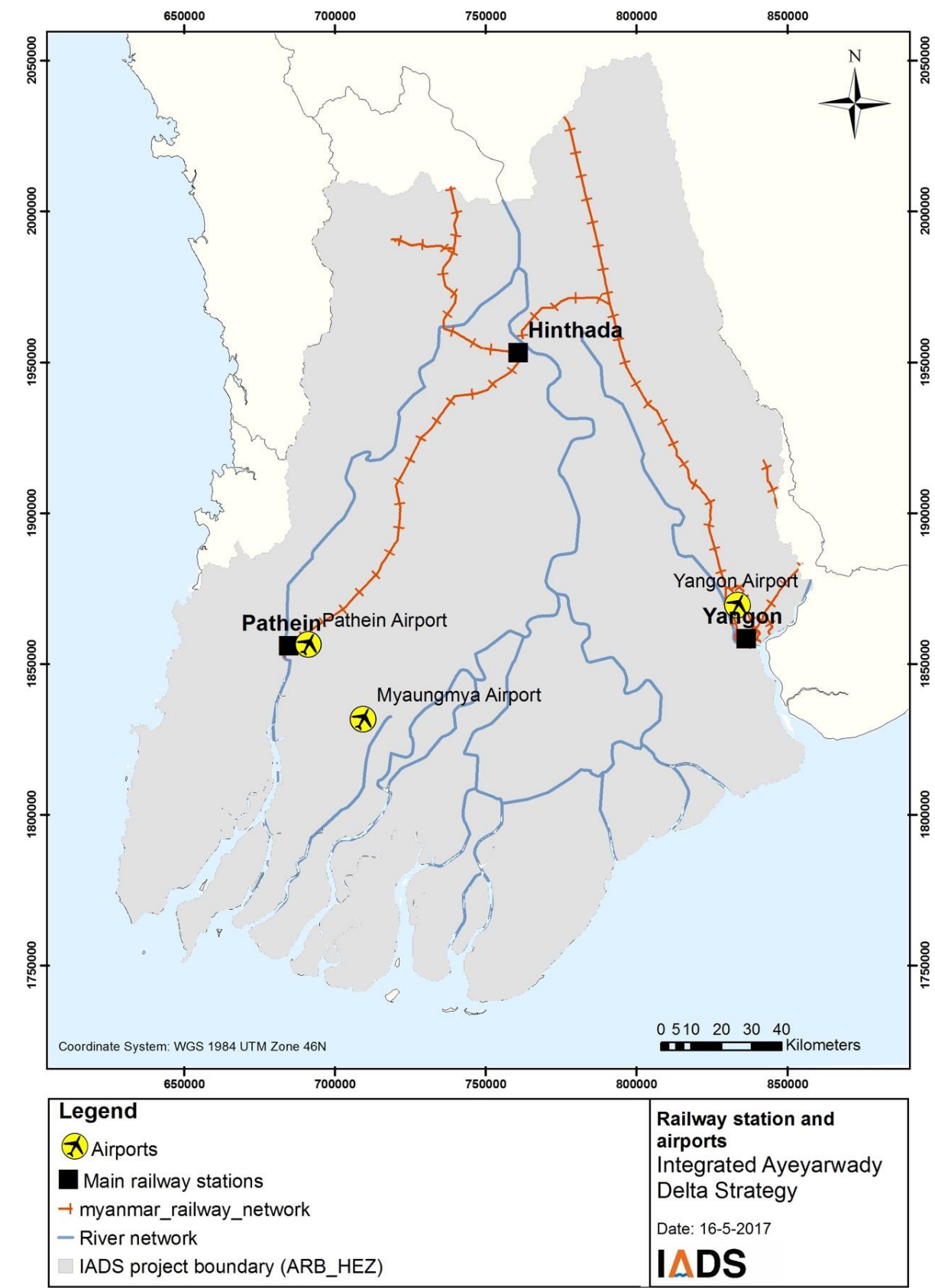


Figure 2-2: Railway network and airports in the delta⁷¹

⁷¹ MIMU 2015 rail map

2.4 Water transport

Three out of nine departments under Ministry of Transport are involved with transport over water: Water transport, Inland Water Transport, and Marine administration. Some of Myanmar's many natural harbours are Patheingyi, Bhamo, Mandalay, Yangon, and Dawei. The government stimulates the construction of new ports and expansion of existing ones. Figure 2-6 shows that gross and net tonnage in the Yangon port has grown rapidly over the years. The country's waterways are an important mode of transportation to many remote areas of Myanmar. Table 2-5 shows there is more navigable water than roads (Table 2-1) in the delta, with a total navigable length of 3801 km. There is commercial transportation on the Ayeyarwady River for about 1,300 km: between Hinthada and Bhamo (1,080 km) throughout the year and between Bhamo and Myittha (200 km) for only seven months.⁷² The total transportation network consists of express service terminals and regular service terminals (Figure 2-6). Sedimentation might cause problems for accessibility by large vessels in the future so dredging or sediment reduction is necessary to keep ports accessible. Rice is the most common good transported on the rivers. Other goods transported through the waterways are: petroleum, cotton, and local commodities. Teak logs, of which Myanmar is the leading exporter in the world, are floated downriver to be exported. Outside the monsoon season transport over sea is possible, but this is too dangerous during the monsoon.⁷³ The Twante Canal (although not shown on the map) is the main connection between the Ayeyarwady River and the Hlaing/Yangon River and therefore the main route for transportation from the Delta to the city of Yangon. The 35 km long canal was constructed by the British in 1883 but over time experienced big problems with siltation and sedimentation hindering navigation. In some parts of the Twante canal, sedimentation caused a reduction of the canal depth by more than half its original depth in 4 years time. In 2010, the mouth of the canal was widened by 180 m. In addition to sedimentation, high speed currents are observed during ebb tide reaching maximum values of 3.5 m/s. Other important shipping routes for Yangon are the Pan Hlaing river, the Toe river and the Kokkwa river.⁷⁴

Table 2-5 Inland water transport in Ayeyarwady region⁷⁵

Region	Total length	No. vessels	No. pontoons	Functions	Express routes	Regular routes	Ferries	Hire	Total
Ayeyarwady	3801 km	68	25	Passenger and cargo transport	9	1	5	1	16

Table 2-6 Navigable length of inland waterways (Source: DWIR 2014)⁷⁶

Name of river	Navigable length (km)
Ayeyarwady	1534
Chandwin	817
Thanlwin and other river in Mon State	380
Delta Region	2404
Rivers in Rakhine State	1602
Total	6737

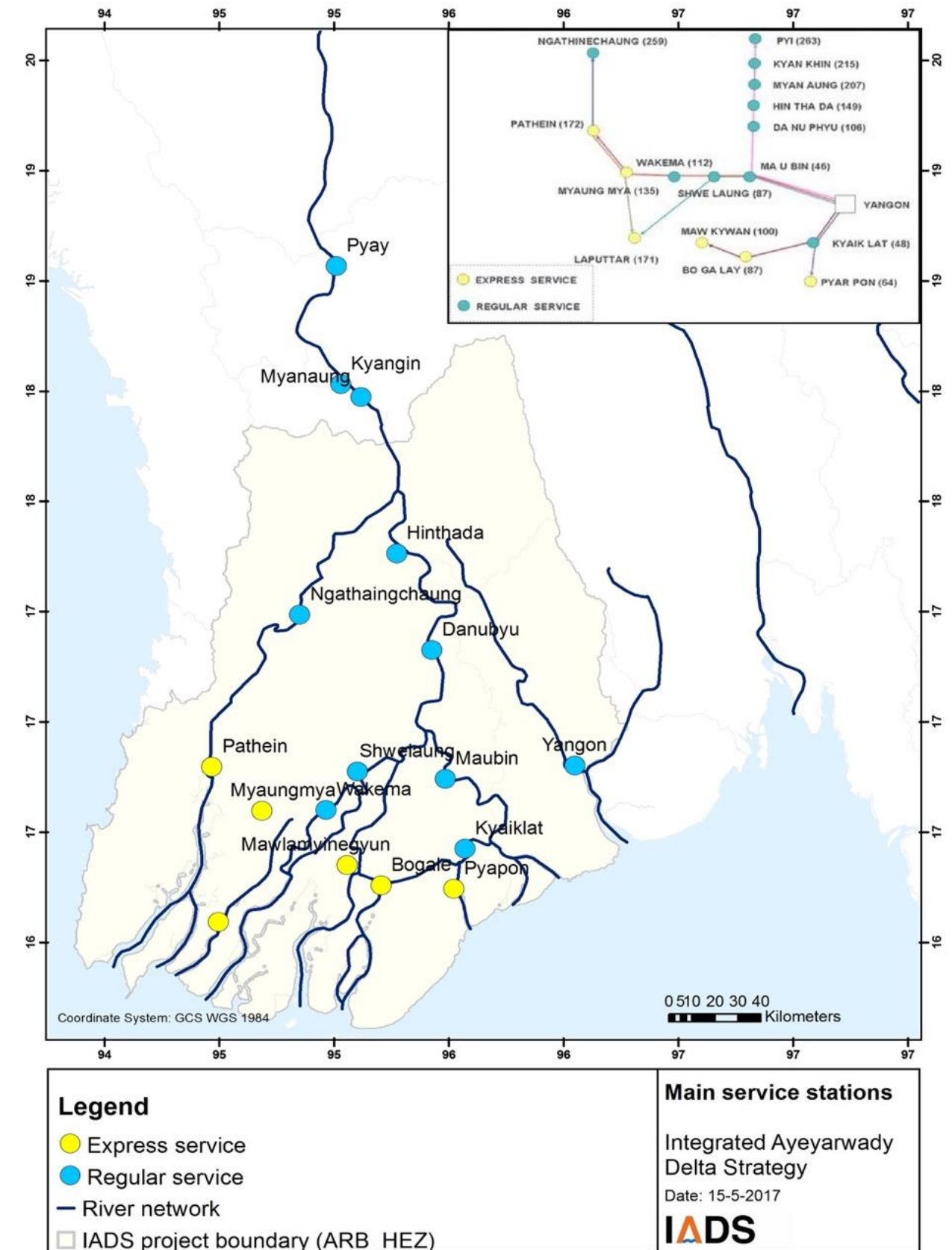


Figure 2-3: Schematic overview of routes and stations by IWT Delta division⁸⁰

⁷² Britannica; <https://www.britannica.com/place/Irrawaddy-River>

⁷³ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

⁷⁴ ISAN Corporation (2017), Twante Canal Integrated Management Project in Myanmar, Powerpoint Presentation

⁷⁵ Inland Water Transport http://www.iwt.gov.mm/en/Delta_Division

⁷⁶ Myanmar Integrated Water Resources Management: Strategic Report (2014), p156



Figure 2-4: Yangon-Ayeyarwady Delta connectivity⁷⁴

With the liberation of the economy, upcoming industry and international trade, port developments are essential in maintaining a sustainable growth of the country's economy.

Yangon Port is situated on Yangon river, about 32 km inland from the Elephant Point on the Gulf of Martaban. All vessels calling on Yangon Port use the Yangon river estuary's navigation channel. For vessels over 200 GRT (Gross Register Tonnage), pilotage is compulsory. Navigation from Elephant Point to the Yangon harbour is generally only possible at high tide. Yangon port faces big problems with sedimentation of the approach channels hindering the entering of bigger vessels in the near future. The port can serve vessels up to 15,000-20,000 deadweight with work underway to increase this number to 35,000 deadweight capacity. Now, the port handles 85% of Myanmar's import and export. Design vessel is 167 m LOA, 9 m draft and 15,000 DWT. The expansion of the Yangon port is in line with the development of a Special Economic Zone (Thilawa) near the mouth of the Yangon River. Moreover, deep sea ports are now under planning.⁷⁷

The port of Pathein is at the Pathein river, 5 km from the city. It consists of several jetties, where most jetties are not suitable for cargo vessels. The jetties that are suitable are designed for cargo vessels up to 600 GRT, draft of 7 metres with no cargo handling equipment.

The development of inland ports and terminals along the Ayeyarwady is becoming critical. According to Nam&Win (2014)⁷⁸ the inland water transport sector has been lacking investment and planning. Despite the great potential of inland water transport, constraints to navigation are characterized by insufficient depths, narrow channel width, sharpness of bends and high velocities that are caused by braided channels, insufficient water depth in the low water season, dangerous flood/serious erosion in the wet season and large sediment deposits. Furthermore, the inland navigation fleet is in state of overcapacity. Port facilities for inland waterways are very poor. Cargo loading and discharging are still being manually operated and jetties are barely found.

⁷⁷ Myanmar Maritime Quickscan (2016), Nederland Maritiem Land, Powerpoint Presentation

⁷⁸ Nam, K. & Win, E. (2014), Competitiveness between road and inland water transport: the case of Myanmar, Transport problems, 9(4)



Figure 2-5: Map of major ports in Myanmar (existing and under construction)

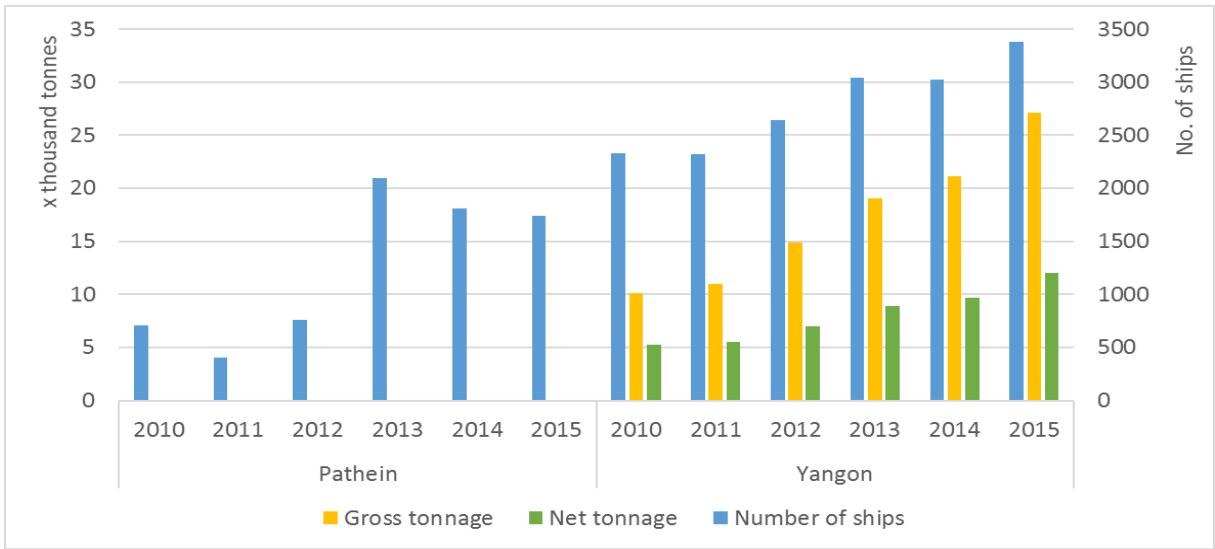


Figure 2-6: Ships and shipping in two important ports in the delta⁷⁹

Table 2-7: Frequency of round trip for most important transport routes in Delta⁷⁷

No.	Sub Division	Routes	Frequency (Round Trip)
1	Delta	Yangon-Dala	46/day
2	Delta	Yangon-Khanaungdo	8/day (6.5/day in summer)
3	Delta	Wahdan-Dala	9/day (7/day in summer)
4	Delta	Yangon-Kyonemangae	2/week
5	Delta	Yangon-Mawkyun	3/week
6	Delta	Yangon-Laputta (inside)	1/week
7	Delta	Yangon-Laputta (outside)	3/week

⁷⁹ CSO Myanmar (2017), Statistical Yearbook 2016

2.5 Energy infrastructure

Myanmar has abundant energy resources, particularly hydropower and natural gas. The hydropower potential is estimated to be more than 100,000 megawatts (MW) in terms of installed capacity. Natural gas is a major export resource, which generated \$2.1 billion export revenue in the first half of the FY2014. Additional revenue of about \$2.7 billion per year is likely from new gas fields.⁸⁰ Although Myanmar has abundant energy resources, only 11 % of the people in the Ayeyarwady Region have access to the electricity grid (in Myanmar as a whole 31% of the population has access). The country's total primary energy supply was about 18 million tons of oil equivalent (MTOE) in 2012. Of this, 54% (9.7 MTOE) was from biomass, 16.6% (3.0 MTOE) from hydropower, 15.3% (2.8 MTOE) from oil, 11.45% from gas, and 2.6% from coal. Most people have been using traditional biomasses (mainly firewood and agricultural waste), particularly for cooking and lighting (Figure 2-7 and Figure 2-8) which accounted for 77% of the total energy consumption in 2012. Energy consumption grew slowly at an annual average of 1.9% during 2000–2012. In the same period, coal consumption increased by an annual average of 21.4% followed by natural gas at 4.4% annually. The average annual growth for biomass was 1.9% in 2012. The residential sector is the largest consumer of energy—80.0% of the total consumption in 2012. In terms of per capita consumption of electricity, Myanmar has one of the lowest rates in the world—165 kilowatt-hours (kWh) in 2013, much lower than the global average of 3,000 kWh per capita and even lower than the least-developed-country average of 174 kWh per capita.⁸¹

In 2013, 66.9% of the total energy production (3,735 MW) was from hydropower (2,780 MW), 29.5% (996 MW) was from gas, and 3.6% (120 MW) from coal. The high reliance on hydropower and low efficiency of old power systems caused frequent load shedding, especially in the dry season. Figure 2-10 shows the completed and planned hydropower dams in the country. Most of the dams are upstream and none in the low-lying delta. In 2013, Yangon accounted for 50 % of the total electricity consumption. From 2000-2012, electricity consumption has grown with 9.8% per year. Myanmar's electricity grid consists of a network of 230-kilovolt (kV), 132 kV, and 66 kV transmission lines and substations (Figure 2-9). Most of the lines run from the northern part of the country, where most hydropower plants are, to the southern load centers, particularly around Yangon. A 500-kV transmission line from north to south is now under construction. The distribution system comprises a network of 33 kV, 11 kV, and 6.6 kV lines and substations.⁸¹ To raise the efficiency of the electricity grid, a plan to replace the 6.6 kV systems with an 11-kV network and to expand the 33 kV systems is considered. The National Electrification Plan in September 2014 wants to attain universal electricity access by 2030.⁸¹

Table 2-8: Energy use per capita for Myanmar⁸²

Year	1990	2000	2007	2008	2009	2010	2011	2012	2013	2014
Energy use (kg of oil equivalent per capita)	254	269	309	296	279	271	275	298	314	361
CO2 emissions (metric tons per capita)	0.102	0.212	0.254	0.192	0.199	0.242	0.274	0.246	0.238	-
Electric power consumption (kWh per capita)	43.4	73.8	87.6	92.1	97.2	121.6	151.0	152.7	181.4	210.6

⁸⁰ ADB (2016), Myanmar energy sector assessment pp. 1

⁸¹ ADB(2017), Myanmar Energy Assessment 2015-2017 - Summary

⁸² World Bank 2016 <http://data.worldbank.org>

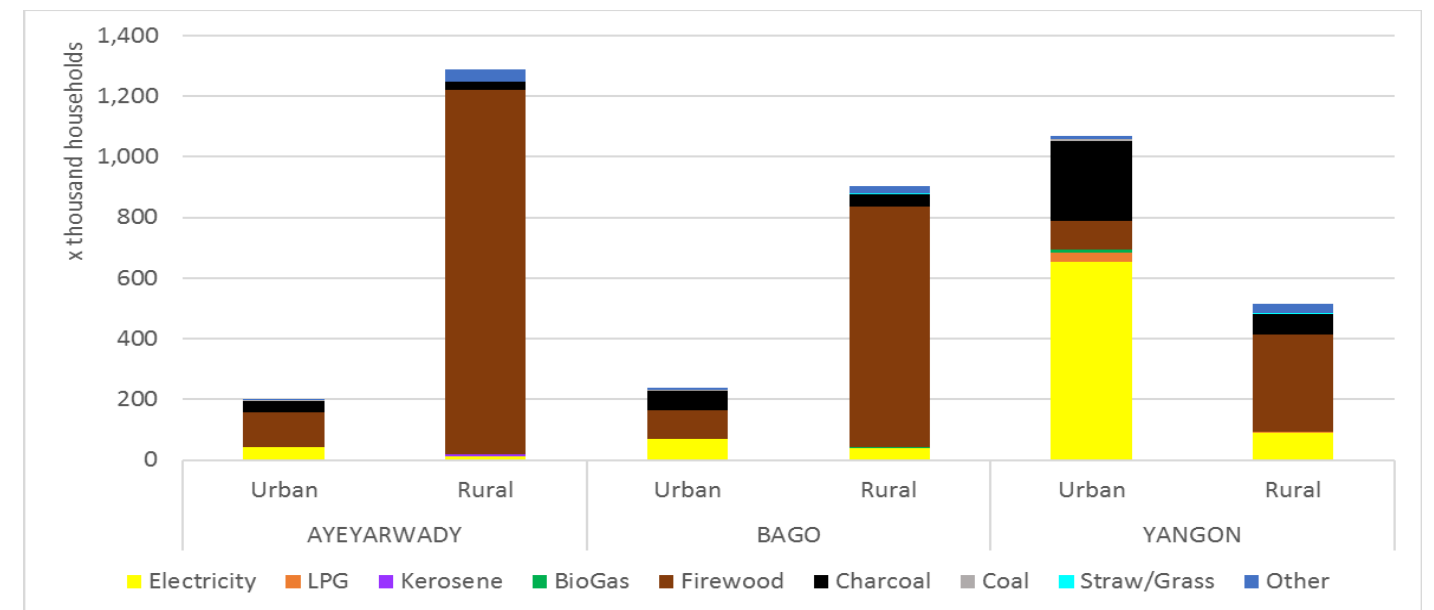


Figure 2-7: Main energy sources for cooking per household in 2014 (DoP, 2015)⁸³

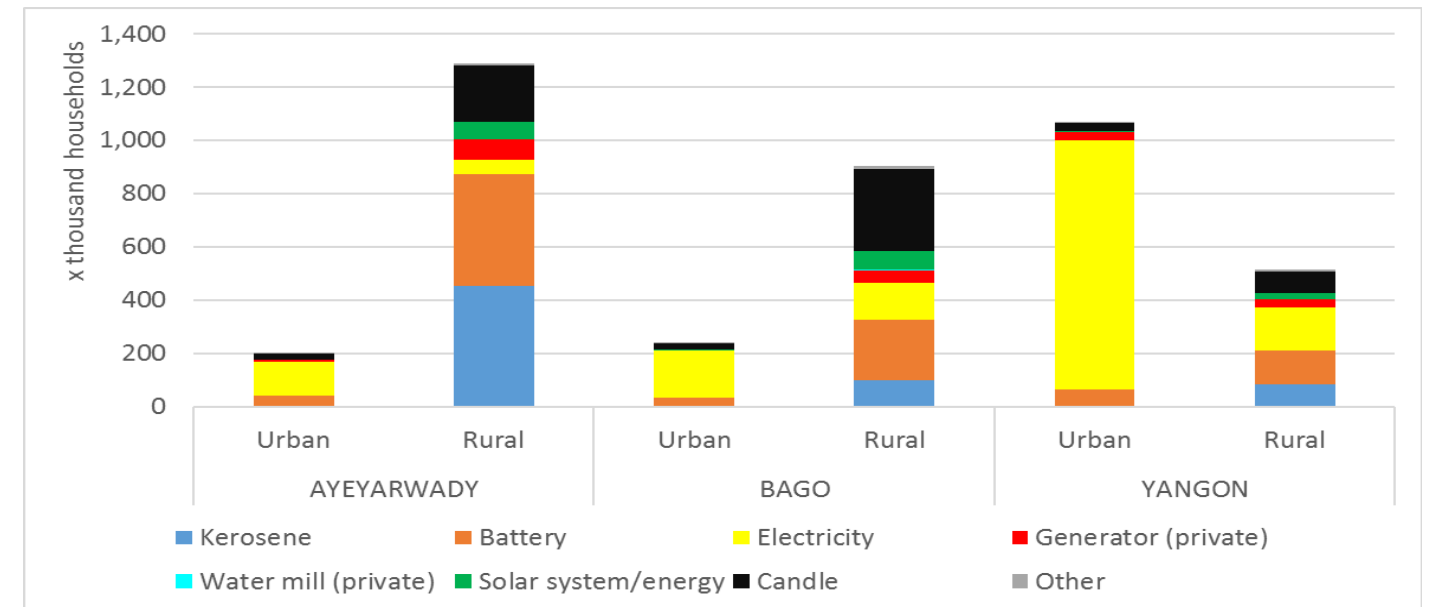


Figure 2-8: Main energy sources for lighting per household in 2014 (DoP, 2015)⁸³

⁸³ DoP (2015), The 2014 Myanmar Population and Housing Census, Ayeyarwady Region, Census Report Volume 3-N. Department of Population, Ministry of Immigration and Population, the Republic of the Union of Myanmar.

NATIONAL GRID SYSTEM

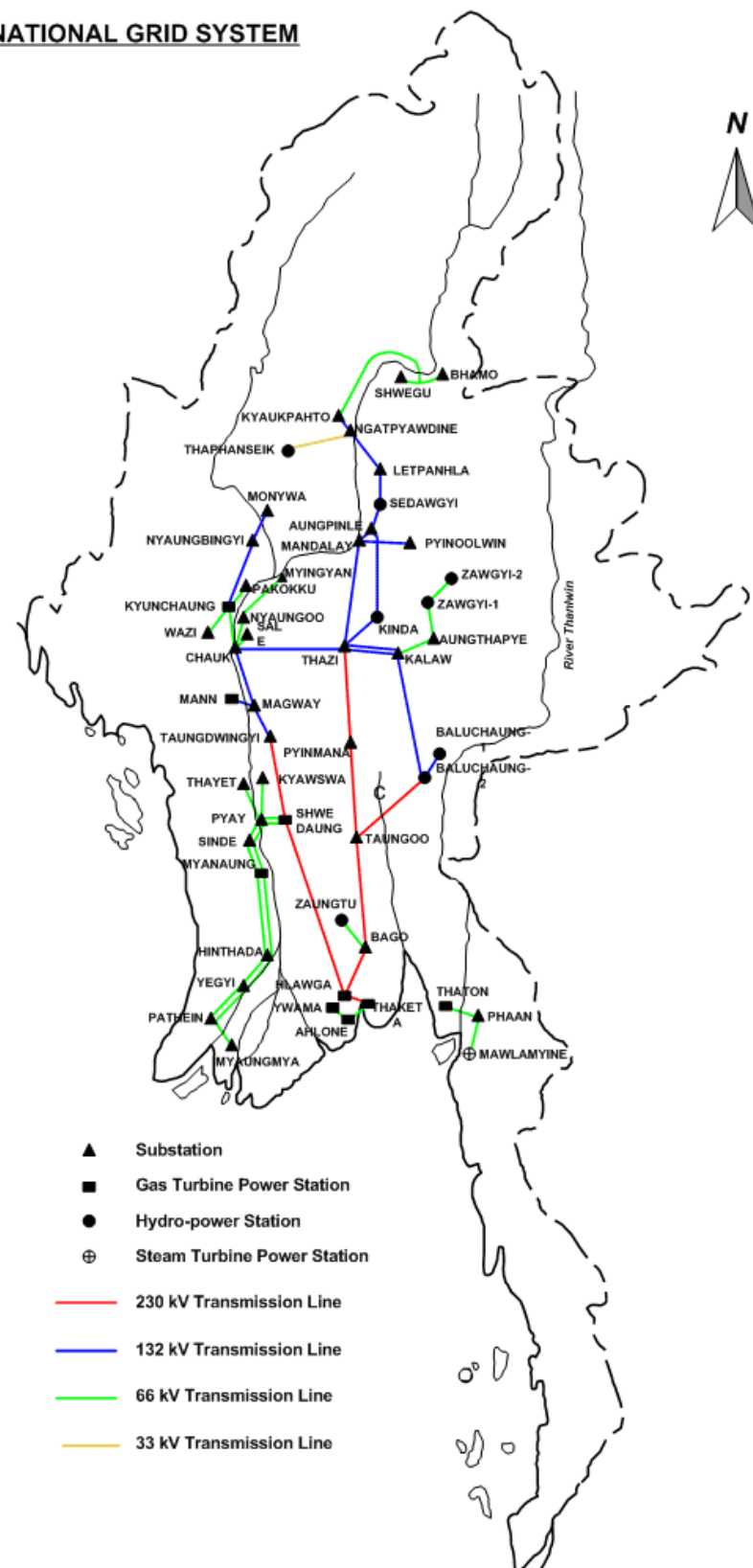


Figure 2-9 National energy grid⁸⁴

⁸⁴ http://www.geni.org/globalenergy/library/national_energy_grid/myanmar-burma/myanmarnationalelectricitygrid.shtml

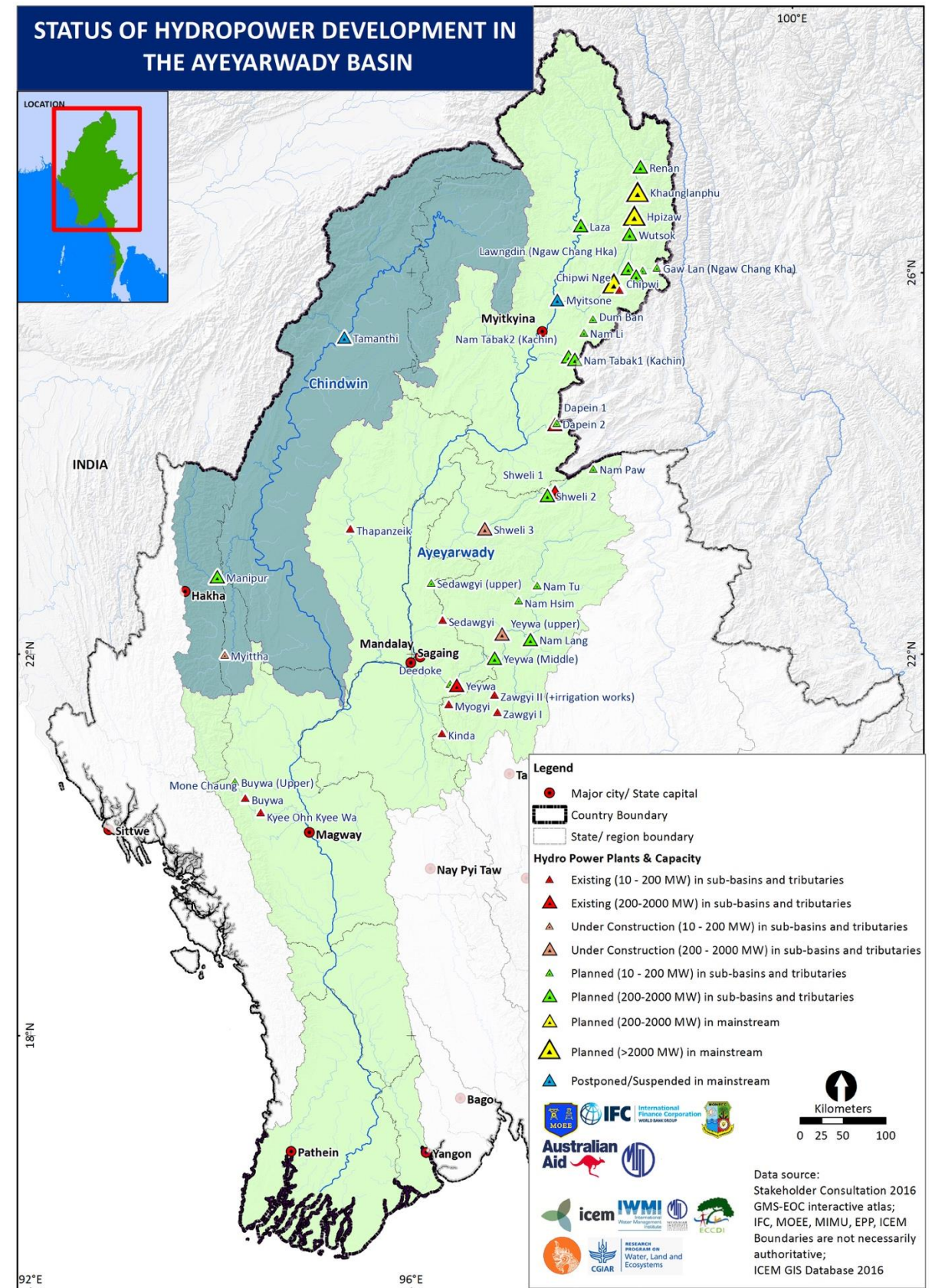


Figure 2-10 Existing, planned and dams under construction in the Ayeyarwady Basin⁸⁵

⁸⁵ IFC (2017), Draft Baseline Assessment Report, Hydropower Chapter, Strategic Environment Assessment (SEA) of the Hydropower Sector in Myanmar, Yangon

Wind energy application can be a helpful contributing factor for the sustainable development of the country and to secure energy availability. There is a wind potential of 365.1 TWH per year, with 9 months of south-westerly winds and 3 months of North-easterly winds. This study was performed by NEDO of Japan in 1997.⁸⁶ Most promising spots are the hilly Chin and Shan States and the Coastal zone. At the moment feasibility studies are ongoing for potential sides of large scale wind power projects done by two foreign companies in agreement with the Department of Electric Power; Gunkul Engineering Public C. and China Three Gorges Co. Available installed capacity in proposed sites in 4032 MW. The latter company is doing feasibility studies for the Ayeyarwady and Yangon Region. Average wind speeds measured in the Ayeyarwady vary from 6 to 7 m/s. However, further development is still hampered by high initial investments and lack of wind power technology in Myanmar. Furthermore, the wind pattern in Myanmar is not regular and low in capacity to produce wind energy.

The electricity demand for low and high case scenarios are estimated to be 329 MW and 406 MW by 2030. According to Thi Thi Soe, et al. (2015)⁸⁷ study who mapped the wind potential for the Ayeyarwady Region, the highest potential can be found in the lower stretches of the Delta with wind power density (WPD) estimates up to 259 W/m². This in contrast with the proposed site locations of the feasibility studies which are located more northern in the delta with WPD estimates of 100-180 W/m². As can be seen in the map, the three locations in the Ayeyarwady Region are more in the upper Delta, in the townships Myan Aung (100MW), Ingapur (120MW) and Lemyathnar (90MW).

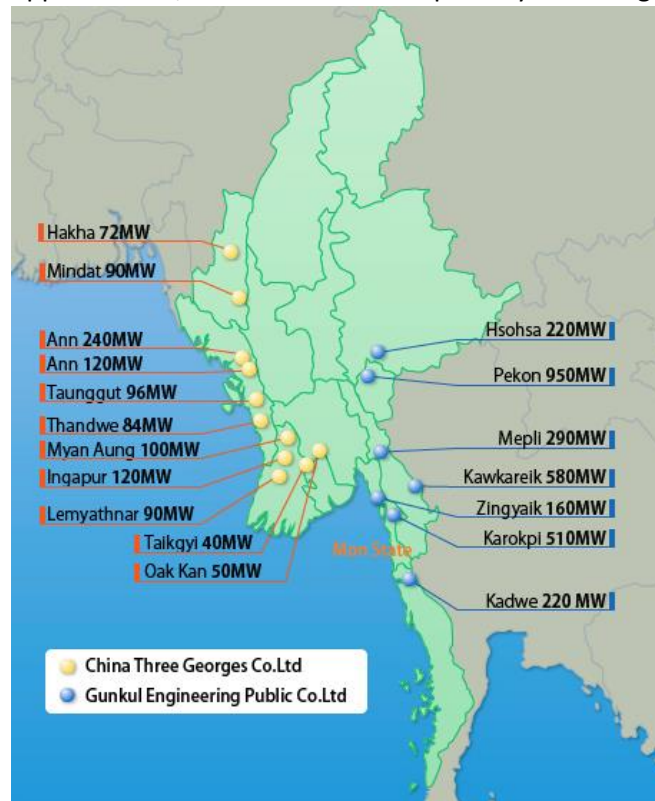


Figure 2-11: Proposed sites for feasibility studies⁸⁷

⁸⁶ Tint Lwin Oo (2014), Wind power resources, potential and recent initiatives in Myanmar, Department of Hydropower planning, Ministry of Electric Power, Powerpoint Presentation

⁸⁷ Thi Thi Soe and Maosheng Zheng. and Sreevalsan, E. (2015), Pre-feasibility study of wind energy resources in Myanmar, Asean Engineering Journal Part A, 6(1), 27-37

2.6 Irrigation system

Traditionally the paddy lands were fed by water as shown on the left image in Figure 2-14. The efficiency of this method is low and the downstream farmer largely depends on the maintenance of the farmers upstream. Therefore, the Irrigation and Water Utilisation Management Department (IWUMD, under the Ministry of Agriculture, Livestock and Irrigation) chose to use the modern irrigation system as shown in the same figure on the right. This method has the advantage that there is only one shared irrigation and drainage canal for all farmers, so all farmers benefit directly from maintenance of these two canals. A local group of farmers is responsible for the maintenance of the secondary and the tertiary canals, whereas the IWUMD is responsible for maintenance and operation of the resources, canals and inlet structures. Irrigation in the lower delta is practiced in the dry season from November to April. However, irrigation is limited to a small number of paddies near larger drainage canals. During the dry season three types of irrigation methods are used in different parts of the delta; (1) diesel pumps that lift water from canals or the ground water into small ditches or straight on the plots in the lower delta, (2) tidal irrigation in the middle delta and (3) gravity irrigation when there is an upstream intake or pumping as well.⁸⁸ Irrigation is often not needed in the monsoon season due to the large precipitation quantities. However, only the construction of embankments, sluices, gates and drainage systems make monsoon paddy cultivation in the lower delta and part of the middle delta possible (Figure 2-12). This is why the Paddy Land Development Projects 1 and 2 have been realized (Figure 2-13). The Paddy 3 project is currently under construction in the south of Yangon (Figure 2-13). Due to the heavy rainfall intensities, the role of drainage canals is very important. The slide gates of the sluice are kept open from 15 May to mid-September and the drainage is controlled by the flap gates of the sluice to keep the water level of the drainage canals as low as possible.⁸⁸ Close to the polders, the drainage canals are predominantly artificial while in other areas existing and old river courses function as main drains.

19% of the country's cultivated area is covered by irrigation facilities (2.3 million ha) of which 39% is irrigated in the dry season. The extra coverage serves as supplementary irrigation if the monsoon precipitation falls short of the crop water requirements. Most of the irrigation is done by the pumps mentioned above which cover about 38% of the total irrigated area, surface irrigation from dams and weirs cover 29%. The Water Resources Utilization Department is responsible for pumped irrigation and groundwater and IWUMD is responsible for dams and weirs. Both departments are part of MOALI.

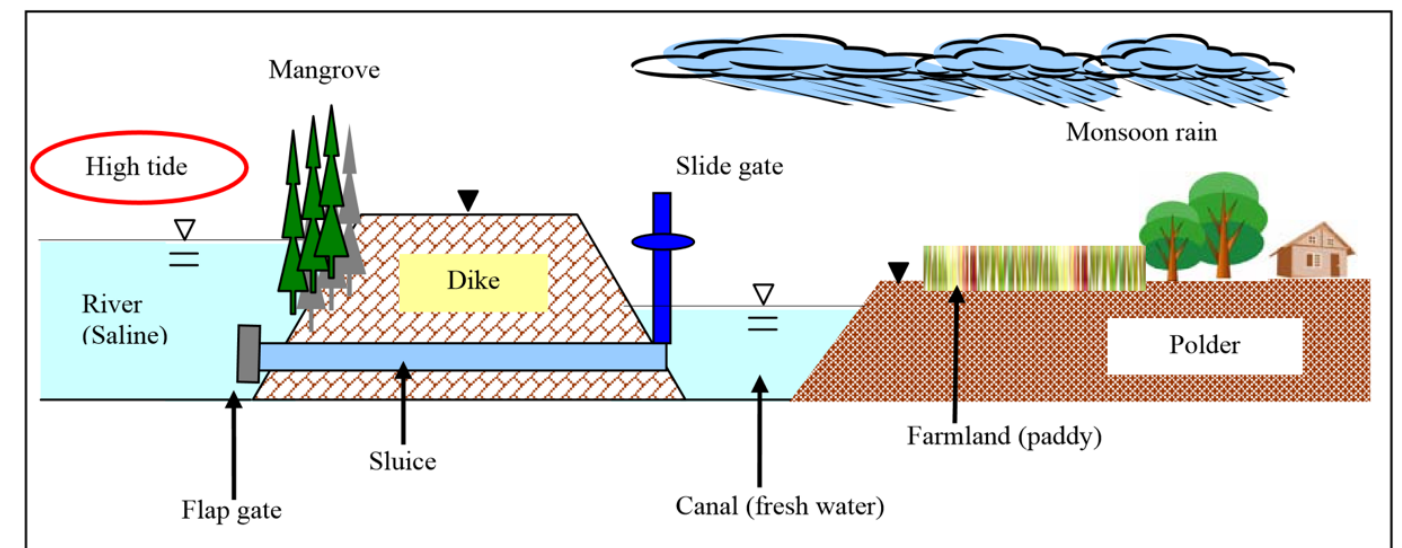


Figure 2-12: Functioning of a polder in the lower delta⁸⁹

⁸⁸ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

⁸⁹ JICA (2011), The project for preservation of farming area for urgent rehabilitation of agricultural production and rural life in areas affected by cyclone Nargis in the Republic of the Union of Myanmar

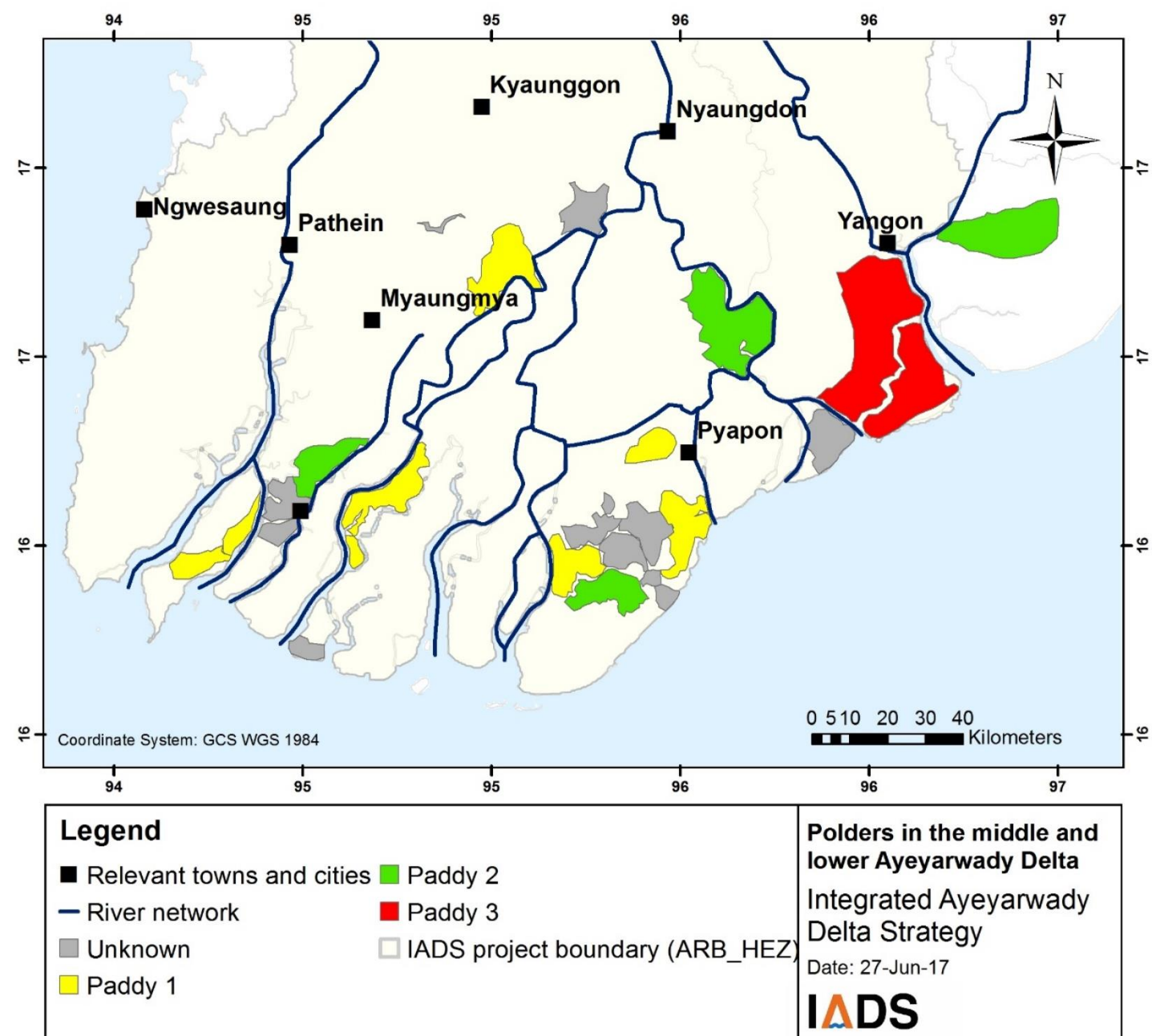


Figure 2-13 Implementation Paddy I, Paddy II⁹⁰ and Paddy III⁹¹

Table 2-9: Embankment length and protected areas by the Paddy 1 and Paddy 2 projects⁵⁴

Type of works	Paddy 1		Paddy 2	
	Length (km)	Area (acres)	Lengths (km)	Area (acres)
Flood control embankments	660		410	
Drainage channels	1239		354	
Drainage sluices	72		113	
Flood control and salt water intrusion		120,000		125,000
Reclamations of fallow land		65,000		50,000

Table 2-10 Construction of embankments for flood control in Ayeyarwady delta through the ages⁵⁴

Period	Year	Major number	works	Length in km	% total	Protected in acres	area	% total
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⁹⁰ Ayeyarwady (2017), Irrigation and Water Utilization Management Department, Powerpoint Presentation

Colonial	< 1948	10	674	31%	1,121,300	68%
Palimentary	1948-1962	14	316	15%	171,400	10%
Socialist	1962-1988	43	1074	50%	332,400	20%
SPDC	1988-2010	2	95	4%	26,400	2%

Table 2-11: Implementation of lower Myanmar Paddyland development projects⁹¹

	Polders	Length	Drainage	Sluice gates	Beneficial area	Commenced	Completed
Phase	(no.)	(km)	(km)	(no.)	(ha)		
I	11	643.2	664	65	82,983	Aug 1976	Jun 1985
II	4	393.6	430.4	84	76,497	Jul 1978	Apr 1990

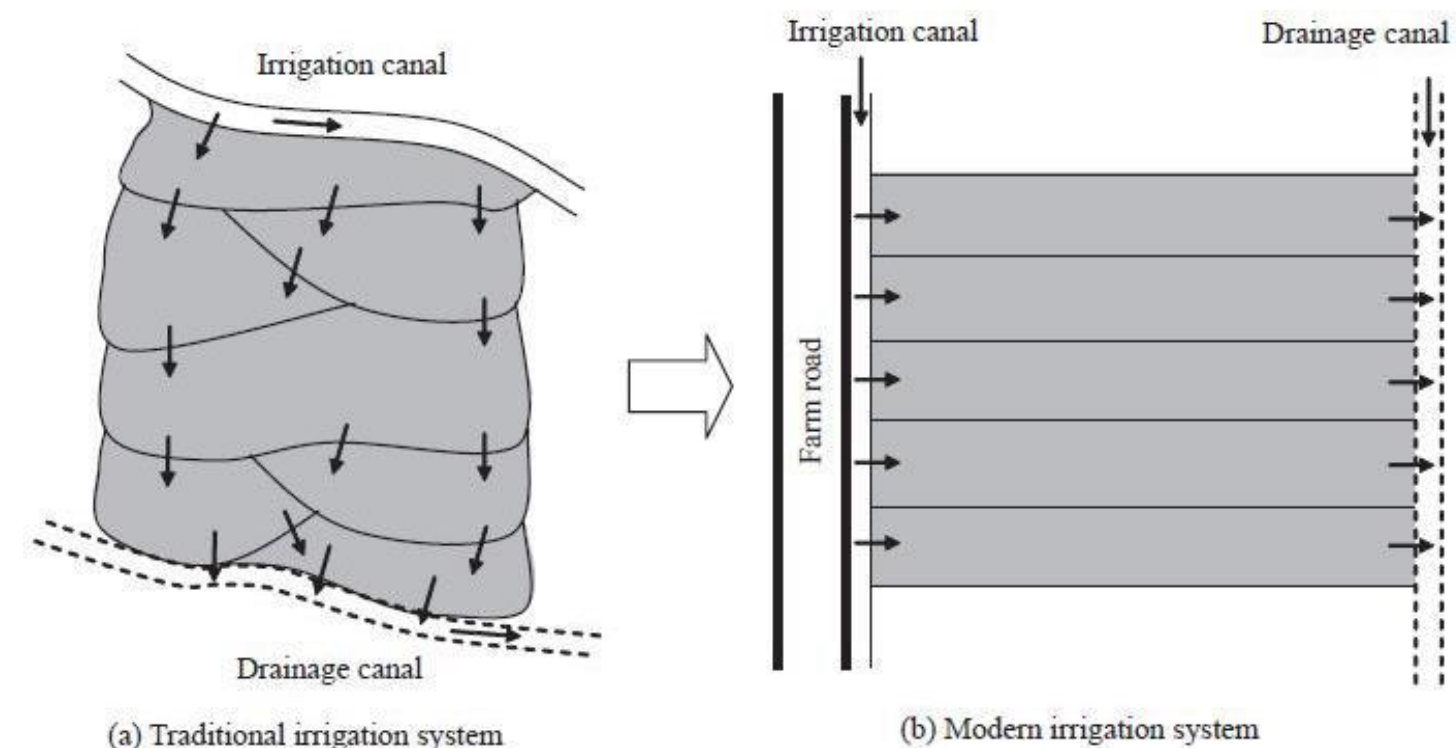


Figure 2-14 Traditional and modern irrigation system⁹²

⁹¹ Yin Mai Wai Aung (2012), Study On Integrated Water Resource management of Lower Myanmar Paddy-land Development Project III Yangon Technological University.

⁹² Hasman, R. (2014), Water Allocation Assessment to Support IWRM in the Major River basins of Myanmar, Delft University of Technology

2.7 Embankments

In the Ayeyarwady River basin, farm land, towns and cities situated in the low-lying area are protected by embankments from flooding since 1881. The protection of the west and east banks of Ayeyarwady River in the delta area was completed in 1929-1930. In the year 1909, the Burma Embankment Act, covering the whole area of Myanmar, was enacted. At the same time, a manual on the care and maintenance of embankments was released. At that time, the heights of embankments were designed to protect 20 years return period only. Over the years, the IWUMD has protected 163,899 ha of land by 41 polders and 1024 km of embankments over the whole country (Figure 2-16). The embankments have a triple purpose as: flood protection, evacuation place and as roads. The flood protection embankments have been built around polders, along several rivers mainly in the upper delta, and in other areas that are prone to flash floods. In addition to irrigation infrastructure, embankments in the delta Region, which include drainage facilities, have been strengthened to protect large areas from flooding and salt intrusion. Prior to Cyclone Nargis, there were 318 flood protection works, of which 88% was owned by the government and 12% privately, protecting a total of 1.2 million ha of cultivable land. Many of these structures were badly damaged during Cyclone Nargis, leaving much of the most productive part of the country vulnerable to catastrophic weather impacts. Currently, 64 embankments are managed by IWUMD in the Ayeyarwady Region (Table 2-12).



Figure 2-15: Embankment along the Ayeyarwady River near Nyaungdon

Table 2-12: Embankments in the Ayeyarwady Region (IWUMD, 2017)

Item	Number	Length (km)	Benefit area (hectares)
Embankment	64	2127.0	689438.9
Dam/spillway	7	-	19723.3
Sluice gate	79	-	156813.4
Drainage	18	47.7	15299.5

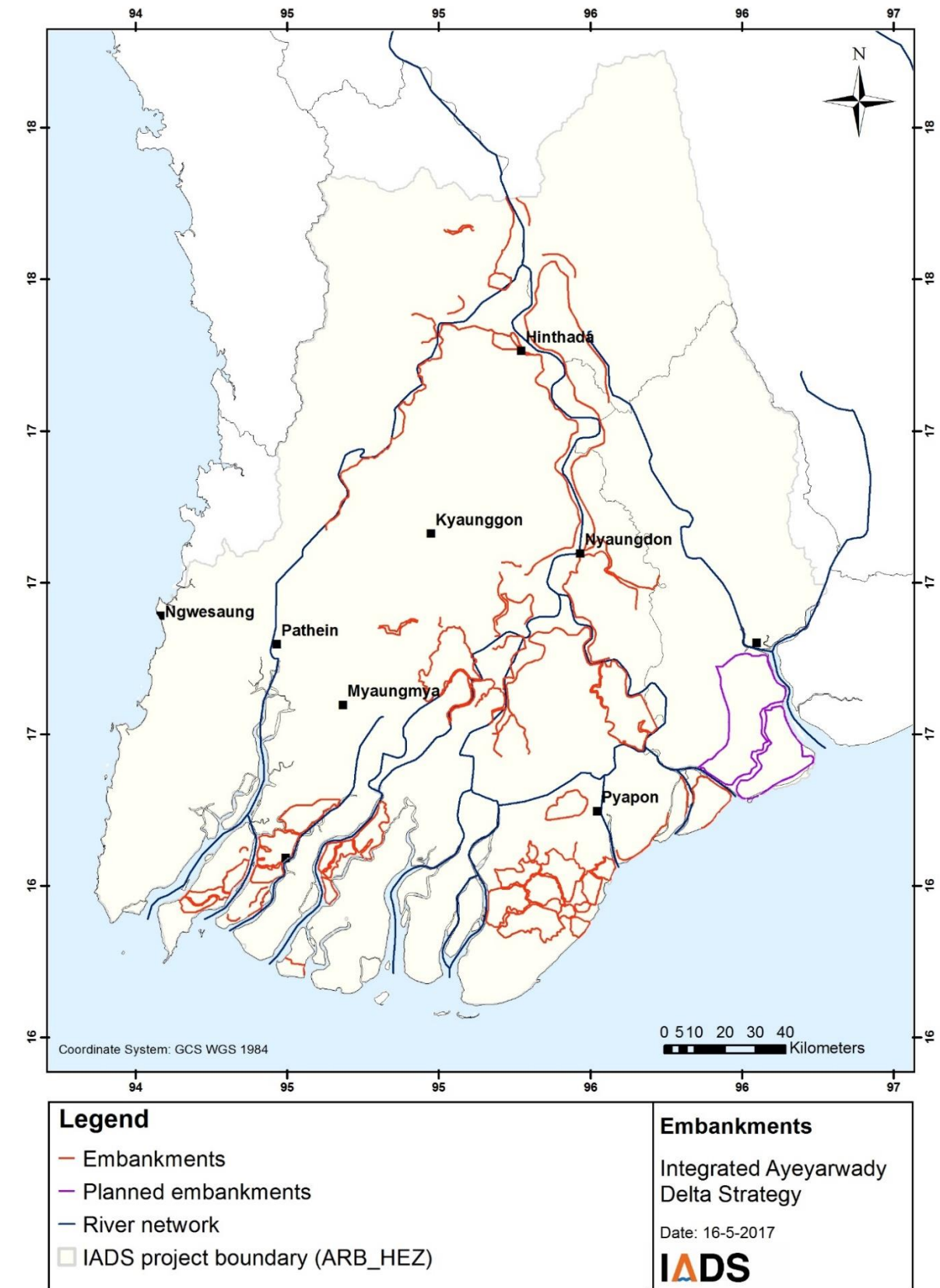


Figure 2-16: Embankment map of the Ayeyarwady region⁹³

⁹³ Irrigation Water Utilization & Management Department (IWUMD) (2016), Ministry of Agriculture, Livestock & Irrigation (MOALI). Ayeyarwady and Bago Region Georeferenced Embankment map

2.8 Drinking water supply

The percentage of the Ayeyarwady population with access to improved water sources is 50.3%.⁸³ However, this number if certainly not equally divided over the different districts. Especially the districts in the lower Delta usually do not have access to improved drinking water sources in contrast with a district like Hinthada in the upper Delta. For most villages, the traditionally sources of drinking water are from rainwater harvesting, communal water ponds and tube and open wells (Figure 2-19). In the coastal area, there is barely access to piped water and nearby tidal rivers are often saline. The (rainwater) ponds help villagers through the dry season, that stretches from November to May, although not always sufficient. The sources for non-drinking water also largely overlap with the sources for drinking water, especially in the rural areas. So, either people are using drinking water for non-drinking purposes or they are drinking dirty water (Figure 2-17).

Only 3%–10% of the country’s water resources is used. Out of this water use agriculture accounts for about 90% of the total, while domestic and industrial uses account for 10% (excluding hydropower generation). Most water used is obtained from surface water. Only 9% of the total water used comes from groundwater despite its potential for dry season irrigation.⁹⁴ Floods and high waves through cyclones or monsoons affect the salinity of this groundwater.⁹⁵ Cyclones and monsoons also affect the interaction between surface water and groundwater, which differs per season.

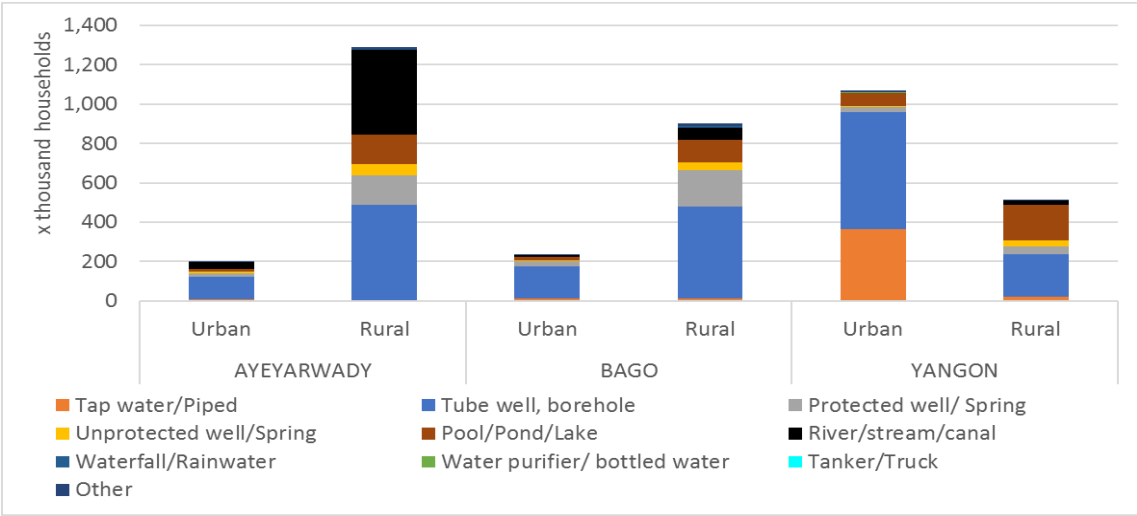


Figure 2-17: Sources for non-drinking water per household in 2014⁹⁶

Table 2-13: Water use by different sectors In Myanmar in 2008/2009⁹⁷

	Surface water	Ground water	Surface + Ground water
Domestic	(3%)	(68%)	(8%)
Industrial	(3%)	(9%)	(3%)
Agriculture	(94%)	(23%)	(89%)

The city of Yangon has a comprehensive network of water reservoirs and pipelines bringing water to the city. In 2013, the demand coverage of the city was only 30% with an incredible leakage loss of 50%. The water is non-drinkable. However, the Yangon City Development Committee has set an ambitious plan to decrease the leakage rate, increase the

⁹⁴ ADB (2013) Myanmar: Agriculture, natural resources, and environment initial sector assessment, strategy, and road map. Mandaluyong City, Philippines: Asian Development Bank
⁹⁵ Miyaoka, K, S. Haruyama, Y. Kuzuha, T Hlaing Kay, (2012), Groundwater - surface water interactions in the Ayeyarwady River Delta, Myanmar.
⁹⁶ DoP (2015), The 2014 Myanmar Population and Housing Census, Ayeyarwady Region, Census Report Volume 3-N. Department of Population, Ministry of Immigration and Population, the Republic of the Union of Myanmar.
⁹⁷ WRUD (2014), Groundwater potential of Myanmar and groundwater development activities of WRUD. Groundwater Division. Ministry of Agriculture and Irrigation Water Resources Utilization Department

demand and make the water drinkable for 2025. Especially the increase in the demand coverage is interesting, since a lot of inhabitants are using private wells to extract groundwater. This number is therefore likely to decrease in the future.

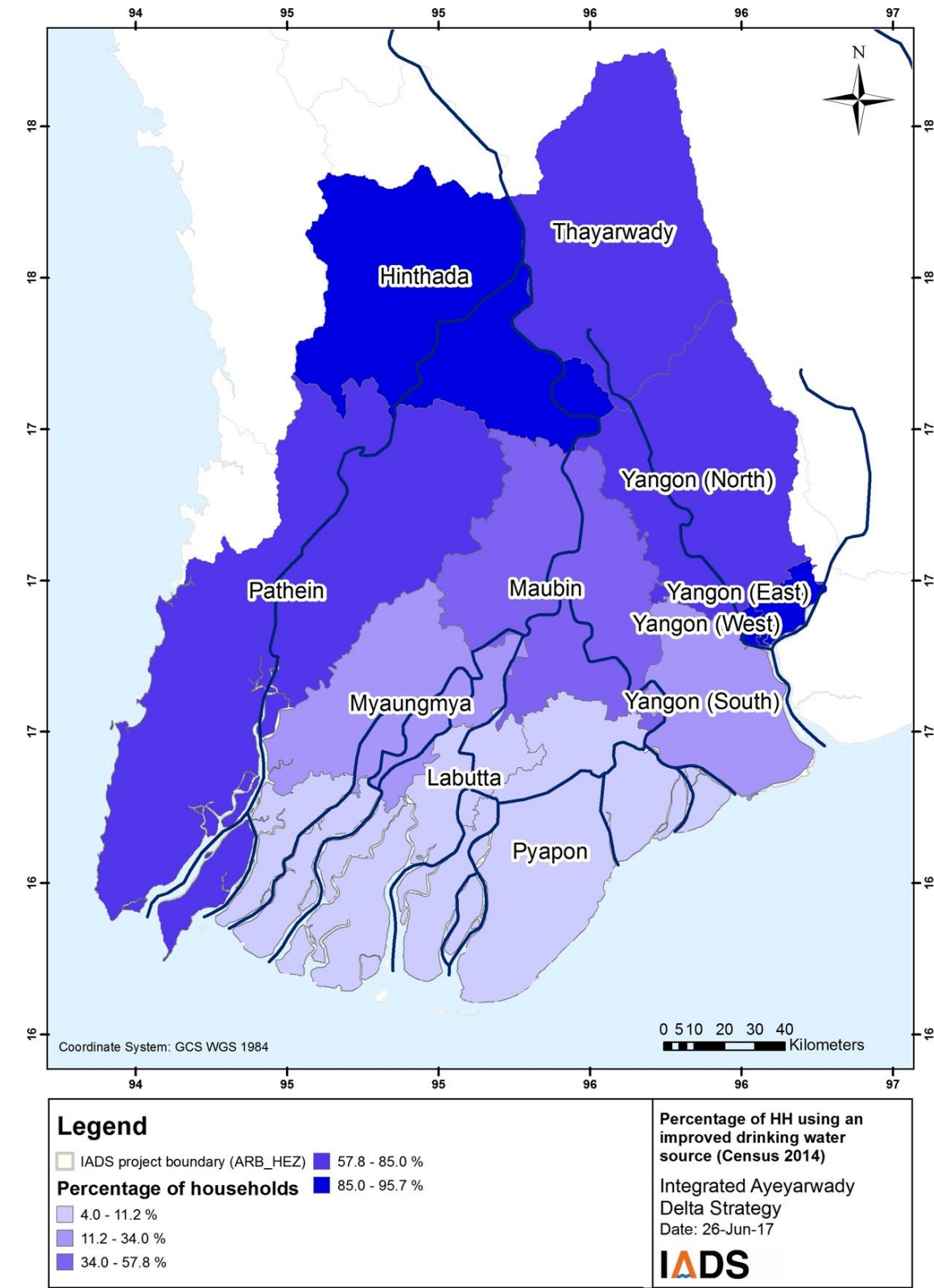


Figure 2-18: Percentage of households with access to improved drinking water sources based on census data (DOP, 2014)

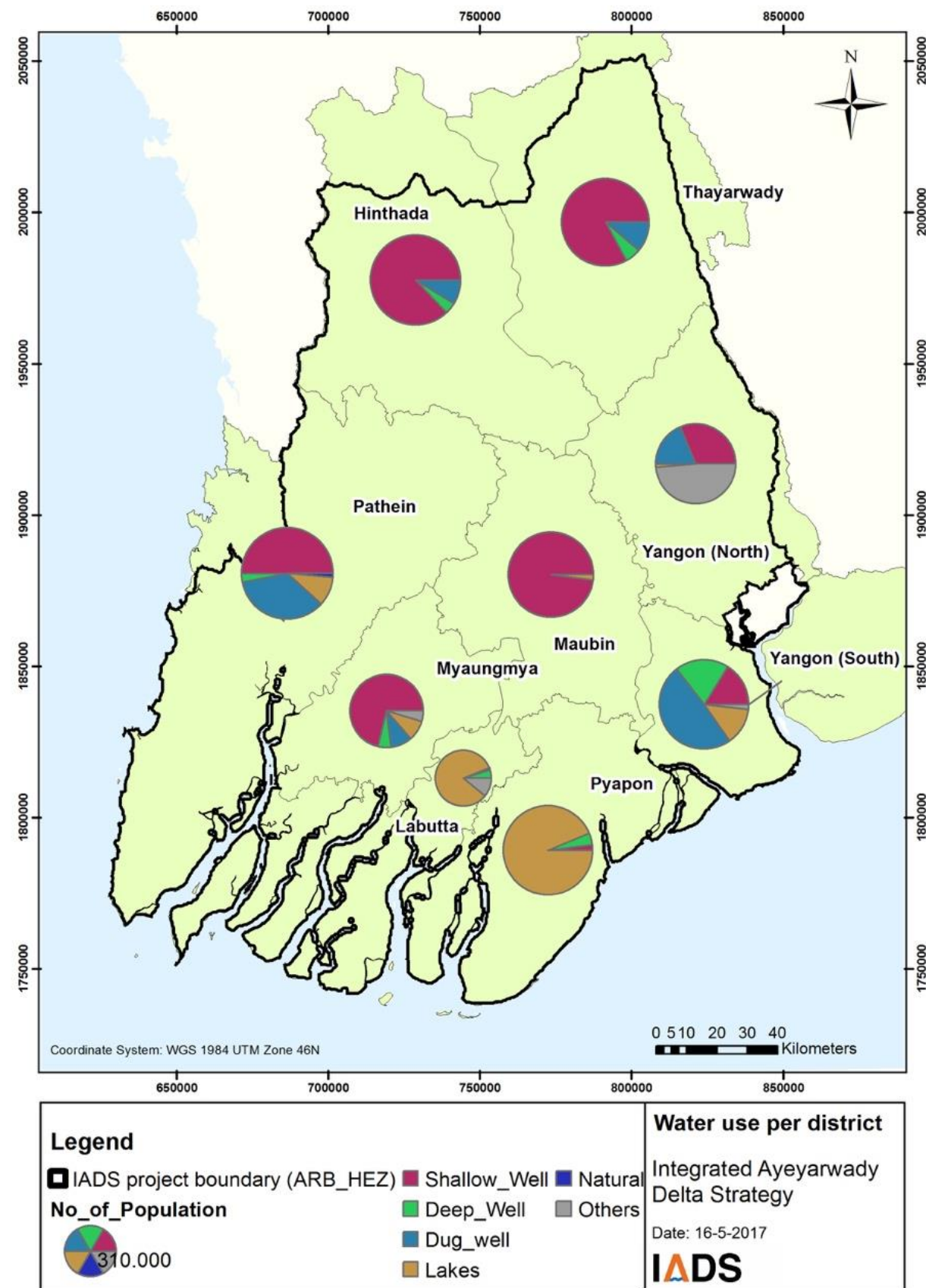


Figure 2-19: Source of water per district⁹⁸

⁹⁸ Department of Rural Development (2016), Water use per township

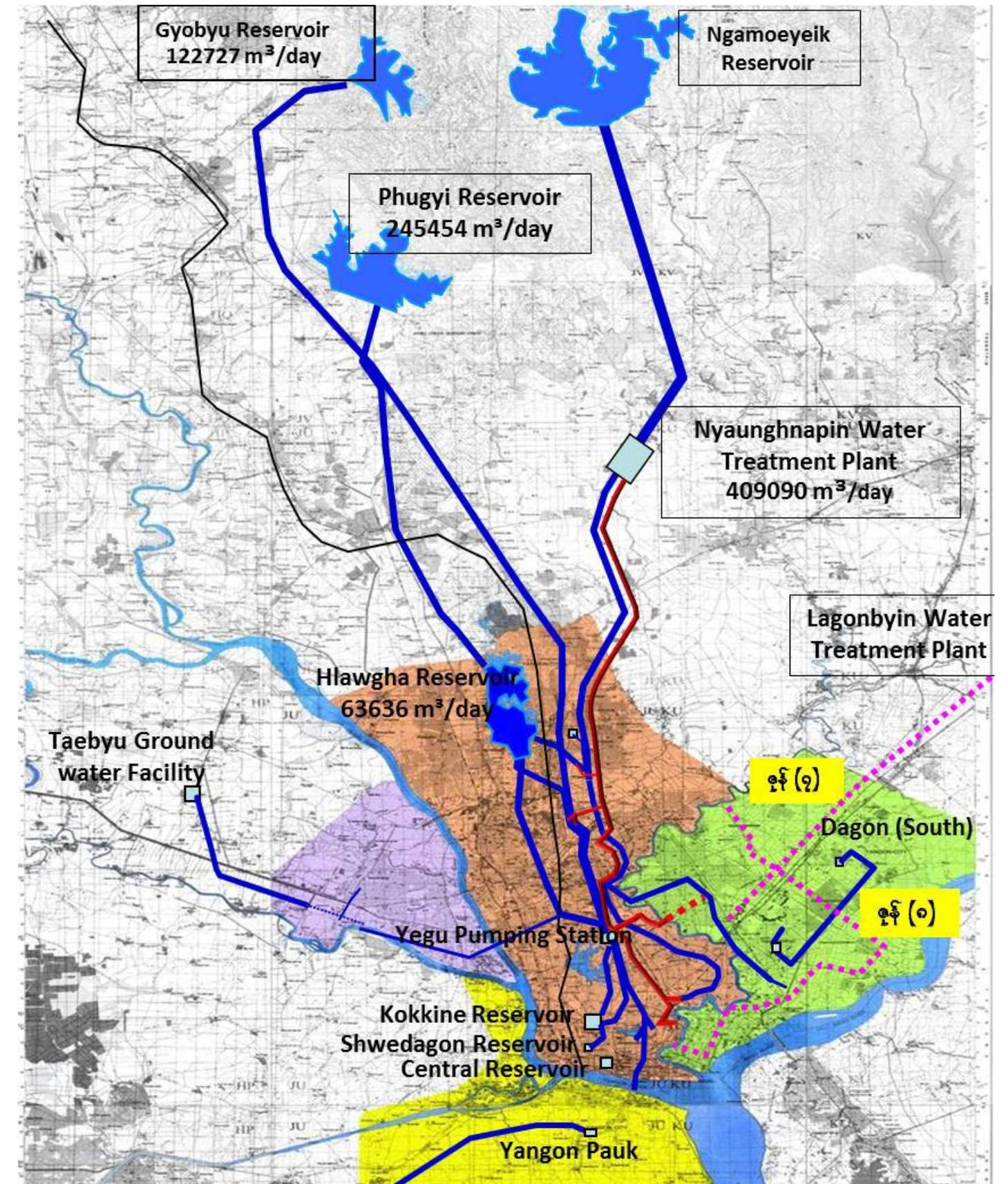


Figure 2-20: Water reservoirs for Yangon city⁹⁹

⁹⁹ Water Sanitation Department (2014), Water supply, Sewerage system and the improvement projects for Yangon City, Powerpoint

2.9 Sewerage and sanitation

Inadequate waste water and sanitation services, combined with underinvestment in preventative health care, have resulted in significant environmental and human health challenges.¹⁰⁰ Except for central business districts in large cities, solid waste management is well below acceptable levels in cities and often even worse in rural areas. Domestic waste water is usually discharged into natural waterways or storm water drains. The negative effects on health and environment will continue to expand with the growing population and industrial sector.

In the Ayeyarwady Region improved sanitation is accessible by 74.9% of the population while in the urban areas 89.6% of the populace has access.⁸³ Increased oxygen demand and deteriorating hygienic conditions of the surface waters are expected due to discharging raw sewage from towns and cities, increased pesticide and fertilizer use in agriculture and increased industrial and mining activities. The latter will further decrease water quality by the input of heavy metals, organic micro-pollutants and oils. Clear rules, regulation and monitoring are absent which make legal action against these polluting activities difficult. Therefore, introducing water treatment plants, monitoring systems and standards is essential to protect water quality and thus public health.¹⁰¹

In line with the water supply ambitions, the city of Yangon is investing heavily in the expansion of water treatment plants and service reservoirs (Figure 2-22). The current water treatment plant is located far outside the city and the new plans for 2040 will help controlling the waste water in a better and more organized way.

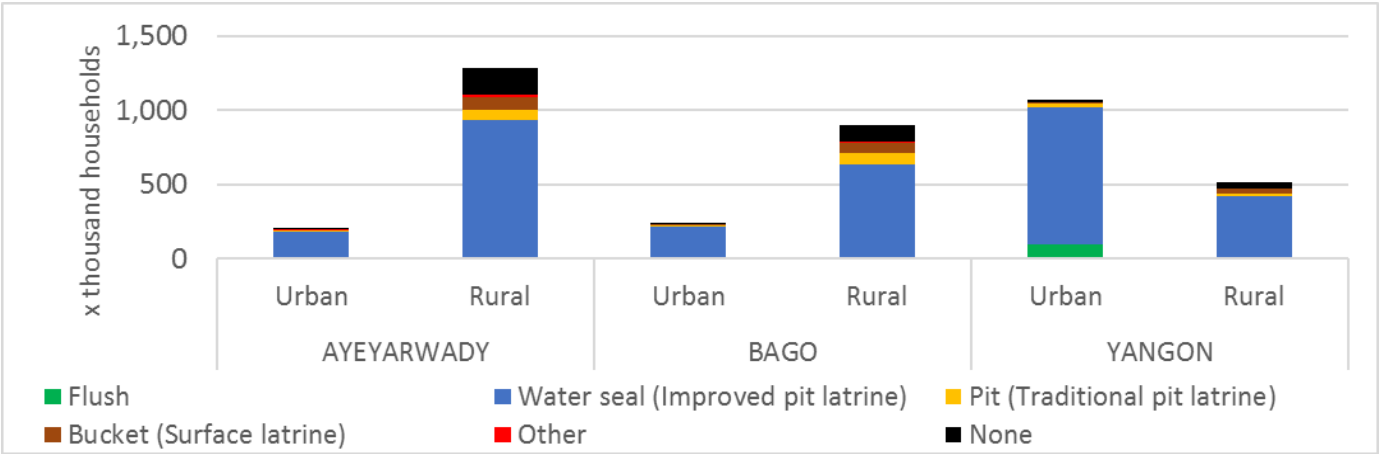


Figure 2-21: Type of toilets used per household in 2014 (DoP, 2015)⁸³

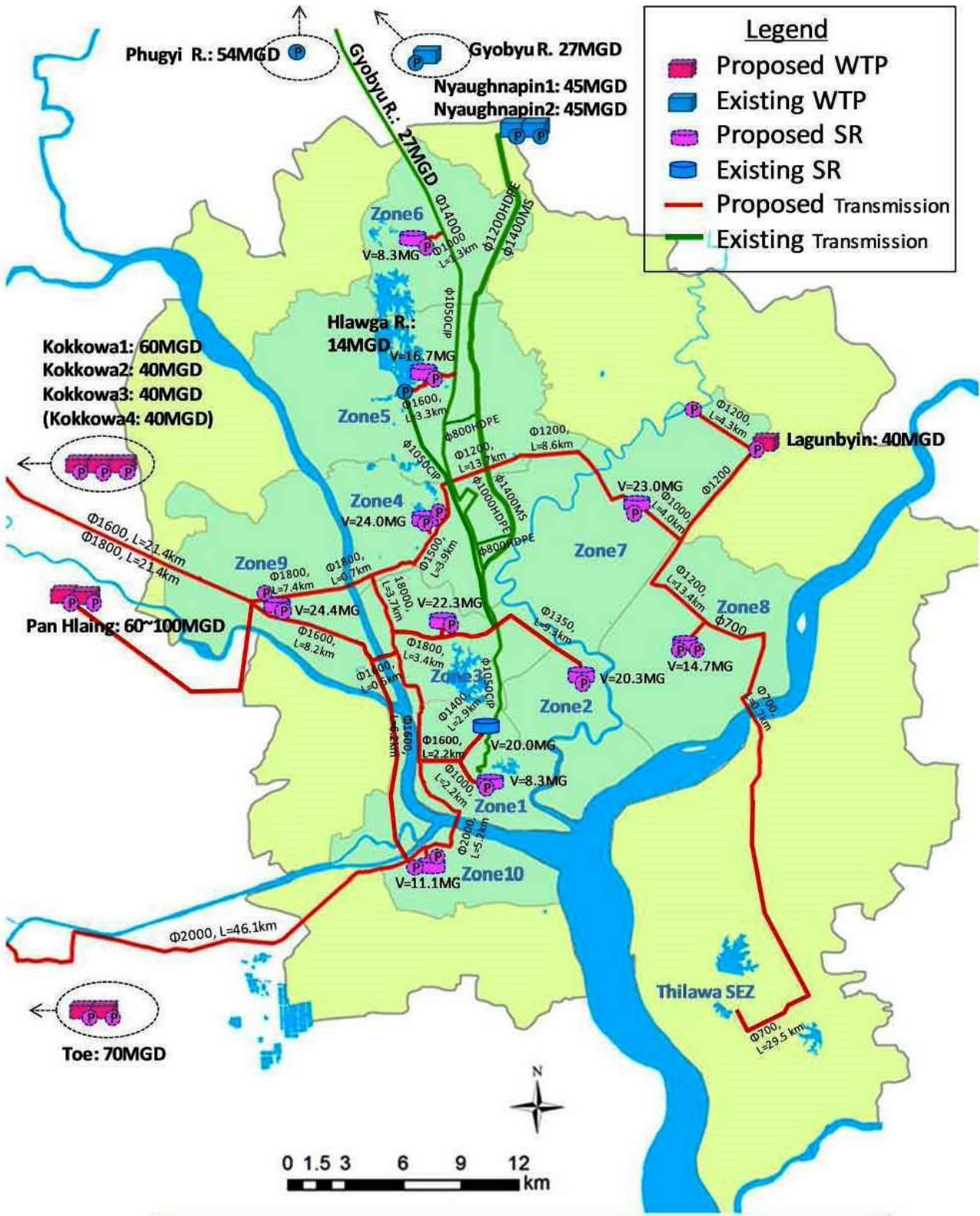


Figure 2-22: Planned Water treatment Plants (WTP) and Service Reservoirs (SR) for the city of Yangon in 2040⁹⁹

¹⁰⁰ IGES and UNEP (2016), Quick study on waste management in Myanmar

¹⁰¹ Department of Health (2000) Quantity with Quality. A report expert group meeting on drinking water quality surveillance and monitoring.

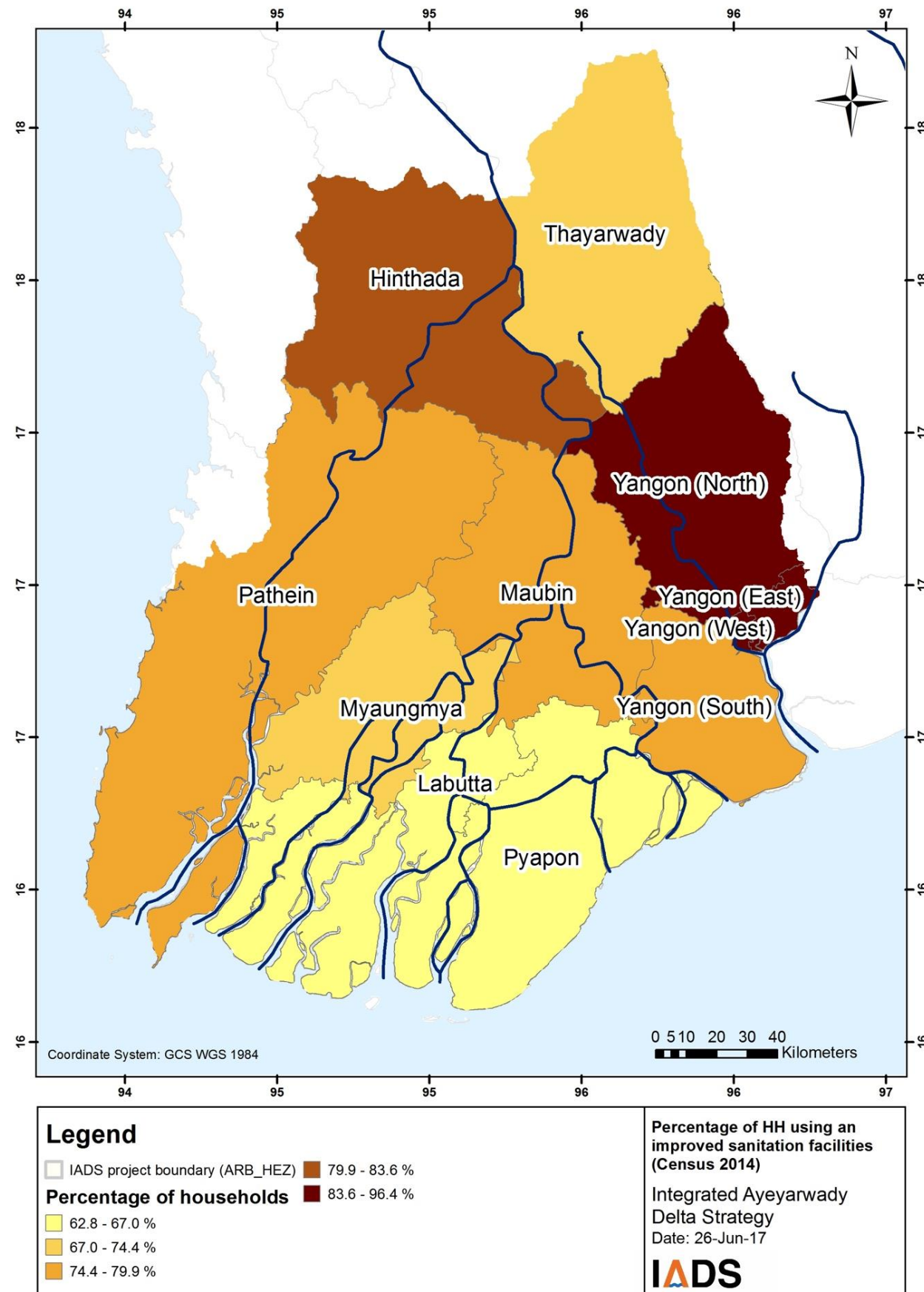


Figure 2-23: Percentage of Households with access to improved sanitation based on Census data (DOP, 2015)

2.10 Solid waste disposal

Most deltas in the world are becoming more urbanized, leading to changes in the hydrological characteristics of these deltas. Rainfall run-off reaches water ways faster and in larger quantities, creating challenges for the existing drainage systems. Even more so, since urbanization also leads to more solid waste. In case this is not properly disposed it often ends up in the drainage canals causing reduced capacities or even blockage of these canals. This is part of the reason why there is an urgent need for maintenance and upgrades of drainage systems as well as solid waste management in the Ayeyarwady delta's urban areas. Most waste comes from households, markets and commercial origin consisting of organic and plastic waste as shown in Figure 2-24.

The local municipal authorities in Myanmar are responsible for the waste management, however, in Yangon an autonomous City Development Committee and their Pollution Control and Cleansing Departments (PCCDs) is tasked with solid waste management. Most waste is currently disposed of in open dump sites or in some cases burned or recycled.¹⁰² Due to the growing population, economic growth, industrialization and changing consumption patterns, Myanmar faces great challenges in managing its solid waste. At the moment, no accurate data exists on the waste generation over the whole delta. The World Bank (2012) estimated solid waste generation in Myanmar was 5,616 tons/day with the per capita waste generation of 0.44 kg/capita/day. In 2025 this is expected to reach 21,012 tons/day and 0.85 kg/capita/day.

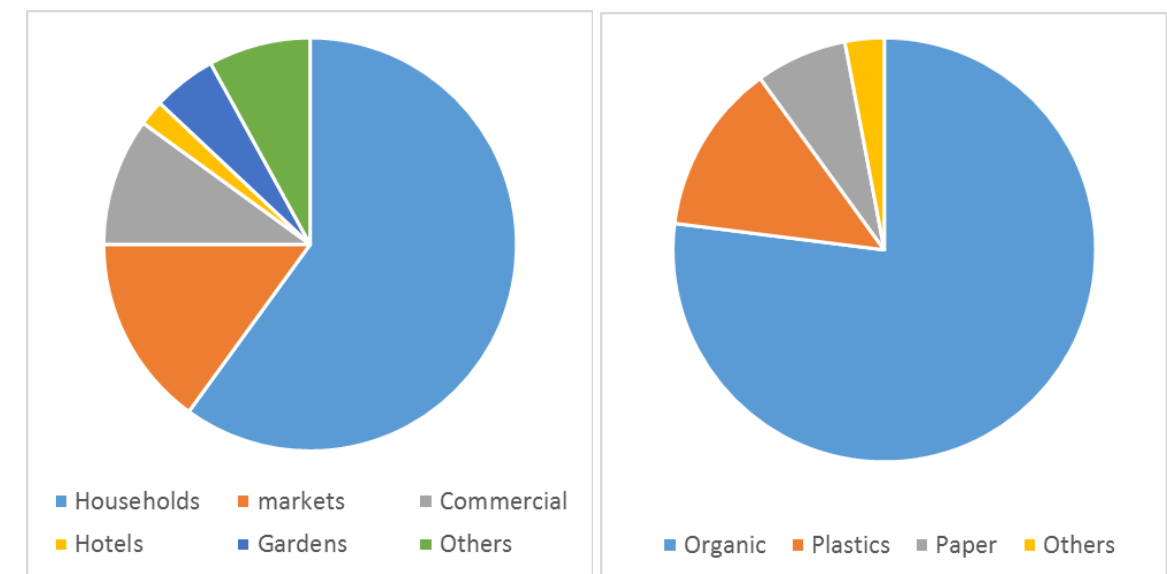


Table 2-14: Solid waste management in Yangon in 2016¹⁰²

Site location	Capacity (ton/d)	Type of management
Hteinpinn	1080	Open dumping
Dawai Chang	843	Open dumping
Shwepyithar	61	Open dumping
Mingalardon	43	Open dumping
Dala	33	Open dumping
Seikyi Khanaungato	4	Open dumping

¹⁰² IGES and UNEP (2016), Quick study on waste management in Myanmar

2.11 Data access

Due to globalization and digitalization, data and communication become increasingly important in the world. Myanmar is not very well developed in terms of communication and data access. Overall, only 6.2% of the people have internet at home and 3.5% a computer while about 50% of the households in Myanmar have television.⁸³ Access to the internet or other communication systems can help people in finding markets and comparing prices. It should be noted that more than 60% of the urban households have mobile phones in 2014 and only 21 % of the households in rural areas. With mobile phones some internet services, e.g. irrigation advice can be accessed through text messages. Another point that should be mentioned is that instead of having internet at home people can use internet cafés or libraries to access the internet. Still, almost 25% and 38% of the urban and rural population in the Ayeyarwady Delta were not still directly reachable through the traditional communication devices in 2014 (Table 2-15).

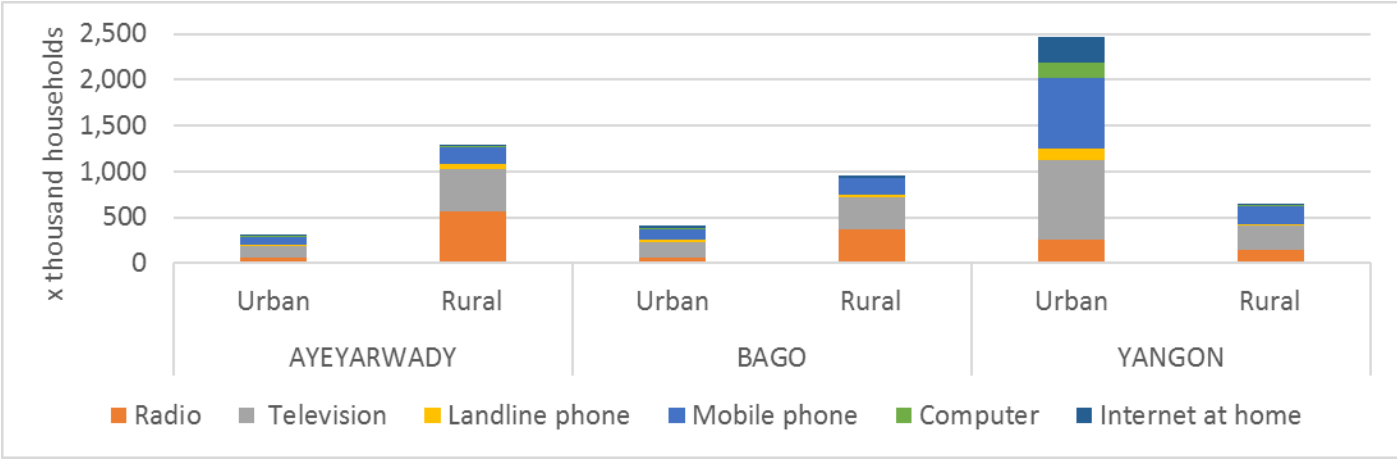


Figure 2-25: Number of households with communication devices (DoP, 2015)⁸³

Table 2-15: Possession of devices mentioned in Figure 2-25 in % of households (DoP, 2015)⁸³

		% of Households with none of the items	% of Households with all of the items
AYEYAWADY	Urban	24.4	0.6
	Rural	37.6	0.1
BAGO	Urban	20.3	0.7
	Rural	35.1	0
YANGON	Urban	11.8	2.4
	Rural	30.1	0.2

2.12 Trends in Network

The main trends of the network layer are discussed in the Working group on the Network layer and are described as follows:

Urban Planning

There is an increasing migration of people from the rural to the urban area. Therefore, urban master plans are being developed to be able to house the growing population of the cities. Population growth creates challenges because water quantity demands rise with the growing population. Moreover, the demand for safe drinking water and improved sanitation are on the rise. In order to provide safe and sufficient water to everyone in the delta, there is a need for more related infrastructure (e.g. rainwater harvesting). These developments can be combined with measures to cope with the increasing demand for sanitation and water quality improvement (pipe network system for rural areas, improving the sanitation system) and healthcare.

Transportation

IADS assumes that the need for better infrastructure will grow, both for agriculture and industry and the people living in the delta, including the increasing demands from tourism. However, the total road length in the delta is only increasing slowly¹⁰³ and while there are plans to expand the railway network no funding is available.¹⁰⁴ The Yangon airport has been upgraded recently to allow 40% more passenger per year.¹⁰⁵ The transport over water is increasing steadily in Yangon and Patheingyi, however no data is available on the rest of the delta.¹⁰⁶ Due to lack of sufficient or slowly developing infrastructure IADS expects that the economic development of the delta will be hampered. Furthermore, sedimentation is assumed to make waterways less accessible or hamper river navigation. In order to secure and expand economic opportunities of the delta, rivers need to be kept navigable. This needs to be complemented by construction and maintenance of roads, communication networks and regional waterways to ensure accessibility to markets and other facilities. IADS also assumes a need for higher connectivity in the future because the mobility of people, the amount of industry and (inter)national tourism are expected to develop.

Energy Infrastructure

The energy demand in Myanmar is increasing with about 2% every year. Due to the economic development in the delta, we expect that the need for a better and more reliable energy network will grow even further. Securing energy for the growing industry and population is crucial to ensure economic and social well-being. There are plans to update and expand the existing networks of national gridlines in the near future.¹⁰⁷ Next to the existing hydropower dams the government has planned about 20 river dams of at least 15 MW to produce more electricity.¹⁰⁸ The need for more (renewable) energy (hydropower/solar/wind/biomass) is expected to expand.

Water system

The embankments continue to expand throughout the delta, however, at an increasingly slowing pace.¹⁰⁹ According to the IADS, planning and focus is needed on upgrading of buildings, bank protection systems, dykes, embankments, drainage systems, storm water management and protection of the ecosystem (mangroves) to cope with floods. Moreover, assuming climate change will result in more high intensity rainfall events, which generate higher river discharges with more erosive power, higher maintenance costs on infrastructures like embankments, bridges and roads are expected. To further increase the agricultural potential in the delta, there are plans for the construction of new

irrigation systems as well as upgrading and repairing of existing irrigation structures such as dams, weirs and canals in the Paddy III project.¹¹⁰ The ongoing industrialization will probably contribute to more pollution of water bodies because proper waste management is lacking. The previously increasing percentage of people with access to improved drinking water and sanitation has stagnated around 80% from 2011 till the last measurement in 2015.¹¹¹ To keep up with the growing population, while at the same time raising or maintaining the level of access to sanitation and drinking water, continuous investments in sanitation and water supply are required.



¹⁰³ Data adjusted from; Source: MIMU Ayeyarwady dataset, Rows 663 - 667

¹⁰⁴ Website Myanma Railways: <http://www.myanmarailways1877.com/eng/>

¹⁰⁵ Website Yangon airport: <http://yangonairport.aero/about-the-airport/>

¹⁰⁶ CSO Myanmar Statistical Yearbook 2016

¹⁰⁷ ADB – Myanmar Energy Assessment 2015-2017 - Summary

¹⁰⁸ WLE greater Mekong

¹⁰⁹ PowerPoint presentation from the 2012 world water week in Stockholm, U Aye Myint, 2012

¹¹⁰ Yin Mai Wai Aung, 2014. Yangon Technological University. Study On Integrated Water Resource management of Lower Myanmar Paddy-land Development Project III.

¹¹¹ World Bank country at a glance, accessed April 2017

Occupation Layer



3 Occupation layer

3.1 Population

The Ayeyarwady Region, covering a large part of the Ayeyarwady Delta has a population of 6,185,000 on an area of 35,032 km² in 2014. Male/female ratio in the delta is approximately 50:50.⁷⁹ Population density increased over the years from 118 inhabitants/km² in 1973, to 142 inhabitants/km² in 142 ending up at 177 inhabitants/km² in 2014. It is most likely that this trend will continue like this. The Ayeyarwady Region can be considered as a rural region with a relatively low level of urbanization. This can be seen from the large number of villages as displayed in Figure 3-4. These numbers only concern the Ayeyarwady Region and not the other two regions in which the remaining part of the Ayeyarwady Delta is located: the Yangon Region, including the urban agglomeration of Yangon (some 5 – 7 million inhabitants) and Bago Region. Population density in the Yangon region is considerable higher with 716 inhabitants/km².

This population density in the Ayeyarwady Region is relatively low compared to for instance the Mekong Delta (approx. 500 inhabitants/km², excluding Ho Chi Minh City) and the Ganges-Brahmaputra-Meghna Delta (more than 1,200 inhabitants/km², including large urban agglomerations like Dhaka and Khulna).⁶²

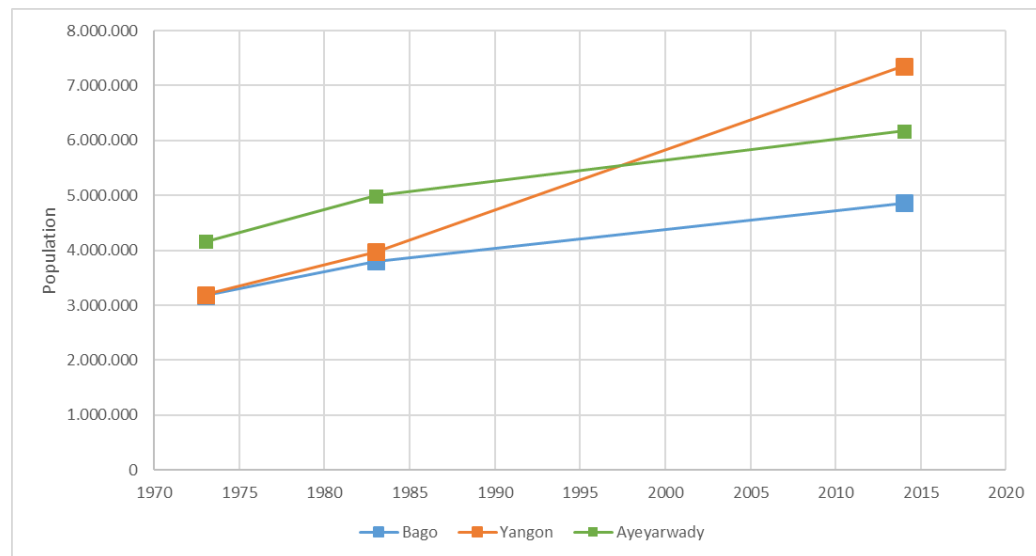


Figure 3-1 Trends in population between 1973 and 2014¹¹²

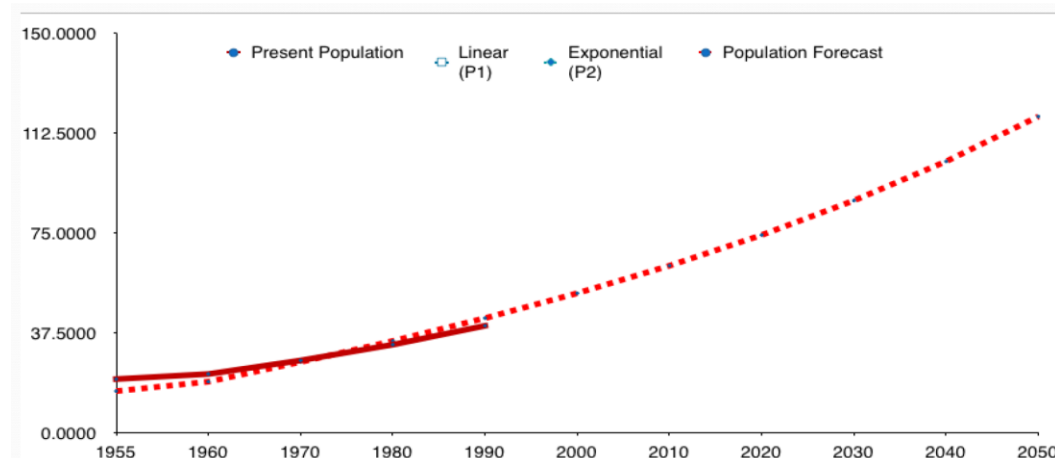


Figure 3-2 Population forecast using average of linear and exponential curve fitting (Myint, 2012)¹¹³

¹¹² MoNREC (2016). Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016–2030. Ministry of Natural Resources and Environmental Conservation, the Republic of the Union of Myanmar.

¹¹³ U Aye Myint (2012), 2012 World Water Week Stockholm, Powerpoint presentation

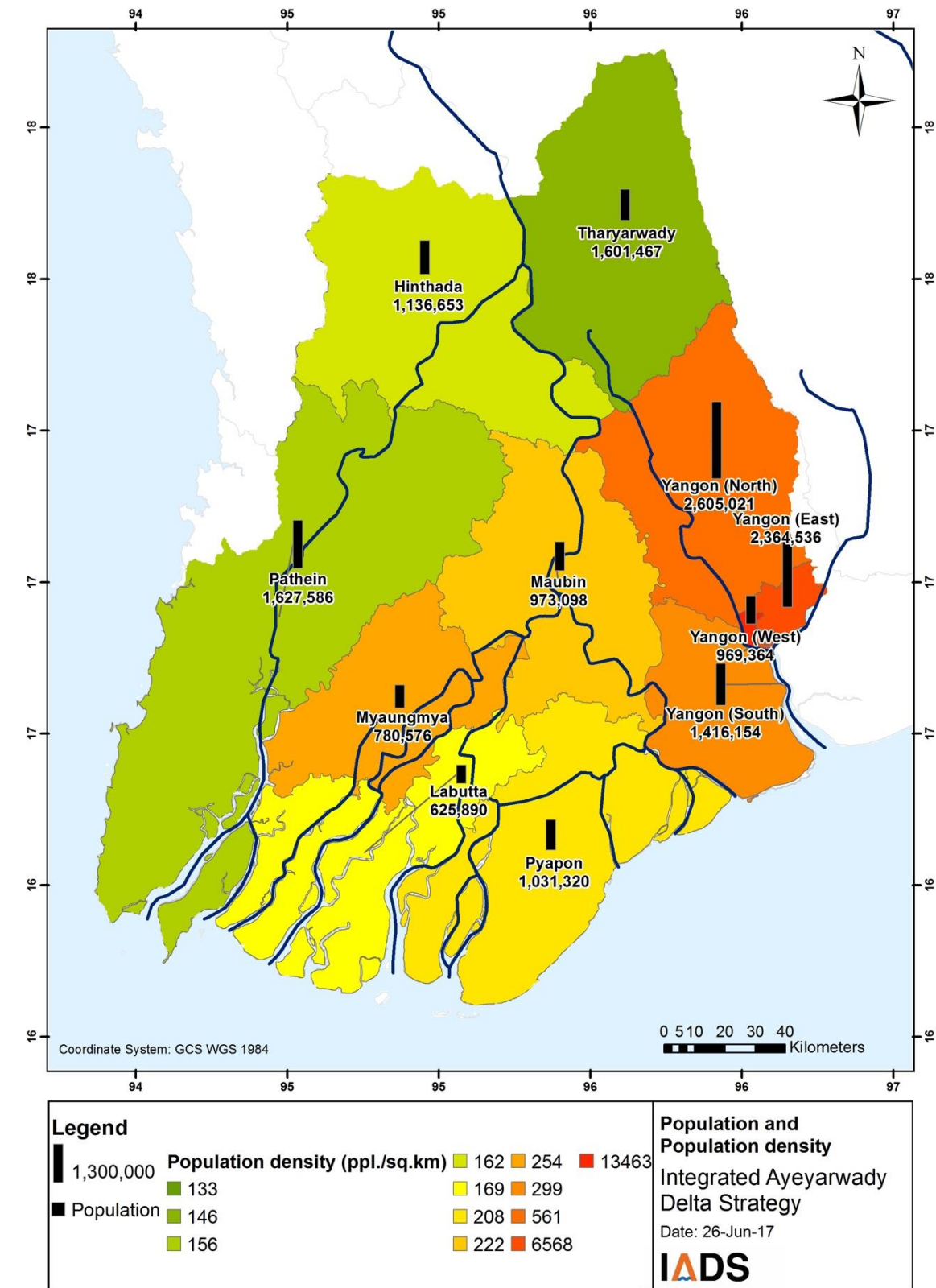


Figure 3-3: Population and population density based on census 2014 data (DOP, 2014). Note: Yangon east and Tharyarwady districts are only for a certain extent included into the project boundary zone therefore do not represent the entire district area.

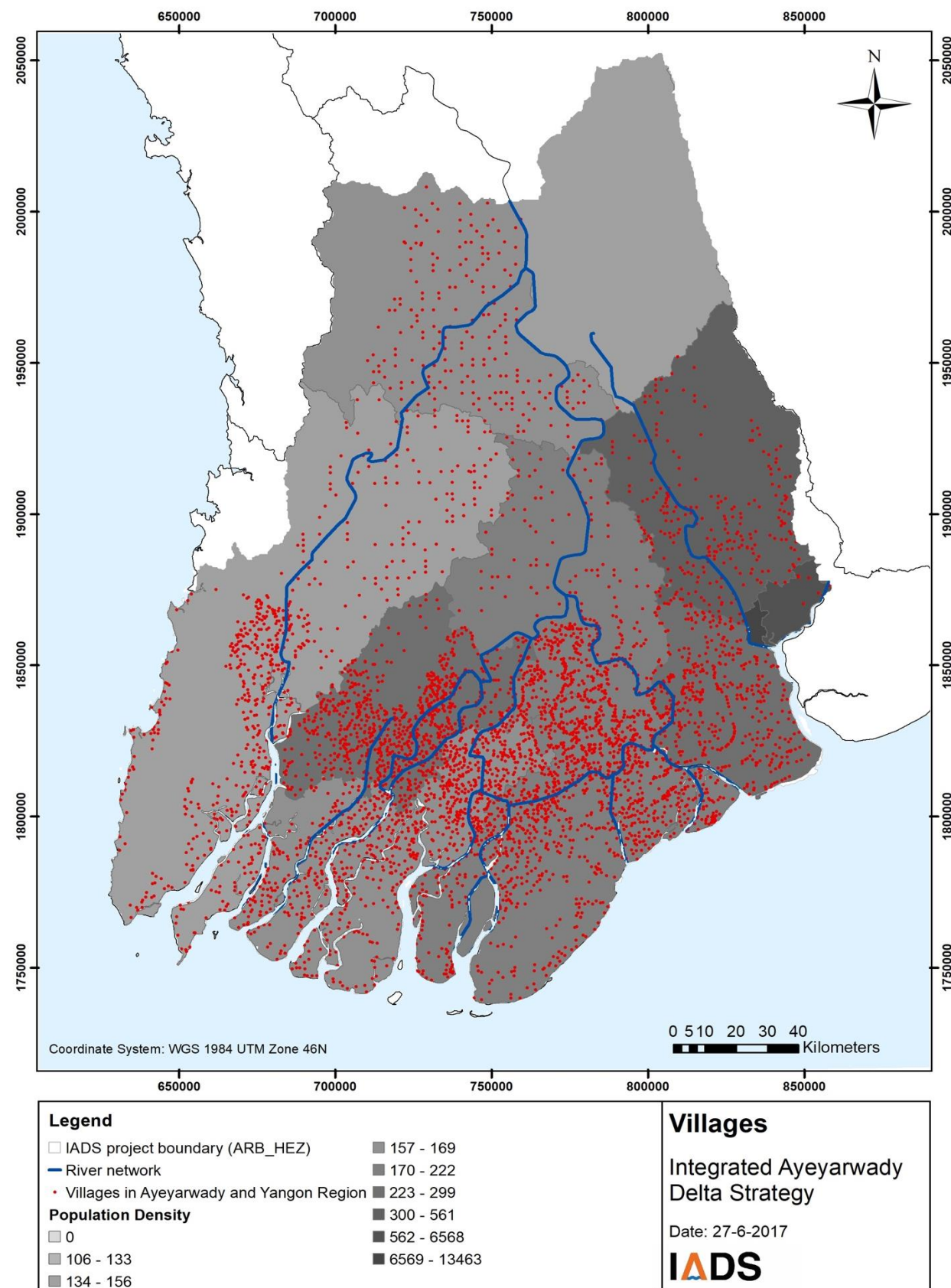


Figure 3-4: Villages in the Ayeyarwady and Yangon Region¹¹⁴

¹¹⁴ MIMU (2017), Ayeyarwady Region village points and Yangon Region village points, <http://www.themimu.info/doc-type/shape-files>

3.2 Housing and urban development

The population in the Ayeyarwady delta is dominated by a rural population. The exact definition of rural and urban population is not entirely clear, but in general a rural area is classified as a village tract with low population density and land use, which is predominantly agriculture. Urban areas on the other hand are classified as wards with an increased density of building structures, population and better infrastructural development. In 2014, communication devices in the Ayeyarwady delta were mainly radio and television. Mobile phones are upcoming and in 2014 only 2.1% of the population was using internet. Houses in the delta are for a large extent made of local material like bamboo, wood, dhani, theke or In leaf. The proportion of the population with access to 'quality roofing' is 39% in 2010.¹¹⁵ Corrugated sheets are sometimes used as a roof. However, the proportion of quality material like tiles, brick and concrete is low and therefore most houses are not resistant against natural forces like cyclones and floods. Most people are owner of their homes and therefore responsible for the damages and maintenance to their houses.

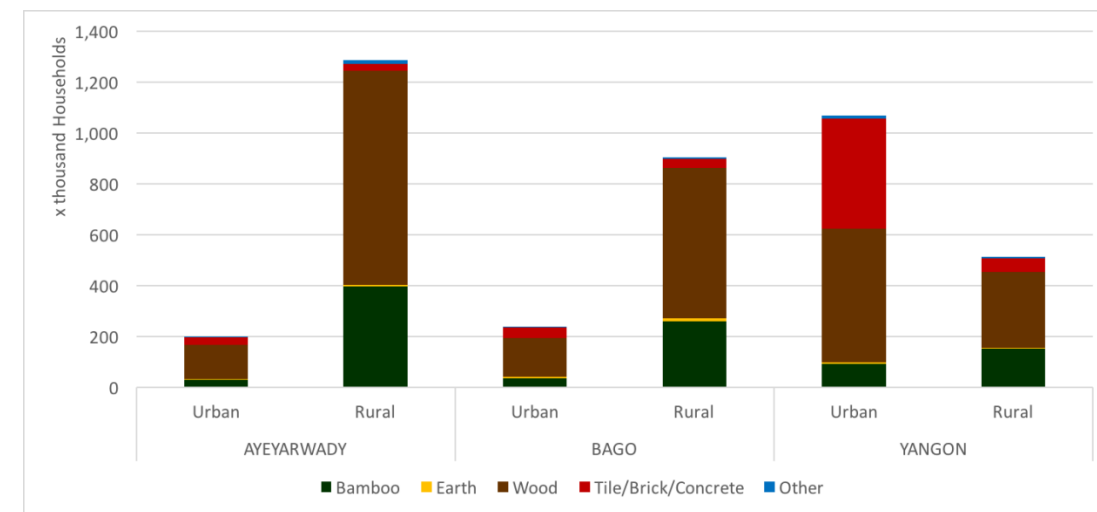


Figure 3-5: Materials used for floors per household (DoP, 2015)⁸³

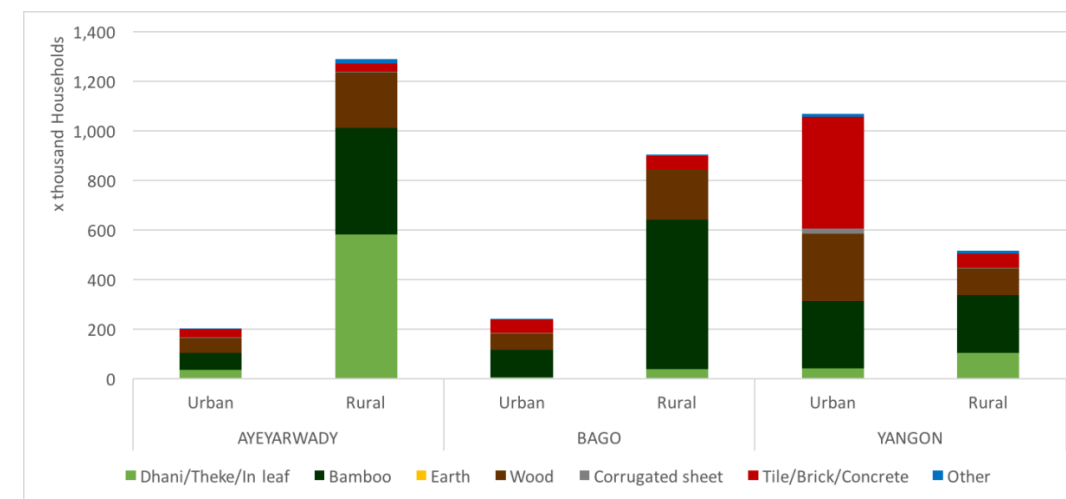
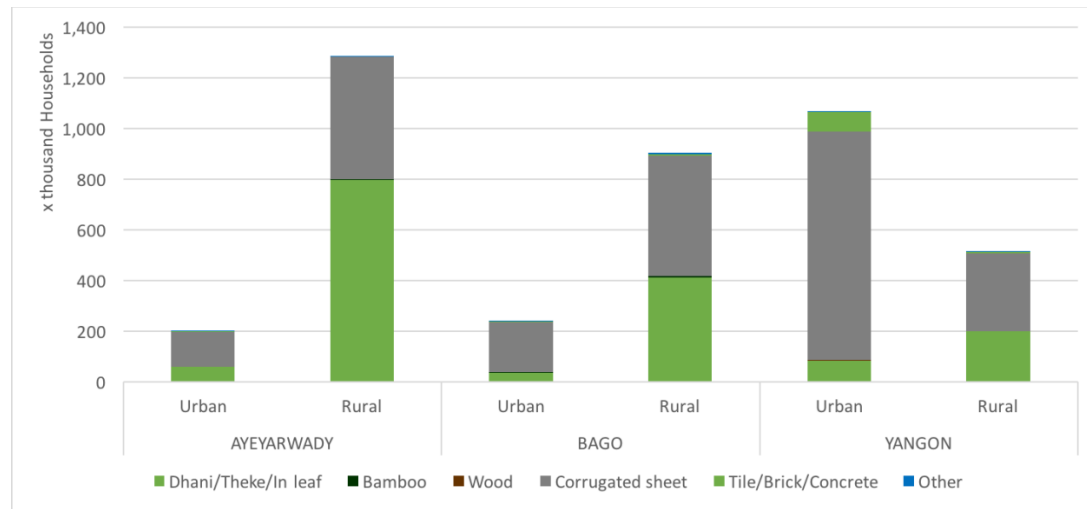
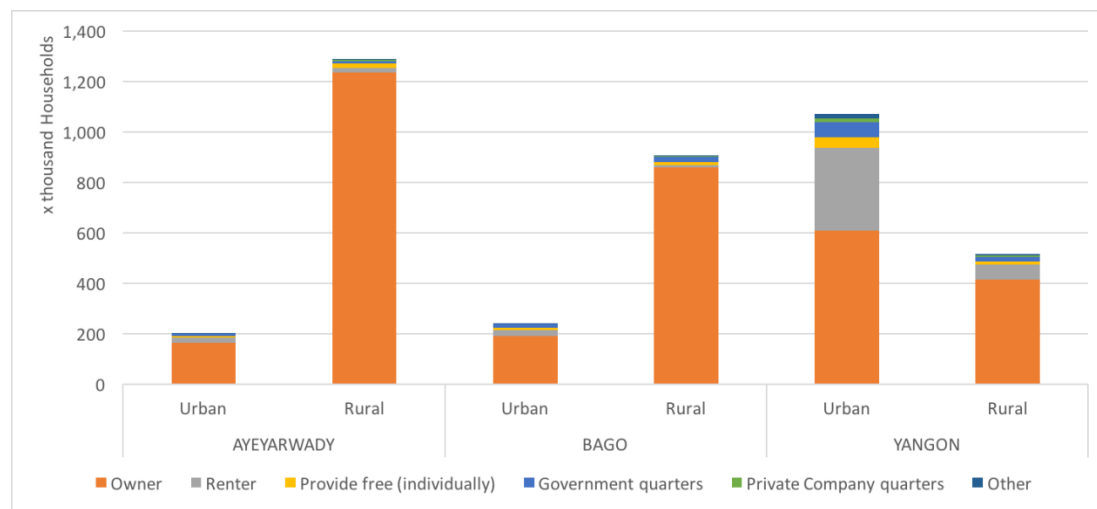


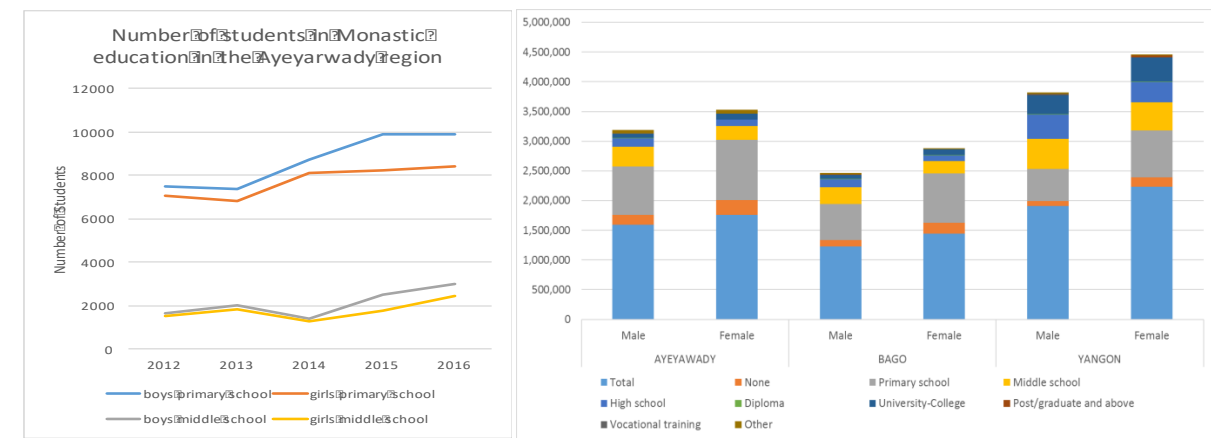
Figure 3-6: Materials used for walls per household (DoP, 2015)⁸³

¹¹⁵ MIMU Ayeyarwady dataset, Cell 170 J

Figure 3-7: Materials used for roofs per household (DoP, 2015)⁸³Figure 3-8: Types of ownership (DoP, 2015)⁸³

3.3 Education

Three types of education are present in the current educational system of Myanmar: public school, private school and monastic schools. The official entry age for primary education in Myanmar is 5 years. Out of a population of 43,517,147 persons aged 5 years and over living in conventional households, 8,461,477 are currently attending school. Of those currently attending school, 3.4 million are aged 5-9 years, 2.9 million are aged 10-13 years, 935,352 are 14-15 years old, while 938,459 are aged 16-20 years.⁷⁹ As can be seen from the statistics, there is a high dropout going from primary school going to middle school and high school for public education. This is the result of the high direct costs of sending children to school, such as buying books and uniforms. In rural areas, children are also expected to work for their parents, which is another reason for not attending school. For those who cannot afford public school, monastic schools are another option. In the Ayeyarwady region, 125 primary and 56 middle monastic schools are situated. These schools are becoming increasingly popular, especially the middle schools which are being built more and more. In 2011 1643 boys and 1532 girls attended monastic middle school. This number is increasing to 2988 and 2431 in 2015-2016, almost a doubling. The same trend can be seen for the number of students attending public schools middle and high school in the Ayeyarwady region. For those who can afford it, private education aims at teaching students in English and encourage them to leave Myanmar and study abroad. In the Ayeyarwady region, 14 private high schools with an attendance rate of 1933 were found in 2014/2015.

Figure 3-9: Monastic education in the Ayeyarwady delta (left), Highest level of education for people of 25 years and over (right) (DoP, 2015)⁸³Table 3-1 Number of schools and students in public education⁷⁹

Regions	Year	Schools			Students		
		Primary	Middle	High	Primary	Middle	High
Bago	2012-2013	4,000	228	128	501,343	221,823	59,978
	2013-2014	4,091	229	156	507,327	242,344	66,106
	2014-2015	4,090	247	171	501,997	258,722	72,208
	2015-2016	4,129	253	187	501,165	268,950	81,268
	2012-2013	2,273	259	183	559,591	340,678	123,832
Yangon	2013-2014	2,264	258	198	540,916	352,348	127,584
	2014-2015	2,222	283	226	527,303	359,392	127,342
	2015-2016	2,221	285	233	520,059	357,202	126,369
	2012-2013	5,744	279	136	778,711	264,861	72,670
Ayeyarwady	2013-2014	6,054	273	163	718,894	297,531	87,026
	2014-2015	6,023	309	197	710,238	320,990	95,469
	2015-2016	6,094	305	231	680,847	327,075	106,739

3.4 Economic development

Myanmar is now one of the poorest countries in the world by looking at GDP statistics. In 2010, 32% of the households in the Ayeyarwady regions lived under the poverty line.¹¹⁶ This is higher than the national average of 26%. Myanmar’s socio-economic indicators appear to have halted their decline and in UNDP’s 2016 Human Development Index, it is ranked 145th out of 188 states. Nevertheless, in 2015-2016, household incomes deteriorated as a result of widespread flooding.

Myanmar’s economy grew at a rate of 8.5% per year in 2013 and 2014. In 2015-2016, it eased to 7% due to supply shock from flooding in July 2015. The agricultural sector is the major contributor with 37.8% of GDP, 25-30% of total export earnings and employs 70% of the people.

Myanmar aims to become a "modern, developed and democratic nation" by 2030 by focusing on economic, social and environmental development. Policy directions under each pillar include: economic, social and environmental development and climate change. The main aim is to target a shift in sectoral contribution to GDP with industry and services increasing their contributions and the agricultural sector decreasing. This trend can already be observed in country statistics. The decrease of the agriculture contribution is from 46.7% in 2005 to 26.8% in 2015 and the increase of industry on the other hand from 17.5 to 34.5 % in the same period. The added value of agricultural products is also reflected in the revenues of the Ayeyarwady region, the main agricultural producer. Only 6 – 8% of the national revenue is produced by the Ayeyarwady region. The total revenue and expenditure of the regions are increasing over time. Expenditure is generally larger than the total revenue of the regions. In addition, the citizen and foreign investments over time show an increase, although varying over the years.

There is a strong policy focus on developing the capacity of business and human resources to benefit from the business opportunities and jobs associated with structural transformation. The country aims to invest in skills development programs, small and medium-sized enterprises (SMEs) and sustainable business models. Sectors are also adopting innovative practices to support the production and consumption of goods and services.⁶²

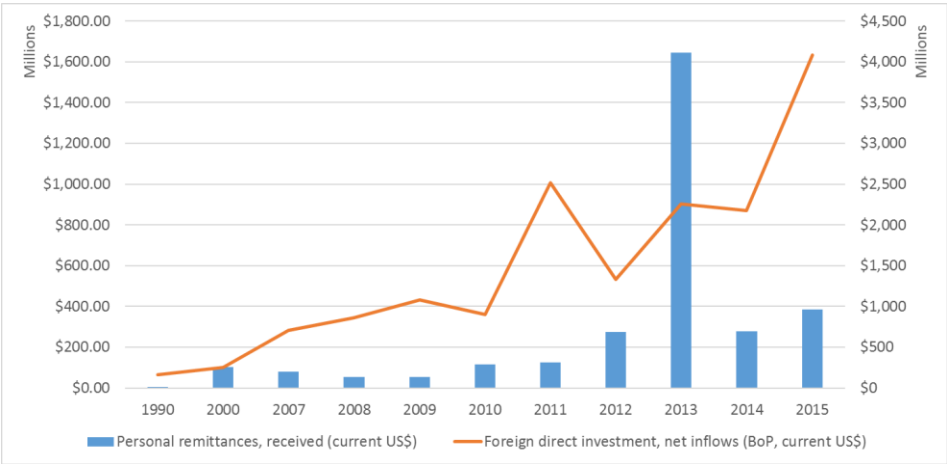


Figure 3-10: Cross national income¹¹⁷

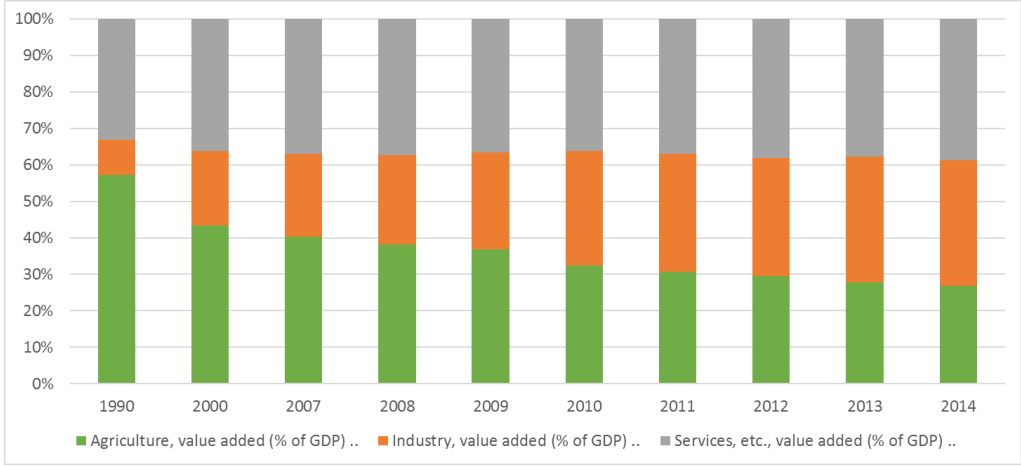


Figure 3-11: Contribution to GDP per sector¹¹⁷

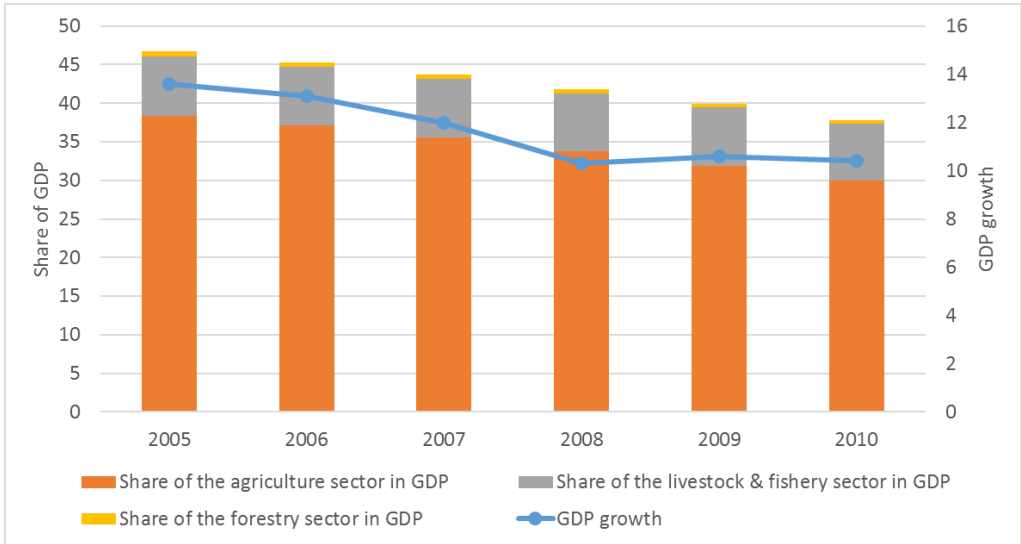


Figure 3-12: Agriculture, fishery, livestock and forestry sectors contributions to GDP¹¹⁸

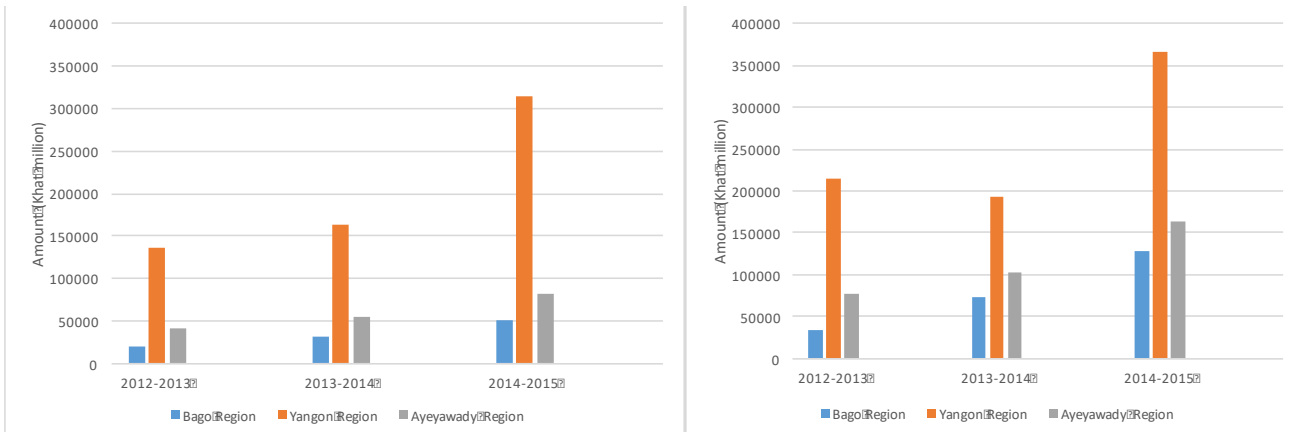


Figure 3-13 Revenue and expenditure of the three regions⁷⁹

¹¹⁶ UNDP (2014), Human Development Report 2014- Sustaining Human Progress: Reducing Vulnerability and Building Resilience

¹¹⁷ WorldBank (2015), World Development Indicators, <http://databank.worldbank.org/data/reports.aspx?source=2&country=MMR>

¹¹⁸ FAOSTAT (2010), Data on agriculture, fishery, livestock and forestry sectors contributions to GDP

3.5 Employment

As was already mentioned frequently, most of the people employed in the delta are working in agricultural, forestry and fishery. Unemployment rates are low in the delta regions. The reason for being economically inactive is studying and being a household worker.

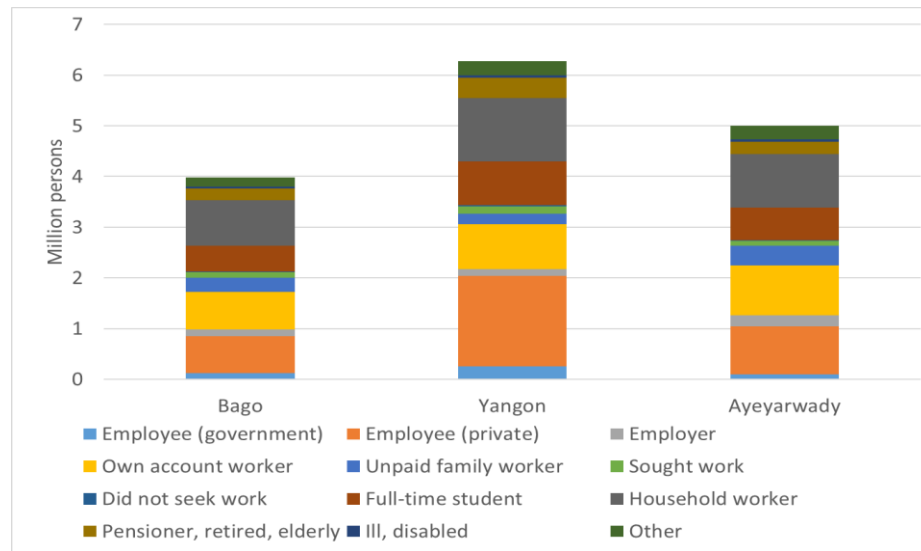


Figure 3-14: Employment division in the Bago, Yangon and Ayeyarwady regions¹¹⁹

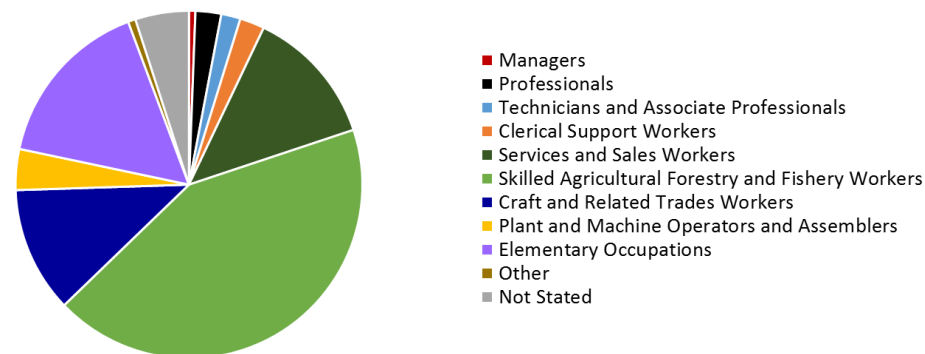


Figure 3-15: Percentage of employed person aged 15 years and over in Myanmar¹¹⁹

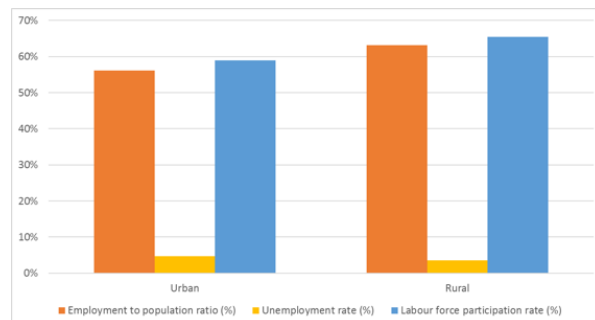


Figure 3-16: Employment for people over 15 years old¹¹⁹

3.6 Health access

The Department of Health and the Department of Health and Planning are responsible for the health institutions in Myanmar. This means in the first step to try and minimize the risks of getting ill and if people do get ill they need access to doctors and medicines. The first step is already problematic in Myanmar because of its tropical climate diseases are abundant and spread easily. The changing climate will increase the risk of spreading of infectious diseases, heat exhaustion and dehydration. While at the same time the rising sea level and higher flood risks endanger freshwater resources.¹²⁰ The following problems are of main concern: Arsenic pollution (groundwater abstractions), waterborne diseases (malaria, dengue), flood related health issues, access to doctors / health centers, affordability of health care.¹²¹ The number of hospitals and beds in the Ayeyarwady and Bago regions are constant over the last 3 years, where Yangon is increasing its number of hospitals. The main causes of death in the country are infection and parasitic diseases.

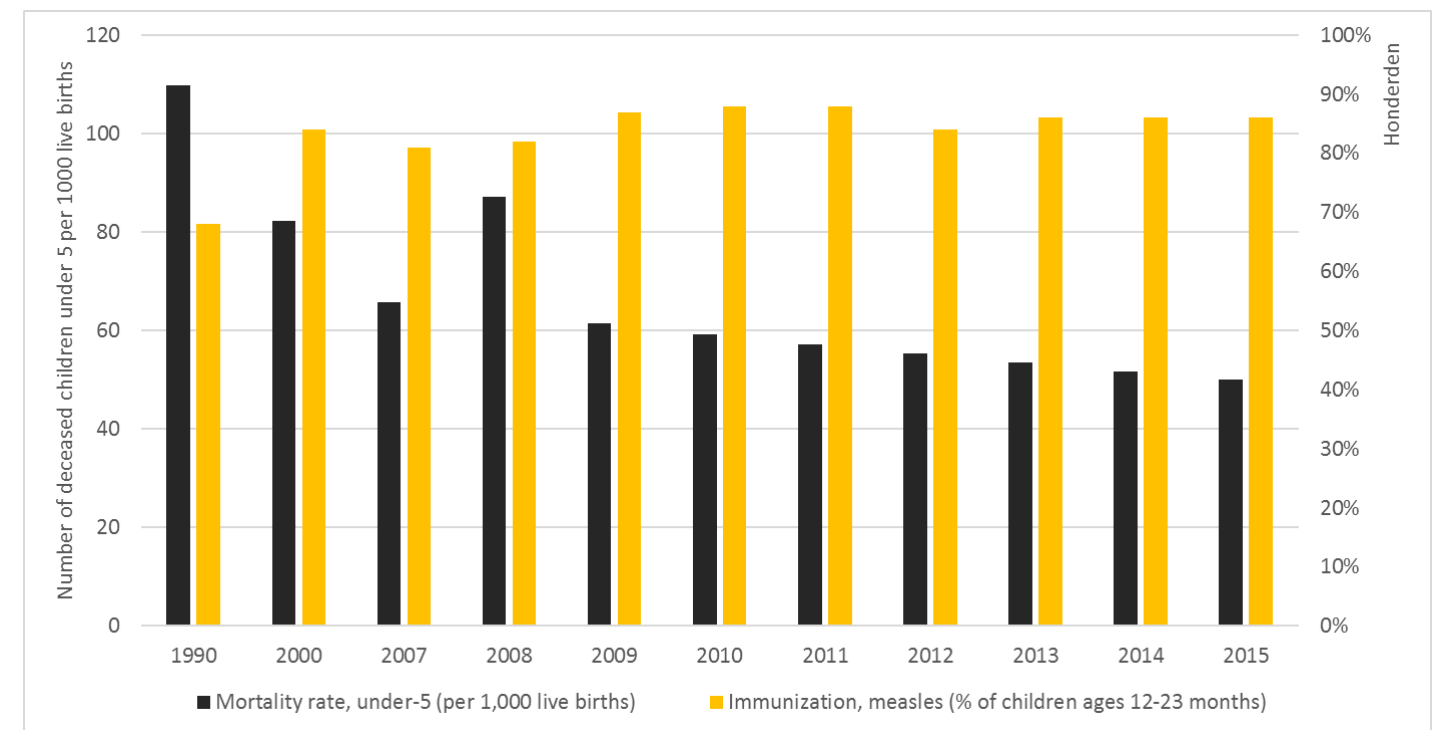


Figure 3-17: Mortality of children under 5 and % immunized against measles¹¹⁷

¹¹⁹ DoP (2015), The 2014 Myanmar Population and Housing Census, Ayeyarwady Region, Census Report Volume 3-N. Department of Population, Ministry of Immigration and Population, the Republic of the Union of Myanmar.

¹²⁰ Lian, K. K. and Bhullar, L.(2010), Adaptation to Climate Change in the ASEAN Region.

¹²¹ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

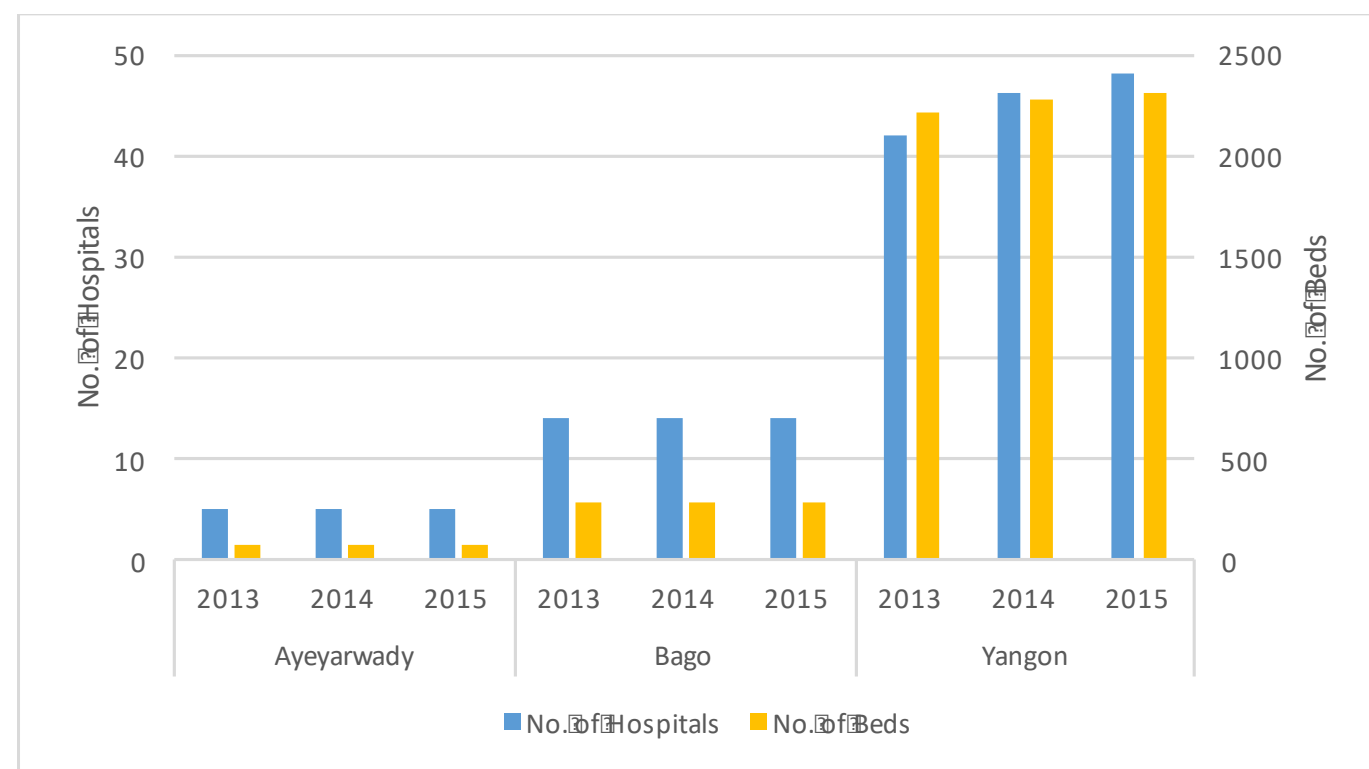


Figure 3-18: Private hospitals and number of beds⁷⁹

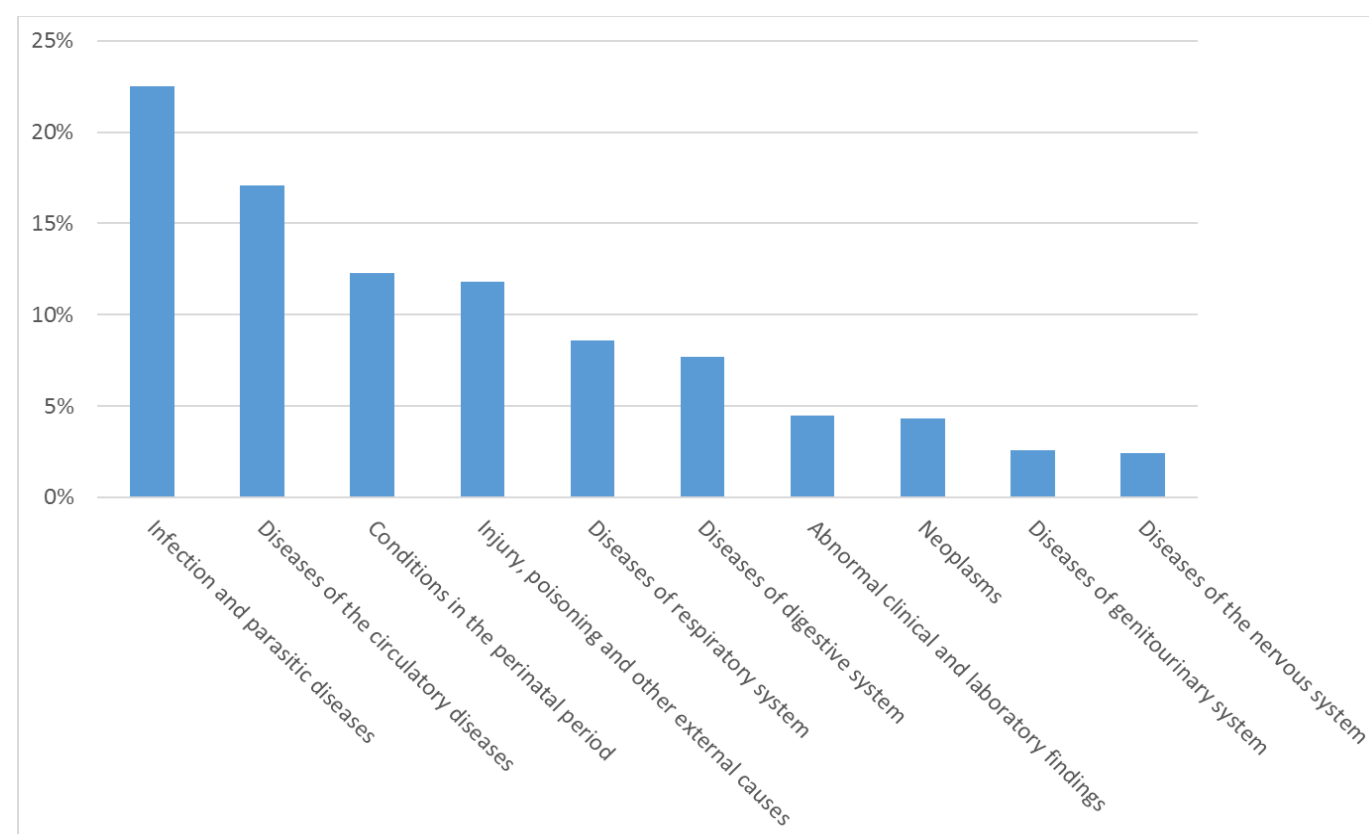


Figure 3-19: Causes of deaths in public hospitals¹²²

3.7 Industry

Industries apart from those related to farming and fishery are not yet well developed in the region. Nevertheless, the opening up of the country to the outside world and the accompanying liberalisation of the economy will attract more industry to Myanmar. ¹²¹ The Ayeyarwady has the potential of becoming a major industrial zone. Already three designated industrial zones are found in the region; Hinthada, Myaungmya and Patheingyi. The industry will mainly concentrate in the economic free zones, of which Thilawa, near Yangon is the main area now but another economic free zone is underway in Patheingyi. Patheingyi has a large potential for industrial development because of its proximity to Yangon (only 4 to 5-hour drive). ¹²³ Waste water is now still largely discharged directly on open water surface. However, when it contains high acidity, alkalinity, temperature or toxic metals, it needs to be treated beforehand. Allowable waste effluent standards are shown in Figure 3-21.

Table 3-2: Number of land allocation for industrial zones and land use in Ayeyarwady region¹²⁴

Region/state	Township	Developed plot	Allotted plot			Balance plot	Free plot	
			Industry	Unused	Total		Ware house	Free plot
Ayeyarwady		764	173	486	659	105	19	385
	Myaungmya	115	23	86	109	6	19	45
	Hinthada	169	14	155	169			137
	Patheingyi	480	136	245	381	99		203
Bago		914	279	613	892	22	13	320
Yangon		12,765	9,113	3,643	12,756		1,299	2,345

Myanmar has set some industrial targets, with manufacturing expected to become one of the country's most significant economic growth drivers in the coming years. The investment in the new free economic zones will attract industrial and manufacturing investments in the country, where the current low labour costs provide additional incentives for investing in Myanmar. Especially consumer products like pharmaceuticals and food, textiles, ceramics, paper, chemical products, construction materials and heavy industrial products are expected to become the trend in industry. ¹²⁵



Figure 3-20 Special Economic Zones in Myanmar with their respective hinterland¹²⁶

¹²³ The Local State of Governance: Trends in the Ayeyarwady (2014), UNDP

¹²⁴ Excerpt from Appendix D, Myanmar Ministry of Industry, Industrial Policy, Feb. 2016, pp. 58-61

¹²⁵ Industrial Zones in Myanmar, <http://www.myanmarindustries.org/index.php/zone/industrial-zones>

¹²⁶ Myanmar Integrated Water Resources Management: Strategic Report (2014)

¹²² Lhat, N.N., et al (2016), Health care in Myanmar, Nagoya Journal of Medical Sciences, 78(2), 123-134

Parameter	Unit	Range		Remarks
B.O.D.	ppm	20-60	max	Depending on geography of waste discharging point
Suspended solids	ppm	30	max	
Dissolved solids	ppm	2000	max	
pH value		5-9		
Permanganate value	ppm	60	max	
Sulphide	ppm	1	max	
Cyanide	ppm	0.2	max	
Oil and grease	ppm	5	max	
Tar			none	
Formaldehyde	ppm	1	max	
Phenols and Cresols	ppm	1	max	
Free chlorine	ppm	1	max	
Zinc	ppm	5	max	
Chromium	ppm	0.5	max	
Arsenic	ppm	0.25	max	
Copper	ppm	1	max	
Mercury	ppm	0.005	max	
Cadmium	ppm	0.03	max	
Barium	ppm	1	max	
Selenium	ppm	0.02	max	
Lead	ppm	0.2	max	
Nickel	ppm	0.2	max	
Insecticides			none	
Radioactive materials			none	
Temperature	°C	40	max	
Colour and odour				Not objectionable when mixed in receiving water

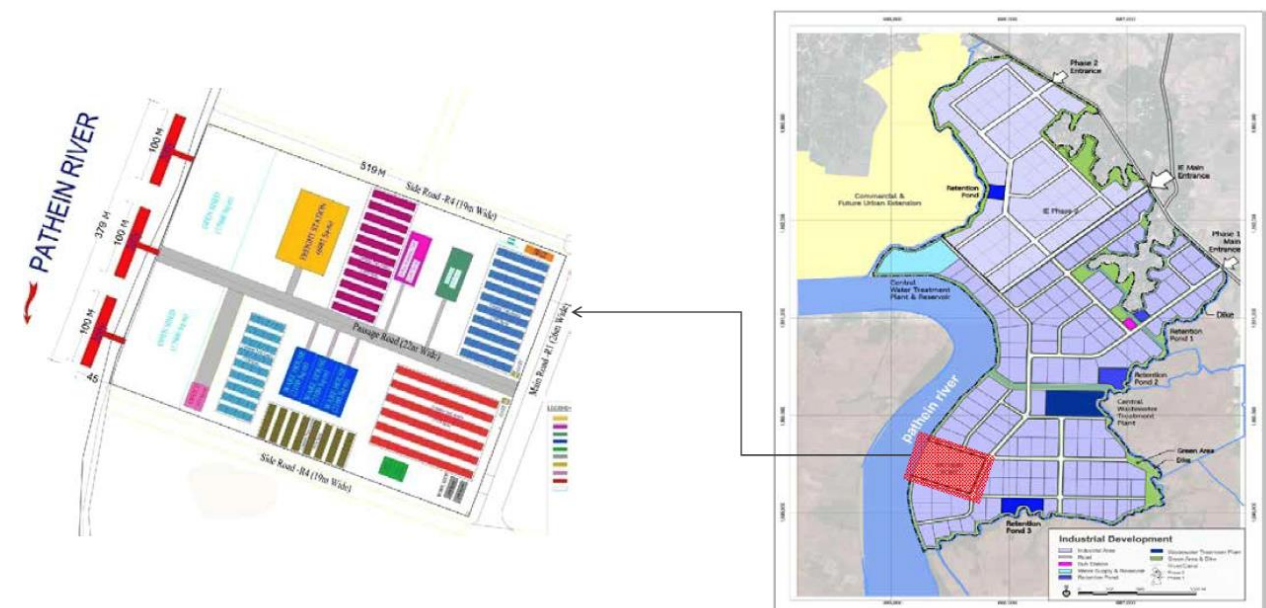
Figure 3-21 Allowable waste effluent standards¹²⁷

3.7.1 Patheingyi Industrial City

In 2018, the development plan for Patheingyi Industrial Zone is planned by to be finalized. The 2,700 acres project will be split in two major zones; zone A, which is an industrial zone and zone B, which is a combined industrial and commercial zone. The aim is to improve livelihood of the area's residents by attracting manufacturing companies to the region and enable investor to expand their manufacturing capacity in a new zone with ample labor supply.¹²⁸ To do this, a new international port with cargo handling of ships up to 10,000 tons will be developed together with two bridges, a waste water treatment plant, retaining walls and a power plant. The industrial zone is located 188 km from Yangon and will serve as the major industrial zone in the Ayeyarwady Region.

The industrial zone can export large quantities of agricultural products such as rice, fishery, pulses and beans overseas or to other parts of Myanmar. It furthermore will reduce the costs of transportation for the domestic businesses in the Region.

Together with the development of Patheingyi Industrial Zone, initiatives are taken to turn the new zone in a sustainable lower carbon city.¹²⁹ This can include waste treatment since all solid waste in Patheingyi is landfilled. Also, initiatives such as making biomass out of rice husk waste can be considered. Furthermore, emphasis will be put to ensure an independent power supply system for the whole industrial zone with possibilities to use renewable energy such as solar power to cover this.

Figure 3-22: Patheingyi Industrial City development plan and Port Expansion plan¹²⁸

¹²⁸ Ayeyarwady Development Public Co (2016), Patheingyi Industrial City: Project milestones, Powerpoint Presentation

¹²⁹ MRI (2016), Study for building a sustainable low carbon city around the industrial zone in Patheingyi City, Ayeyarwady Division, Mitsubishi Research Institute and Fujita Corporation

¹²⁷ Ministry of Industry (2017), Water Resources for Industrial Utilization in Myanmar, Powerpoint Presentation World Water Day 2017

3.8 Tourism

Tourism is not well developed in the delta, except for some seasonable recreation along the west coast near Pathein. Pathein Township serves as an administrative center for the coastal sub-townships of Ngwe Saung and Chaungtha. Tourism is a key growth sector driven by development of the township’s beaches in recent years.

One of the strategic projects for implementation for the Tourism Master Plan 2020¹³⁰ is to add an ecotourism dimension to the tourism opportunities to ensure community participation as well as to explore ecotourism opportunities in protected areas. In the Myanmar Ecotourism Policy and Management Strategy for Protected Areas 2015-2025¹³¹, 21 ecotourism sites are designated throughout the country. In the Ayeyarwady Region, two sites are located and two in the Yangon area close to the project boundaries. In the Ayeyarwady Region, the aforementioned Meinmahla Kyun Wildlife Sanctuary is one of the spots, whereas the other is the Thamihla Kyun Wildlife Sanctuary, a small island along the coast. Furthermore, beach towns Ngwesaung and Chaungtha are mentioned as ‘Primary Tourist Destinations’. However, both ecotourism sites have accessibility problems, whereas the Meinmahla Kyun is recognized as ‘some difficulties to access’ and the Thamihla Kyum as ‘time consuming access’. The latter spot had no visitors in 2014, since no accommodation is provided in the area. According to the same strategy, the Meinmahla Kyun is a priority spot for implementation of plans to support ecotourism.

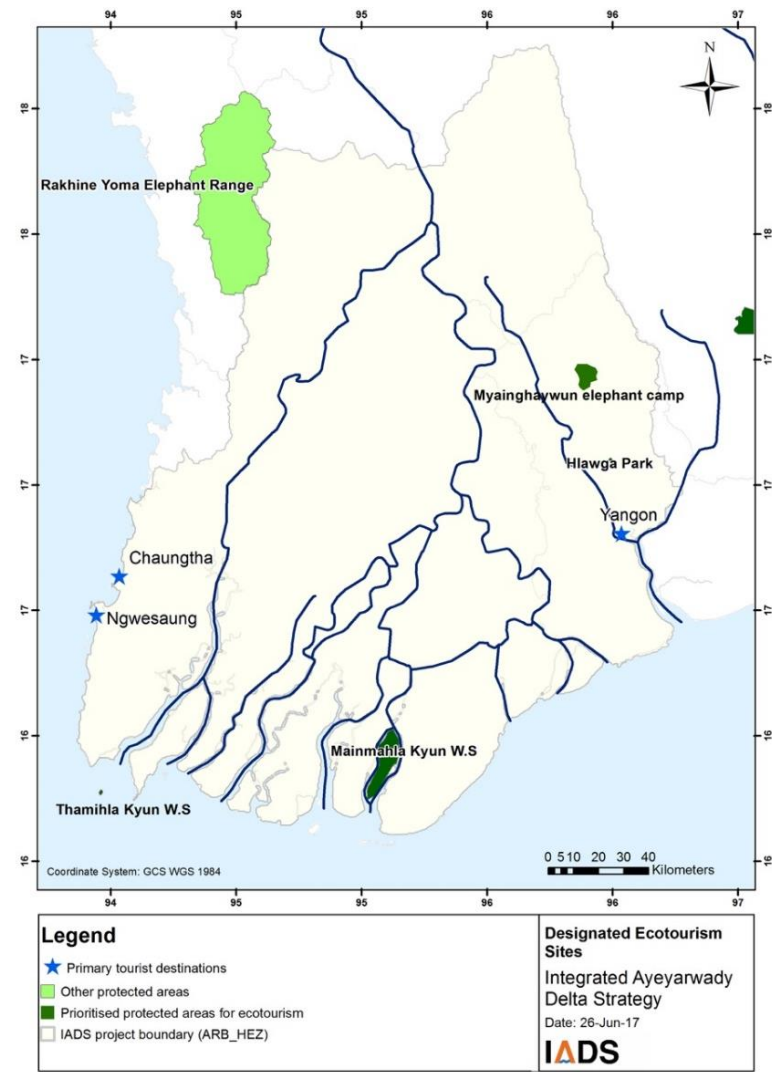


Figure 3-23: Designated Ecotourism Sites in the Ayeyarwady Delta redrawn from Ministry of Environmental Conservation and Forestry (2015)¹³¹

¹³⁰ Ministry of Hotels and Tourism (2013), Myanmar Tourism Master Plan 2013-2020, Final Draft Report, The Republic of the Union of Myanmar
¹³¹ Ministry of Environmental Conservation and Forestry (2015), Myanmar Ecotourism Policy and Management Strategy for Protected Areas 2015-2025, Ministry of Environmental Conservation and Forestry and Ministry of Hotels and Tourism, The Republic of the Union of Myanmar

3.9 Migration

With the slight shift from agriculture towards industry and services, a structural transformation away from a rural, agricultural economy and a beginning of a more urban, industrial and service-based economy is initiated. This will introduce domestic trends of migration towards urbanized areas. A World Bank Study in 2016¹³² shows that in 2014-2015 high levels of migration were observed with about one in five households in the Ayeyarwady Region having at least one migrating member with only 2% of these 20% moving internationally. Migration from villages has increased rapidly in the recent years with a significant increase in the year 2014 as can be seen in the figure showing the year of leaving of migrants in the Ayeyarwady and Magway Region.

These migrants are predominantly young males being better educated than their parents. Main reason to migrate is work-related migration to urban areas, although 20% of the investigated household moved because of economic shocks like extreme weather events or food insecurity. 58% of the migrants in 2014 moved to Yangon and most of them only migrate in case of guarantee of employment by a relative or family member already working in the city of interest. Main drivers identified are: differentials in earnings, job availability, differences in working conditions and lifestyles. Study shows that households with greater diversity of income sources are less likely to migrate. Moreover, especially landless households have a migrating family member. Constrains not to migrate, although wanted to, are lack of money or lack of jobs. Source of financing for migrating members are mainly families of the leaving person.



Figure 3-24: Percentage of households with a current or returned migrant per year of leaving ¹³²

3.10 Land use and cropping patterns

The land-use in the delta is very consistent. In a very broad distribution, half of the land is cultivatable land. The other 50% mainly consists of forest and reserved forest and only 1% is still virgin land. It can be concluded that most of the land is in some way occupied.

Using satellite data analysis, the spatial land-use pattern of the delta was mapped into more detail.¹³³ The agriculture areas were classified based on the number of crop cycles during a year and the sources of water for agriculture. These crop cycles explain the intra-annual vegetation changes in the agriculture areas. Much of the rainfed farming begins in May-June, while irrigated areas have year-round crops depending on the availability of water. The crop cycle has a strong dependence on the annual rainfall pattern. Based on this, the following agriculture water management practices in the region could be identified: irrigated (single, double, triple), rainfed, flood plains, and other non-irrigated water managed areas. Rainfed agriculture was determined from its correlation with rainfall patterns and crop growth and flood plains with their correlation to river proximity. The overall map can be seen in Figure 3-27 and Figure 3-28. If the delta is divided into three pieces; upper, central, lower, a distinct pattern of land-use/water management types can be

¹³² World Bank (2016), A country on the move: Domestic migration in two Regions in Myanmar (2016)
¹³³ IWMI, Mapping Agriculture Water Management, Crop Cycle and Natural Land Cover in the Salween and Ayeyarwady basins

distinguished. In the upper delta, rainfed irrigation is possible. Behind the horse shoe embankment in the middle of the upper delta, water managed irrigation areas are found fed by a system of sluices, dams and drainage canals. The Patheingyi river on the left shows some areas with flood plain agriculture because of seasonal flooding of the area. On the left side, some double irrigated lands are found. The middle delta is mainly single and double irrigated land-use with brackish water conditions at some places. The lower delta consists of mainly water managed land-use due to the ever-saline water conditions. The construction of the various polder projects in the lower delta enables water managed irrigation.

There exists a distinct difference in cropping patterns between the Lower, Middle and Upper Delta mainly related to the availability of fresh water during the various seasons. In fact, due to the ever-saline water in the rivers in the Lower Delta only rice paddy during the monsoon season can be grown with locally some possibilities for a second crop (e.g. beans) on residual water in soil and drainage canals. In the Upper Delta, however, two or three crops can be grown, due to the fact that fresh water is available all year round.¹³⁴ In the rainfed area with multi crops per year, summer paddy and pulses are harvested in the beginning of the year followed by June. End of July, beginning of August the monsoon paddy is planted.

Type	Area in ha	%
Cultivable Land	1,818,467	51.91
Forest and Reserved Forest	720,088	20.55
Cultivable Waste Land	149,168	4.26
Virgin Land	23,020	0.66
Other Area	792,447	22.62
Total	3,503,190	100

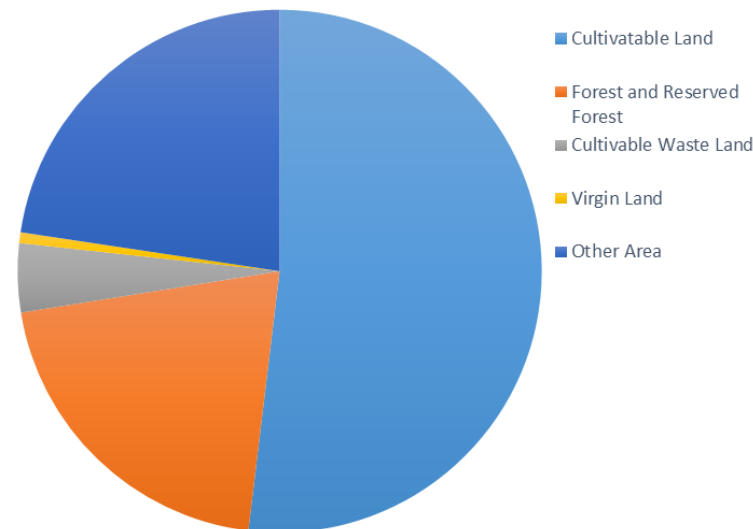


Figure 3-25 Land use in the Ayeyarwady Region 2012 – 2013
(Source: IWUMD)

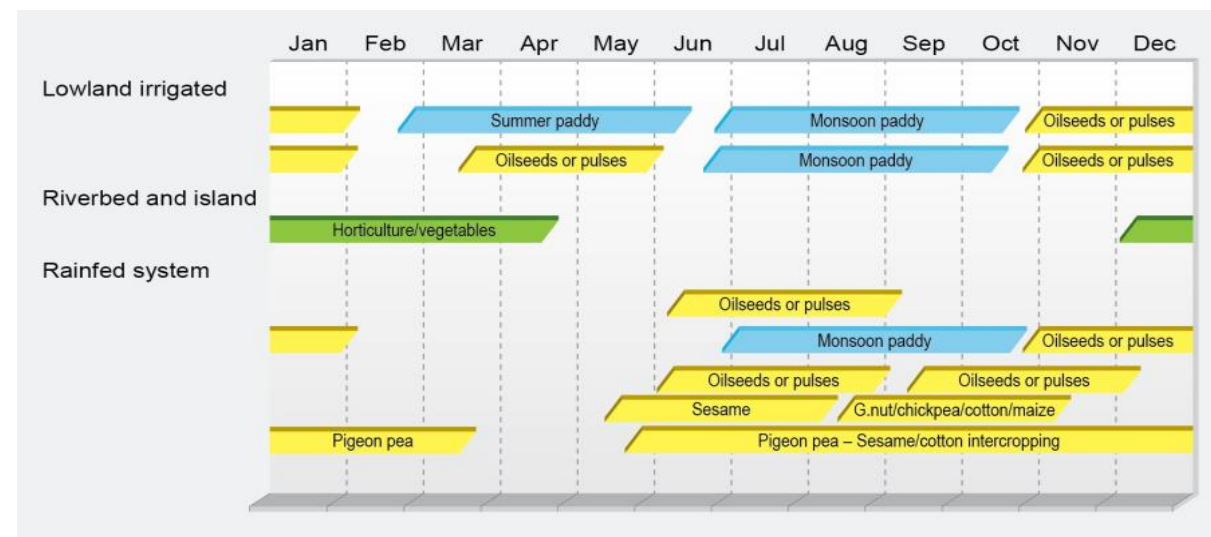


Figure 3-26 Cropping pattern¹³³

¹³⁴ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

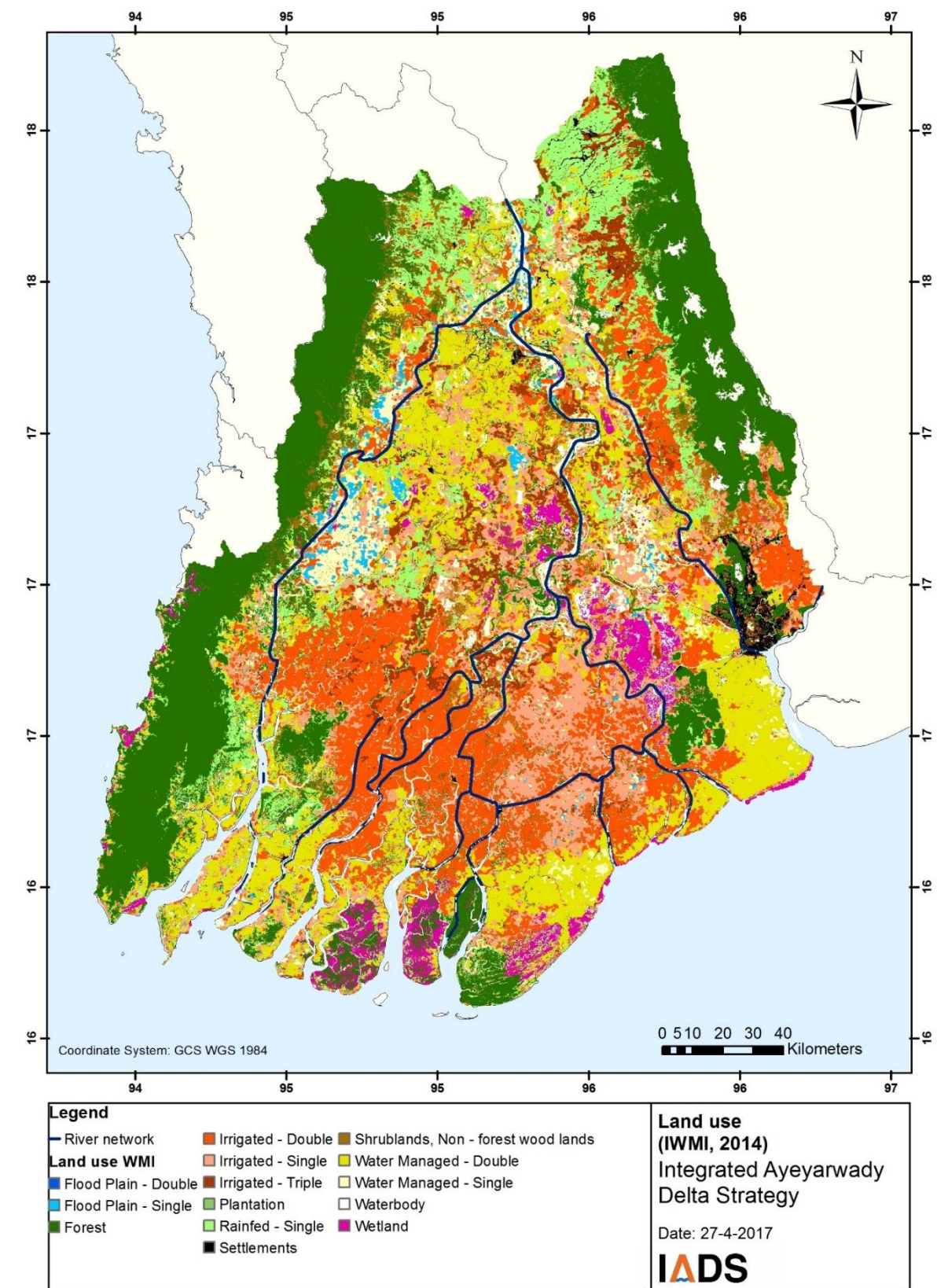


Figure 3-27 Land-use of the Ayeyarwady delta based on IWMI data (2014)

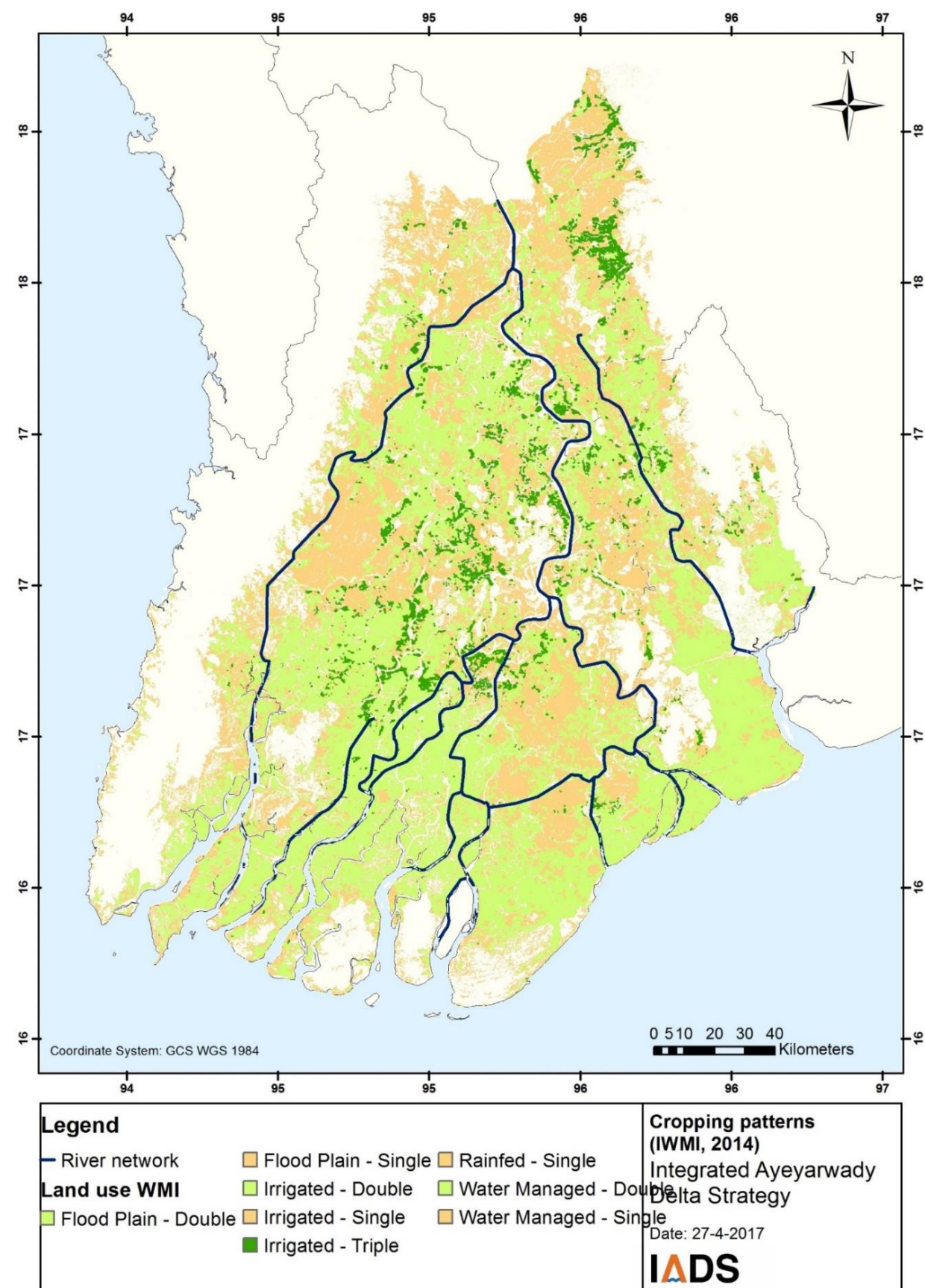


Figure 3-28: Single, double and triple cropping in the delta region based on IWMI (2014) data

3.11 Agriculture

3.11.1 Importance of the agricultural sector

Official statistics indicate that agriculture is the largest economic sector in the country, accounting for nearly 43 percent of GDP and providing the main source of livelihood for nearly 70 percent of the population. Agricultural productivity in Myanmar is low compared with most of Southeast Asia, which partially explains the disparity in relative incomes across the countries. Raising Myanmar’s productivity to the level of its agro-ecologically similar neighbours, and thereby spurring rapid agricultural growth, could significantly raise rural incomes and reduce overall poverty.¹³⁵ Rice export numbers show very clearly that Myanmar is lacking behind with their main competitive countries. This is most probably because of the low agricultural productivity. However, it is expected that paddy yield will increase in the next decades.

Myanmar’s agricultural sector offers substantial unexploited potential to underpin the country’s inclusive economic development. With extensive land, water, and labor resources, as well as proximity to fast-growing markets, the country’s agriculture has key competitive advantages. However, it still lacks behind since farmers are using water buffalo’s and manual labour, using tractors only on a limited scale.

Key actions to address these constraints include improving land tenure, expanding credit availability, investing in input markets for nutrients and machinery, developing drainage and irrigation systems, and enhancing rural transport and electricity connectivity.⁶⁴ However, the statistics of the paddy of the country are somewhat questionable. Myanmar statistics differ from the US statistics. According to US statistics, rice production is only growing sparsely, where Myanmar statistics report a vast increase over the years.

Table 3-3: Future population versus food security in Myanmar and forecast of rice production in Myanmar for 2050¹¹³

Year	Population million	x	Paddy sown million hectares	Paddy expected yield Mt/hectares	Paddy production million Mt	Rice consumption Basket/year	Rice surplus million Mt
2010	59.130		7.973	4.053	32.337	413.910	10.798
2020	74.042		8.172	4.255	43.802	497.039	9.043
2030	86.972		8.372	4.580	37.349	580.169	7.366
2040	101.657		8.571	4.661	39.976	663.298	5.769
2050	118.481		8.770	4.863	42.684	746.427	4.250

Population forecast is based on average of linear and exponential curve fittings of 44 years of population data from 1953 to 1996

Paddy sown acres is expected to increase by 10% in 2050

Paddy yield is expected to increase by 20% in 2050

Rice consumption per capita is assumed to decrease by 10% in 2050

Table 3-4: Evolution of population and labour force size in millions.¹³⁶

	1998	2003	2008	2013
Total population	47.32	49.58	51.17	53.26*
Total labour force	25.21	27.51	29.43	31.67
Labour force in agriculture	17.90	19.10	19.95	20.93
Percentage of total population	38%	39%	39%	39%
Percentage of labour force	71%	69%	68%	66%

* The preliminary result of the census of March 2014 arrives at 51.4 million

¹³⁵ Tun et. al (2015), Promoting Agricultural Growth in Myanmar: a review of policies and an assessment of knowledge gaps, p1

¹³⁶ Myanmar Integrated Water Resources Management: Strategic Report (2014)

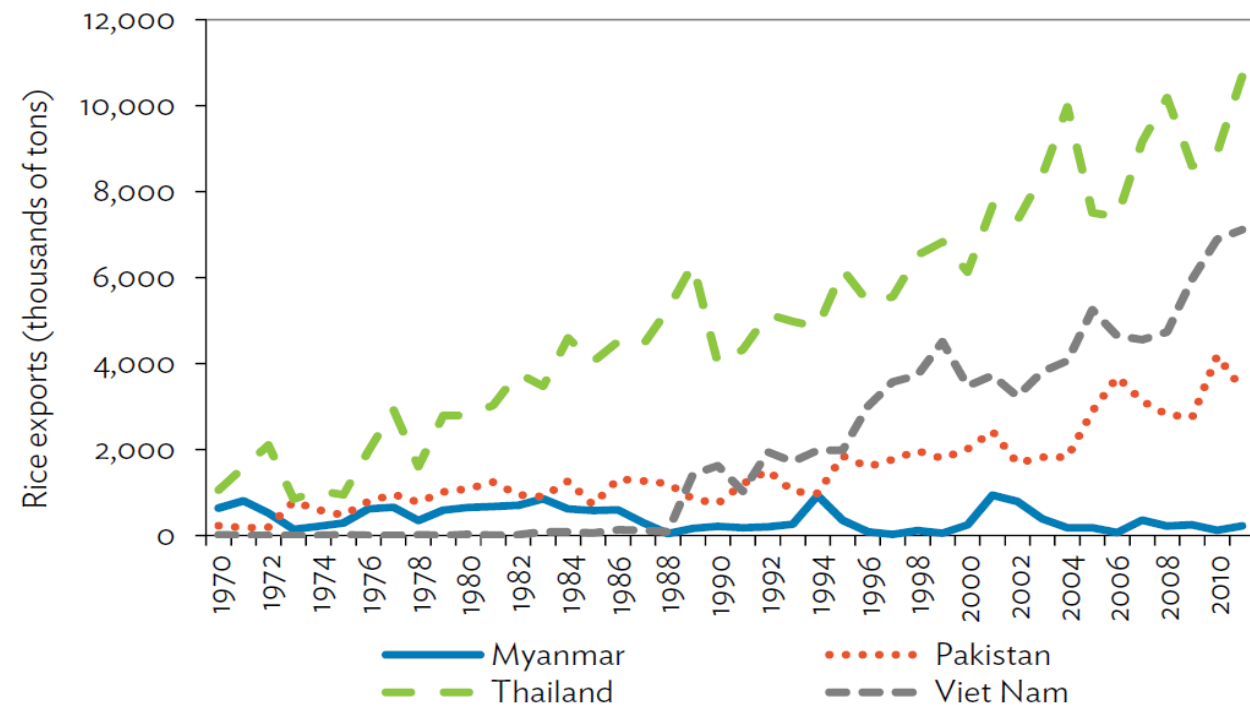
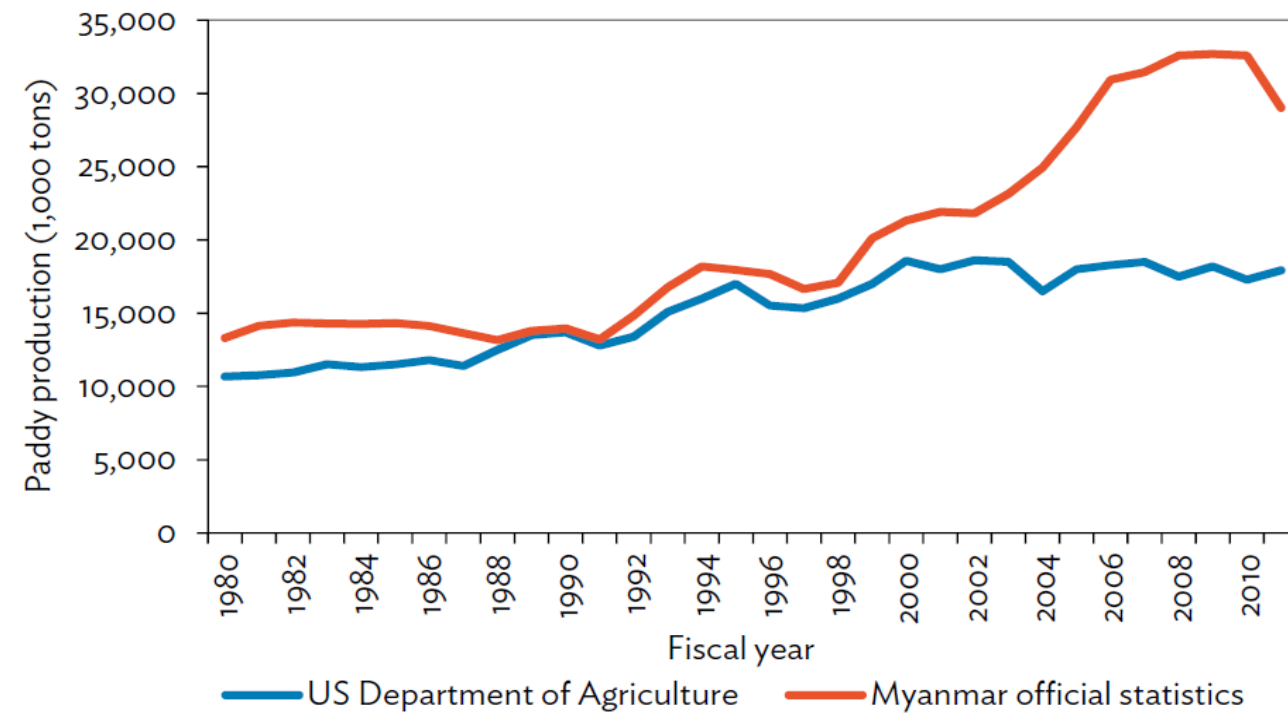


Figure 3-29: Annual rice export by leading exporters between 1970 and 2010 (ADB, 2015)



US = United States.

Sources: US Department of Agriculture, Foreign Agricultural Service. <http://apps.fas.usda.gov/psdonline/psdhome.aspx>; Food and Agriculture Organization of the United Nations, FAOSTAT. <http://faostat.fao.org> (both accessed 20 April 2014).

Figure 3-30: Annual production of rough rice according to the US Department of Agriculture⁶⁴ Original Source¹³⁷

3.11.2 Yields

Despite massive water resources and favourable production conditions in the delta zone, Myanmar has Asia's second-lowest rice yields. Viet Nam and Bangladesh, which have similar productivity potential in their delta regions, have yields that are 114% and 66% higher, respectively.⁶⁴ This is probably because of bad use of fertilizers, lack of knowledge and old production techniques. Yields also differ over the delta, depending on the kind of watering. In the figures below, the yields of rice, maize and pulses are shown for dry and rainy season. Overall, the yields in the upper delta are higher, because they are less dependent on fresh water for irrigation, thus having a more continuous fresh water supply. A direct link between cropping pattern, land-use and yields exist. Figure 3-32 suggests that yields are increasing over the years almost in the same trend as the production of cereals. It is difficult to compare the two yield numbers because one is saying something about the rice yield and the other about the total yield of all cereal products.

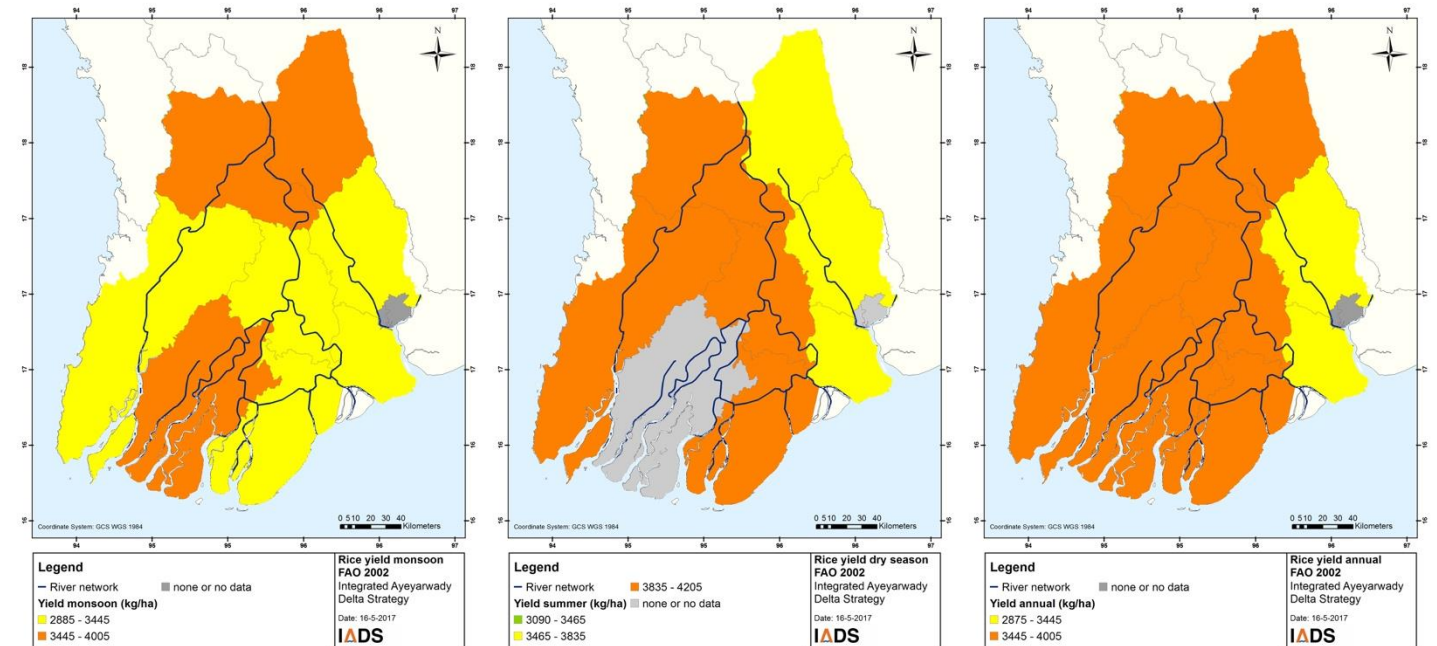


Figure 3-31: Rice yield (kg/ha) in monsoon season, dry season and annual (FAO, 2002)⁶

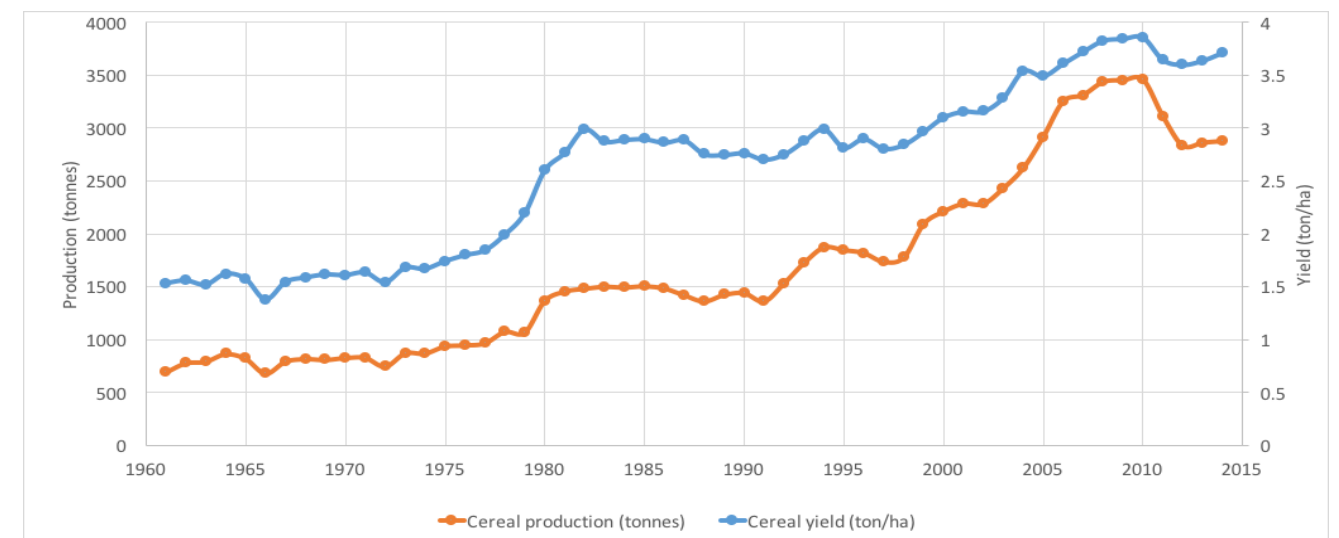


Figure 3-32: Cereal production and yield over the years for Myanmar¹¹⁸

¹³⁷ US Department of Agriculture, Foreign Agricultural Services and Food and Agriculture Organization of the United Nations (FAOSTAT) (2014)

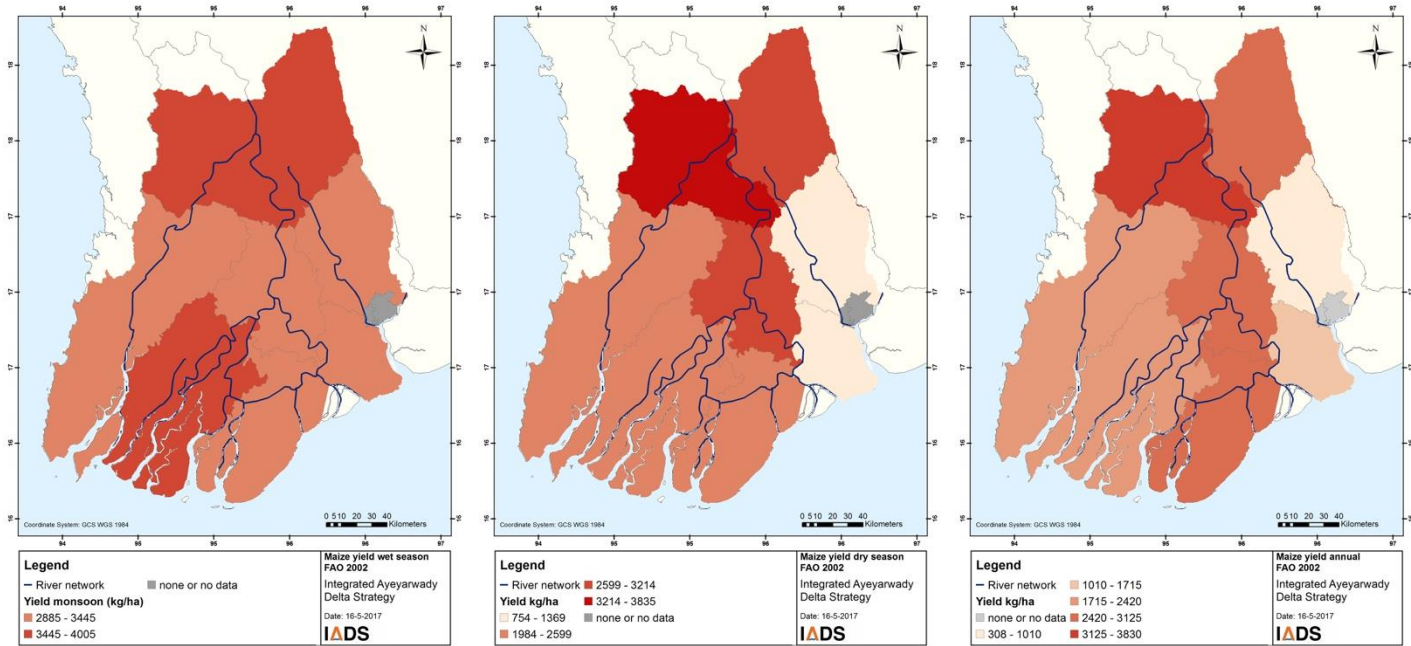


Figure 3-33: Maize yield (kg/ha) in monsoon season, dry season and annual (FAO, 2002) ⁶

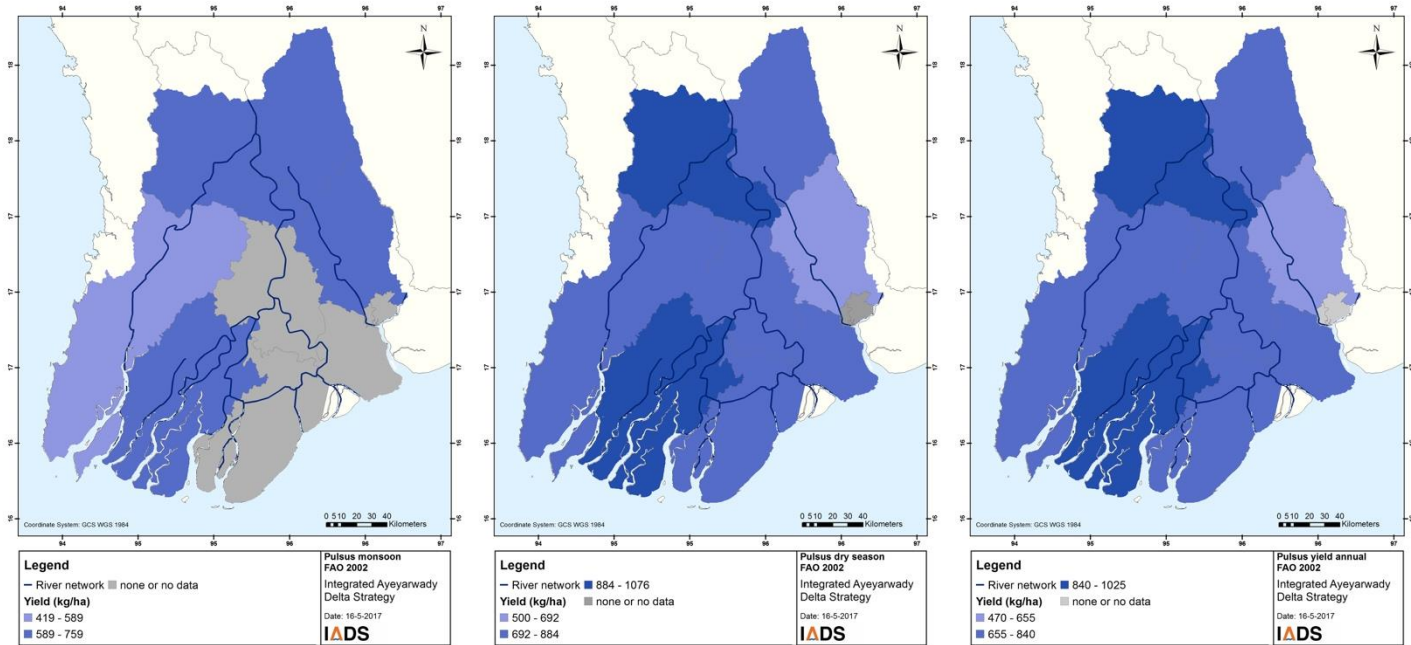


Figure 3-34: Pulses yield (kg/ha) in monsoon season, dry season and annual (FAO, 2002) ⁶

3.11.3 Crop sown acreage

Below the sowed acreages (in ha) of the main crop types in the three regions in the delta are presented. The numbers are expressed in ha based on the Myanmar Statistical Yearbook 2016. From the crop production tables, several trends in agricultural practices can be distinguished. First and most importantly, the paddy production in the three regions kept the same size in ha. Therefore, a higher export of paddy directly implies a higher production per acre. Some crop types did significantly increase in popularity over the years, where other were set aside. Increasing sown acreages are found for coconut and maize in the Ayeyarwady region and pedisin and sugarcane for the Bago region. However, overall it looks like the total amount of sown acreage (in ha) has been reduced over the years.

Table 3-5 Cereals and oilseeds (CSO Myanmar, 2017)

Regions	Year	Cereals (ha)			Oilseeds (ha)			
		Paddy	Wheat	Maize	Ground nut (Rain)	Ground nut (Winter)	Sesa-mum (Early)	Sesa-mum (Late)
Bago Region	2010-2011	1387496	-	770	20318	56495	52776	22988
	2011-2012	1234024	-	827	21655	52905	53092	18342
	2012-2013	1222745	-	2322	23976	54437	47834	19651
	2013-2014	1223182	-	4417	24111	55244	49123	19746
	2014-2015	1222605	-	2779	24747	55207	49147	19981
	2015-2016	1204001	-	3460	24718	54658	50309	20519
Yangon Region	2010-2011	562877	-	40	25	4286	-	1959
	2011-2012	558854	-	50	26	3298	-	1795
	2012-2013	559561	-	53	27	3215	-	1721
	2013-2014	560213	-	63	31	3299	-	1746
	2014-2015	560392	-	66	32	3160	-	1764
	2015-2016	559274	-	70	32	3008	-	1766
Ayeyarwady Region	2010-2011	2019145	839	5821	7691	45548	1564	10239
	2011-2012	1930376	530	6269	7543	38923	1602	9259
	2012-2013	1954344	478	8668	7687	36566	1450	8171
	2013-2014	1979952	478	9109	7678	37692	1433	8088
	2014-2015	2011979	457	9949	7795	38016	1426	8107
	2015-2016	2030840	-	9863	7781	37279	1985	7859

Table 3-6 Pulses (CSO Myanmar, 2017)

States and Regions	Year	Pulses (ha)							
		Matpe (Black-gram)	Pedisein (Green-gram)	Bocatepe (Cow Pea)	Sultani	Sultapya	Peyin (Rice bean)	Pebyugale (Duffin bean)	Pegyi (Labiab bean)
Bago Region	2010-2011	435861	162113	22367	2187	-	-	3910	11968
	2011-2012	482763	170686	21342	1978	-	-	4547	7668
	2012-2013	492905	205662	21794	2732	-	-	4830	8459
	2013-2014	486423	211282	21550	2743	-	-	5298	8050
	2014-2015	473505	228408	21462	2751	-	-	5103	7413
	2015-2016	501344	230113	21866	2747	-	-	5491	8084
Yangon Region	2010-2011	19653	145266	878	-	-	-	1320	-
	2011-2012	20183	146909	686	-	-	-	1116	-
	2012-2013	20196	146671	750	-	-	-	1067	-
	2013-2014	19944	146135	540	-	-	-	1044	-
	2014-2015	19990	149541	666	-	-	-	1155	-
	2015-2016	20202	151133	659	-	-	-	1197	-
Ayeyarwady Region	2010-2011	458647	116943	89044	2341	-	856	-	5600
	2011-2012	454523	89758	76764	2023	-	-	-	4905
	2012-2013	448955	68126	64602	1899	-	-	-	4648
	2013-2014	452825	72341	65606	1872	-	-	-	4616
	2014-2015	458161	78628	65895	1869	-	-	-	4652
	2015-2016	463458	75370	67971	1840	-	-	-	4531

Table 3-7 Beverage, fruit and vegetables (CSO Myanmar, 2017)

Regions	Year	Beverage (ha)				Vegetables and Fruits (ha)			
		Tea	Coffee	Sugarcane	Toddy Palm	Potato	Plantain	Vegetables	Fruits
Bago Region	2010-2011	-	549	18714	352	250	5559	57011	78344
	2011-2012	-	549	18533	352	257	5562	57208	78839
	2012-2013	-	549	19455	352	257	5907	57274	79074
	2013-2014	-	549	24448	333	250	5908	58570	80057
	2014-2015	-	255	27954	333	257	5914	58142	80657
	2015-2016	-	255	22063	351	257	5998	56524	81339
Yangon Region	2010-2011	-	-	2117	36	-	2834	24203	31699
	2011-2012	-	-	2088	37	-	2819	23489	31699
	2012-2013	-	-	2279	36	-	2818	23294	31699
	2013-2014	-	-	2483	36	-	2824	22214	31692
	2014-2015	-	-	2429	133	-	2834	23770	31692
	2015-2016	-	-	2498	133	-	2834	24339	30220
Ayeyarwady Region	2010-2011	-	30	156	564	10	23028	73955	87851
	2011-2012	-	30	117	1040	10	23265	71917	87891
	2012-2013	-	30	93	1186	10	23266	71216	87894
	2013-2014	-	30	58	1134	10	23665	72359	88193
	2014-2015	-	30	79	1198	10	24759	74764	88643
	2015-2016	-	17	79	1134	10	24818	76168	88824

Table 3-8 Spices and tobacco (CSO Myanmar, 2017)

Regions	Year	Spices and condiments (ha)			Tobacco and Betel (ha)			
		Chillies	Onion	Garlic	Tobacco (Virginia)	Tobacco (Myanmar)	Betel nut	Betel leaves
Bago Region	2010-2011	2581	1063	29	43	926	1037	395
	2011-2012	2044	829	13	41	848	1037	827
	2012-2013	2241	850	13	42	772	1037	935
	2013-2014	2249	871	13	42	906	1037	979
	2014-2015	2210	856	13	27	856	1037	985
	2015-2016	2140	850	13	27	852	1037	988
Yangon Region	2010-2011	523	2	-	-	2	244	1079
	2011-2012	523	2	-	-	-	244	1028
	2012-2013	581	1	-	-	-	244	1085
	2013-2014	80	-	-	-	-	244	1085
	2014-2015	398	-	-	-	-	244	1009
	2015-2016	395	-	-	-	-	244	990
Ayeyarwady Region	2010-2011	34725	1051	-	-	352	8740	3675
	2011-2012	29785	761	-	-	387	8749	3916
	2012-2013	28320	743	-	-	311	8749	3986
	2013-2014	28542	748	-	-	350	8831	4033
	2014-2015	26938	731	-	-	381	8832	4243
	2015-2016	26948	709	-	-	370	8832	4198

Table 3-9 Fibre and miscellaneous (CSO Myanmar, 2017)

Regions	Year	Fibre (ha)			Miscellaneous (ha)		
		Cotton (Wagyi)	Cotton (Long Staple)	Jute	Rubber	Coconut	Plants (Medicinal)
Bago Region	2010-2011	6954.1	4454.1	402.4	38134.8	2764.2	42.4
	2011-2012	5915.8	1308.6	1085.5	40852.9	2764.2	42.4
	2012-2013	6299.2	785.8	145.8	43513.6	2764.2	42.4
	2013-2014	6377.5	810.8	8.1	44843.6	2764.2	42.4
	2014-2015	6358.6	803.6	6.5	46512.1	2764.2	42.4
	2015-2016	6426.0	695.3	6.1	47144.0	2764.2	42.4
Yangon Region	2010-2011	-	-	12.9	15373.0	3754.8	1137.7
	2011-2012	-	-	26.3	15840.0	3754.8	1211.6
	2012-2013	-	-	1.2	16278.4	3747.9	1203.5
	2013-2014	-	-	2.4	16494.9	3747.9	1203.5
	2014-2015	-	-	2.0	17062.1	3748.3	1203.5
	2015-2016	-	-	2.8	17539.7	3748.3	780.5
Ayeyarwady Region	2010-2011	-	231.1	2997.3	8172.1	24873.5	21.8
	2011-2012	-	126.0	2026.9	8841.1	24843.2	22.2
	2012-2013	-	4.4	297.7	10098.8	24879.5	22.2
	2013-2014	-	-	6.9	10922.9	24998.7	23.0
	2014-2015	-	-	14.9	13562.3	24998.7	23.0
	2015-2016	-	-	44.0	14250.7	25005.2	28.7

3.11.4 Crop export

As shown in Figure 3-29, there are no distinct pattern of increase of crop exports over the years, compared to their neighbouring rice-competing countries. Also export values of rice and other agricultural products like sesame and maize have decreased over time. The country simply did not succeed in using their export potential to get a place in the international market for agricultural products.

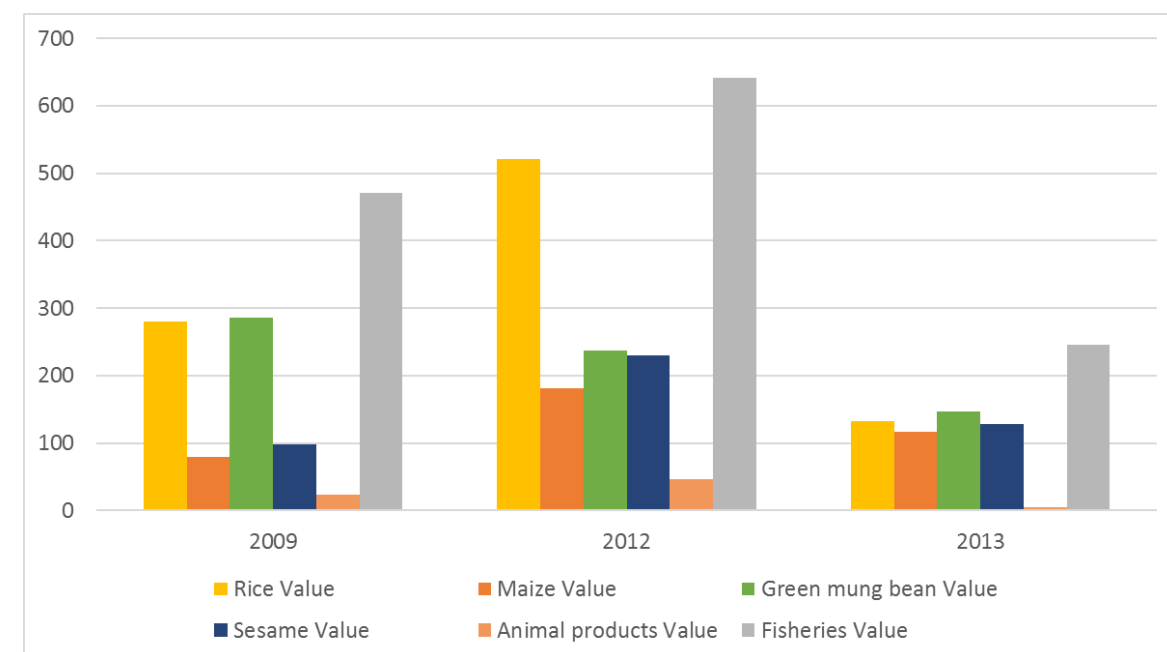
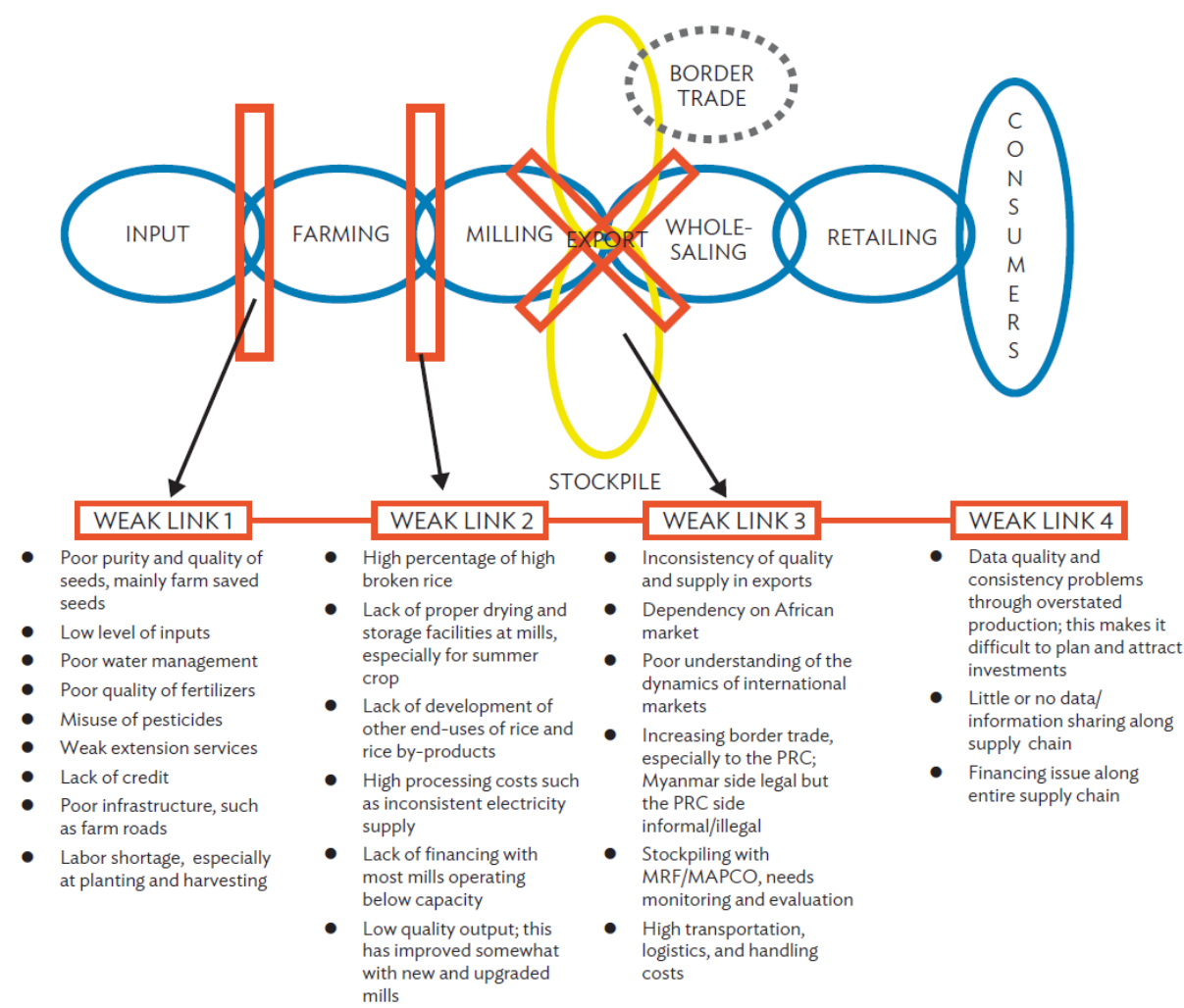


Figure 3-35: Export values in 2009, 2012 and 2013. Compiled from the Central Statistical Organization and the Department of Commerce and Consumer Affairs records⁶⁴

3.11.5 Supply chain

Figure 3-36 shows a generalized rice supply chain for Myanmar. It indicates that certified rice seeds are still largely produced by the Department of Agriculture under the Ministry of Agriculture and Irrigation, although some private

contract farming companies are also beginning to produce certified or high-quality seeds of the varieties that they are promoting, largely for their contract farmers. The supply of fertilizers and agrochemicals has proved to be a problem, with the sale of poor quality fertilizers and inappropriate pesticides, including banned insecticides.⁶⁴ This value chain can explain for a large part the low production and the problems of creating an export-orientated sector. The weak links in production of the crops were already mentioned. But also after production, shortcomings hamper the development of Myanmar's agricultural potential. For instance, a lot of broken rice, and a lack of proper drying and storage facilities. Export is mainly hampered by lack of understanding of the international markets, high transportation and storage costs and inconsistency in supply and export. This all is enhanced by the fact that only about 100 people with post-graduate education are active in the agricultural sector.



MAPCO = Myanmar Agribusiness Public Corporation Limited, MRF = Myanmar Rice Federation, PRC = People's Republic of China.
Source: Wong and Wai 2013.

Figure 3-36: Prioritizing and sequencing interventions in Myanmar rice supply chain⁶⁴ Original Source ¹³⁸

3.11.6 Use of chemicals

Myanmar's agriculture has traditionally involved little use of pesticides. Aggregate fertilizer statistics from international sources indicate that Myanmar farmers apply an average of only 6.5 kg/ ha of inorganic fertilizers compared to rates above 100kg/ha for most other countries in the region and that fertilizer usage in Myanmar may be decreasing. However, concerns about the reliability of the data quality is extensively expressed. The limited survey data available indicates that fertilizer usage may be more widespread than the aggregate statistics suggest.

More recently, the data about the use of pesticides show rapid changes, with massive imports from the PRC and large increases in application rates. Official statistics reflect a 1,000% increase in quantities applied between 2005 and 2010 (CSO 2012). Current pesticide application levels are beginning to approach those of other countries in the region, even though fertilizer levels trail them substantially. At the same time, imported pesticides are poorly documented, barely regulated, and not well understood by the farming population.⁶⁴

Myanmar is making the transition from a state controlled agriculture sector to a free(r) market in which fertilizer prices are less controlled and state production and subsidized distribution of fertilizer has been drastically reduced. Looking at real urea price data starting from 1980, when government programs initiated subsidized fertilizer and high-yield variety distribution, the variability in prices during the transition period from 1988 through 2002 can be seen and the subsequent jump in prices in 2002 when subsidies were fully phased out.¹⁴⁰

Figure 3-39 only shows the amount of legally imported pesticides in Myanmar, whereas the illegally imported pesticides are unknown. Despite the national coverage of the data, it can be expected that similar trends apply for the delta since it is the country's agricultural backbone. Pesticide use has increase from 2.874 tons in 2002-03 to 11.101 in tons in 2011-12. Banned, unregistered or counterfeit products are often widely available on the pesticide market and widespread overuse, misuse, and mishandling of pesticides are all too common. This amount was estimated to be around 4000-6000 metric tons per year in 2006 – 2009. As seen in the figure, still the most popular pesticides are insecticides, although getting less and less popular. Upcoming types are herbicides and PGR.¹³⁹

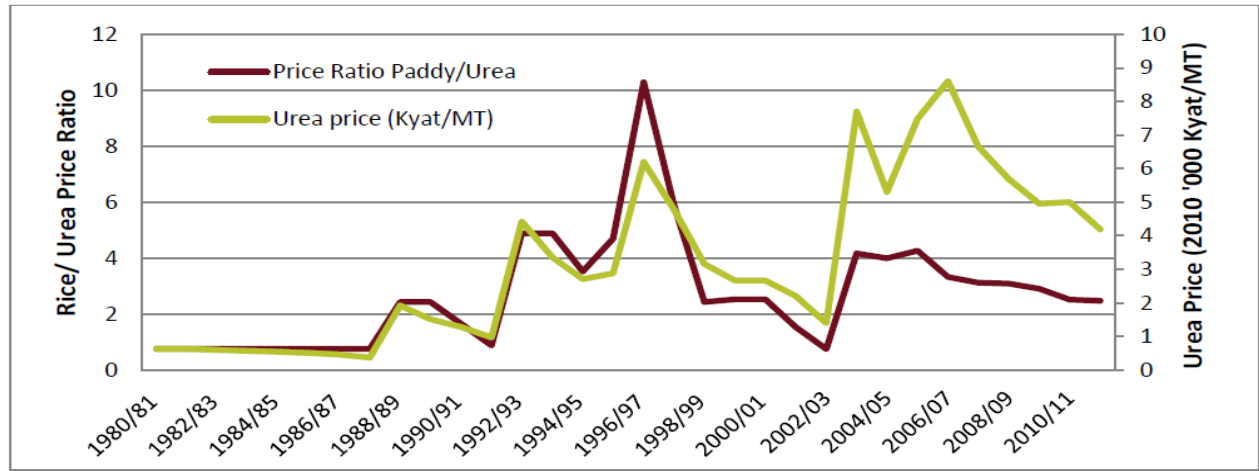


Figure 3-37: Urea prices 1980/81 – 2010/11 (CSO data)¹⁴⁰

¹³⁸ Wong, L.C.Y. & Wai, E.M.A. (2013), Rapud Value Chain Assessment: Structure and Dynamics of the Rice Value Chain in Myanmar, Michigan State University and Myanmar Development Resource Institute

¹³⁹ Peeters, F. and van Meggelen, J. and Schepers, H. (2015), Crop production and pesticide risk assessment in Myanmar, Wageningen University

¹⁴⁰ IFPRI (2015), Promoting Agricultural Growth in Myanmar (2015)

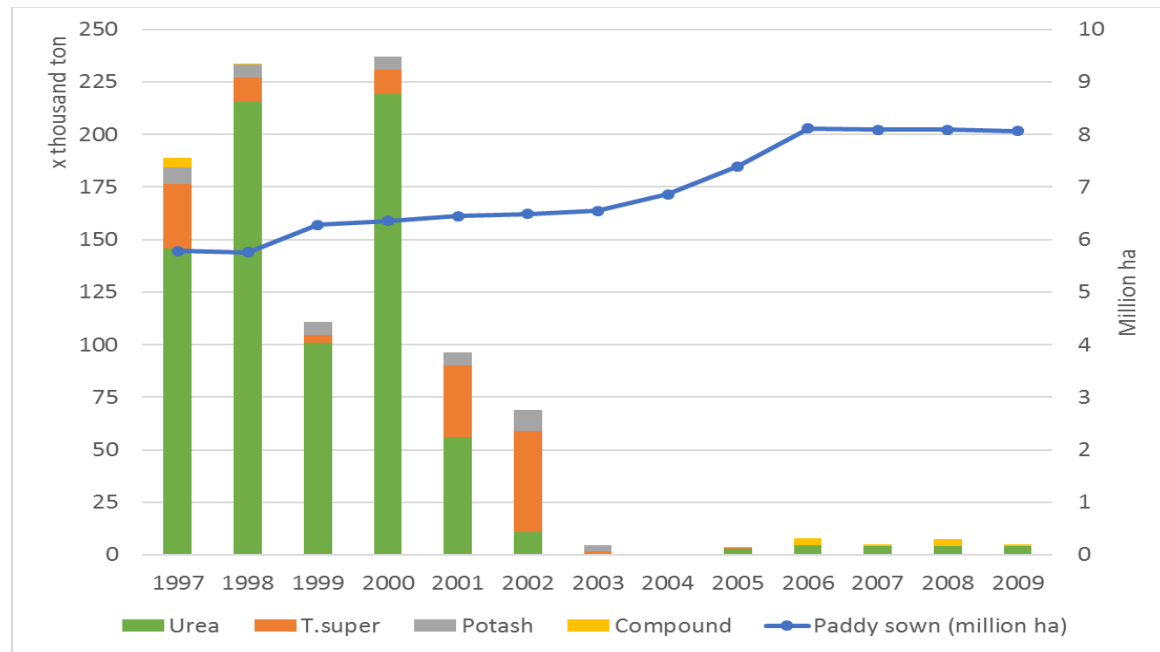


Figure 3-38: Domestic supply of fertilizers and total paddy area sown (JICA 2013)

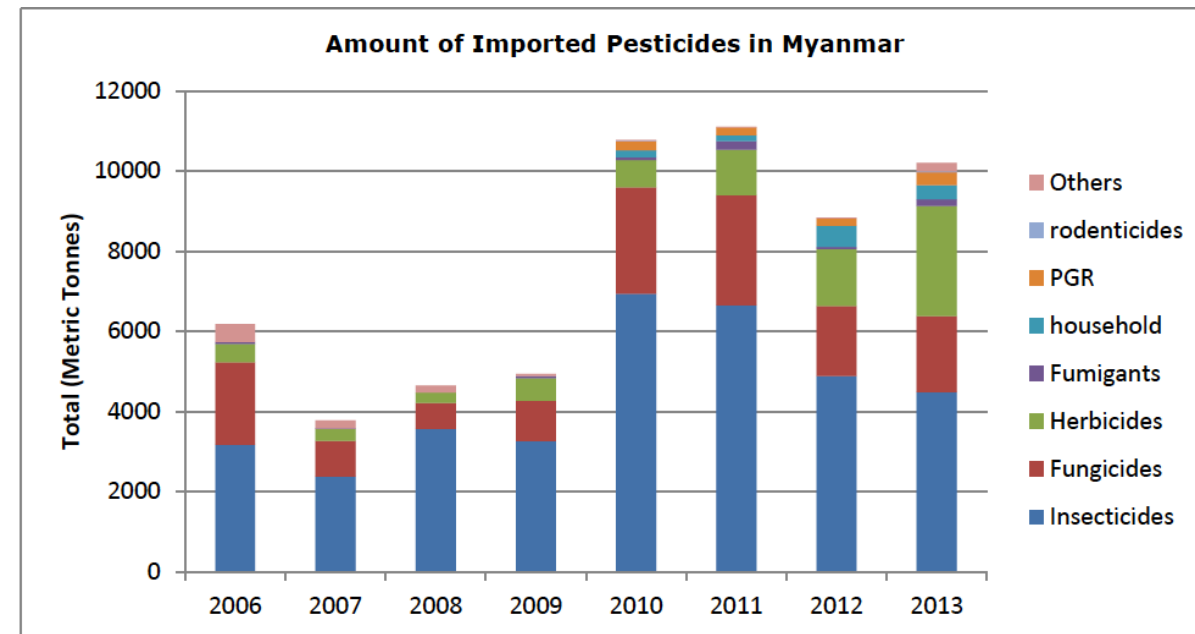


Figure 3-39 Amount of imported pesticides in Myanmar¹³⁹

3.12 Fisheries and aquaculture

Next to agriculture, the fishery sector is the second most important sector for the country. Fish is important for food security since it is one of the main protein intakes in Myanmar's diet. It also provides opportunity for employment. The delta regions house a large variety of freshwater and marine fish species. Moreover, shellfish like prawn are widespread over the delta area.

3.12.1 Fish production and consumption

Rice and fish are among the key staples in Myanmar. Although the figures are rather old, 2001 data indicated that on average 12.3% of household spending on food products was spent on fish. Fish consumption is higher than in Europe. Based on the Department of Fisheries estimations for national fish production (almost 4.5 million tons) and subtracting exports (400,000 tons) suggest a per capita consumption of 51 kg/capita/yr.

Also preserved fish has a good local market. Preserved fish (dried, salted, etc.) plays an evident role in the local diet. However, the small quantities consumed make the consumption of preserved fish products an often-hidden contribution to the overall fish consumption.¹³⁴ From the figure, the trend of increased fishery and aquaculture over the years can be observed. Marine fisheries are among the highest contributor to the overall production as well as open fisheries and aquaculture (as will be discussed later). The fish supply in Yangon, the main fish market in the country, also shows a slow increase in marine and fresh fish supply.

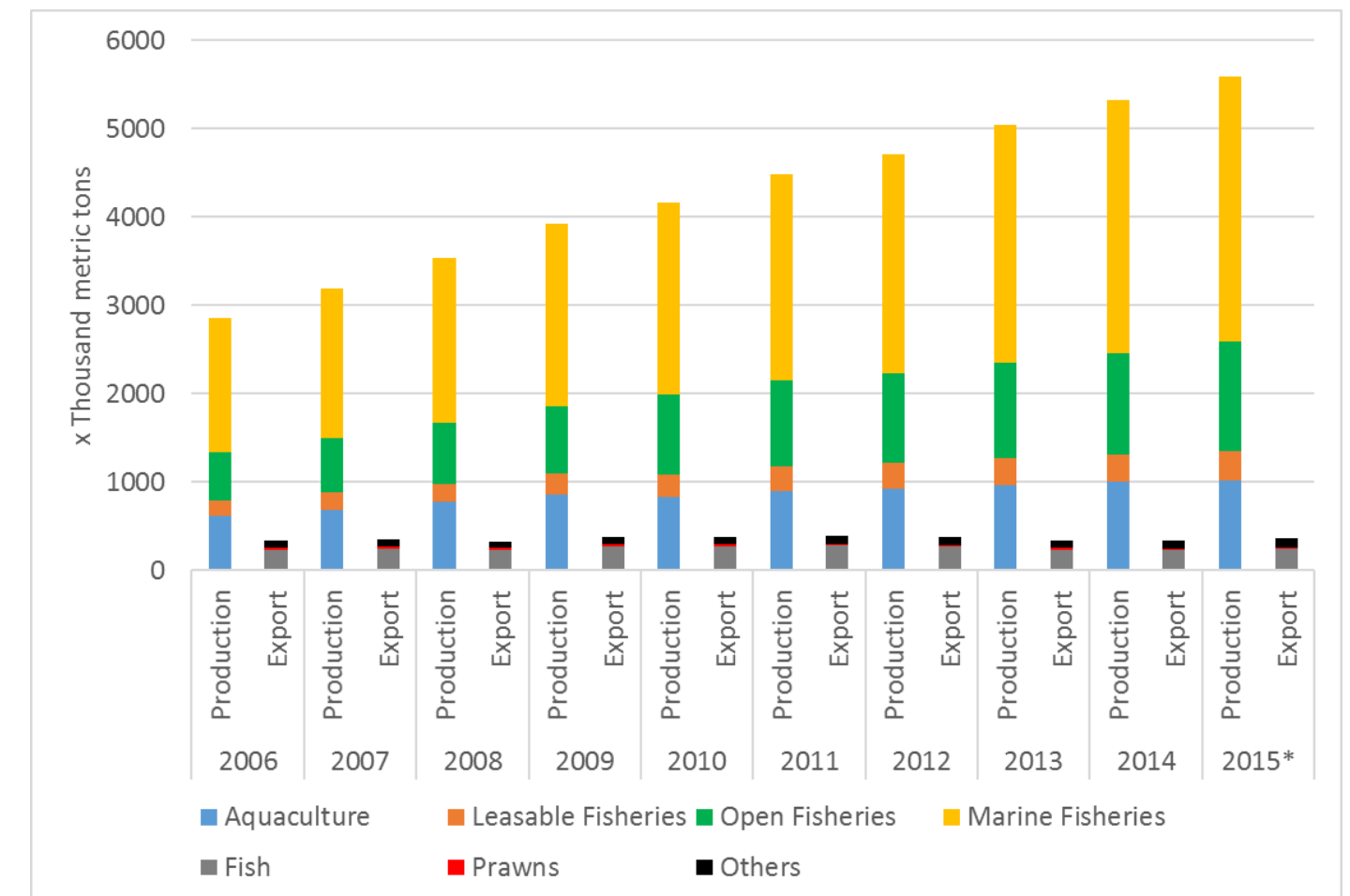


Figure 3-40: Fishery production and export (DOF, 2016) ¹⁴¹

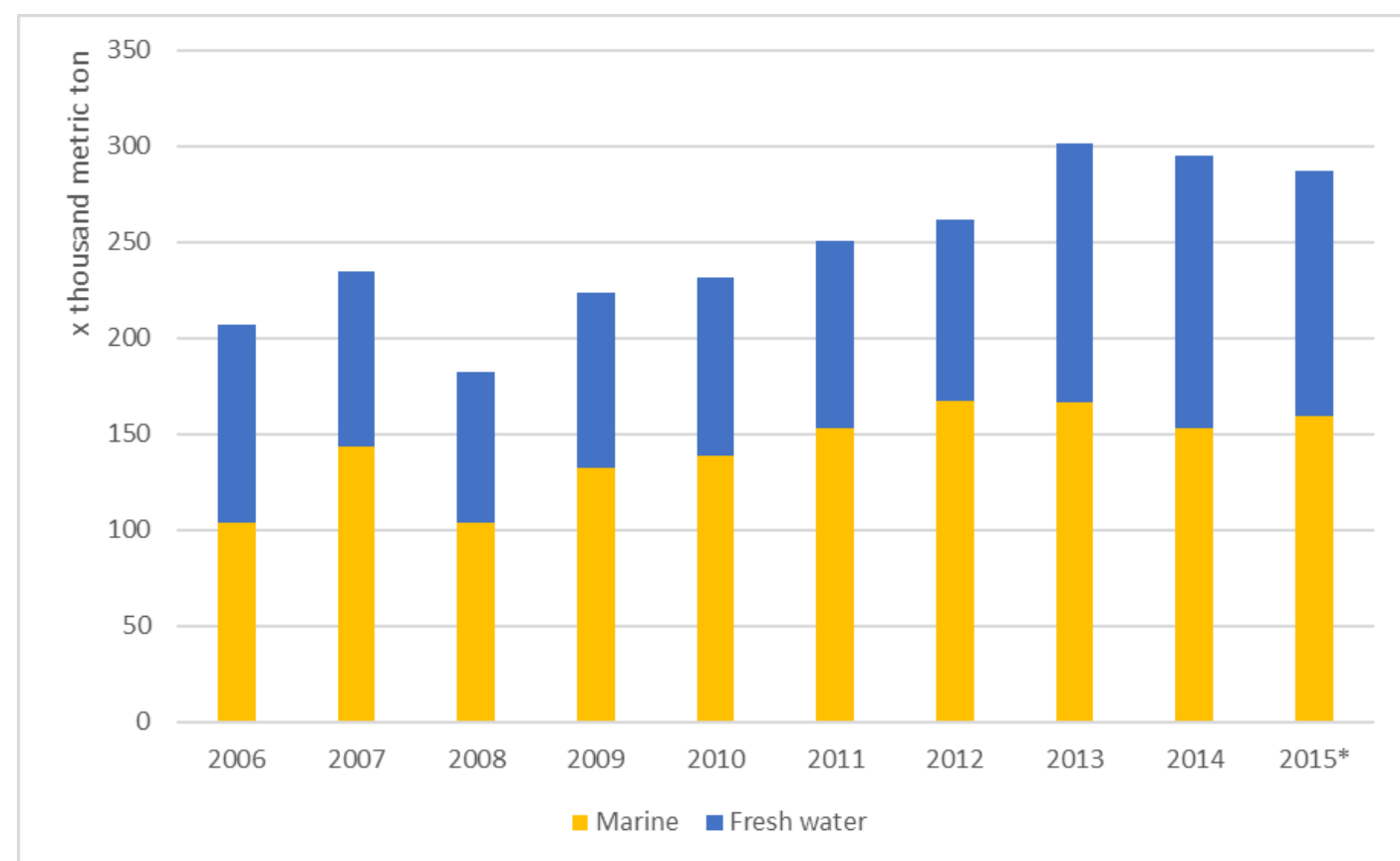


Figure 3-41: Fish supply in Yangon (2006-2007 to 2015-2016)¹⁴¹

Table 3-10: Fish supply Yangon in 2015 (provisionary)¹⁴¹

	Amount	Unit
Population	52.45	(Million)
Production	5591.835	(Thousand Metric Ton)
Non-food use	1677.55	(Thousand Metric Ton)
Export	368.971	(Thousand Metric Ton)
Per capita fish supply	68	(Kg)

3.12.2 Fisheries

A few different types of fisheries can be distinguished based on the nature of the catch. The two main types are fresh fisheries and marine fisheries. The first one consists of aquaculture, leasable and open fisheries. Leasable fisheries are floodplain fishing grounds which are leased to individuals (or groups) for fishery activities. Open fisheries are fisheries in all other areas including all types of fishing operation. The right to fish in these areas is licensed out by the Department of Fisheries (DoF) under the Ministry of Agriculture, Livestock and Irrigation (MOALI). All fishing gears require a license.

Hydrological factors (i.e. flood level, duration and timing) play an important role in the sustainability of inland capture fisheries in the Ayeyarwady Delta.¹⁴² This particularly affects fisheries that depend on migratory species like Hilsa. Hilsa fishery is a very old livelihood for Myanmar local people. Hilsa occurs in inland, marine, and coastal waters

The latter one can be further classified as inshore fisheries and off-shore fisheries. In the onshore fisheries, the fishing boats operate from the shoreline to a few miles from the shoreline. Traditional fishing boats are used accommodated with drift nets. In the offshore fisheries, the bigger offshore vessels operate from the shoreline to the end of the fishing zones as shown in Figure 3-44.

Table 3-11: Inland and marine fisheries production (in thousand metric ton)

Year	Inland	Marine	Aquaculture	Total
2001 - 2002	131	298	87	516
2002 - 2003	145	306	132	583
2003 - 2004	195	308	158	660
2004 - 2005	220	330	219	769
2005 - 2006	121	267	276	664
2006 - 2007	320	395	302	1017
2007 - 2008	368	441	348	1157
2008 - 2009	406	532	404	1342
2009 - 2010	306	316	202	824

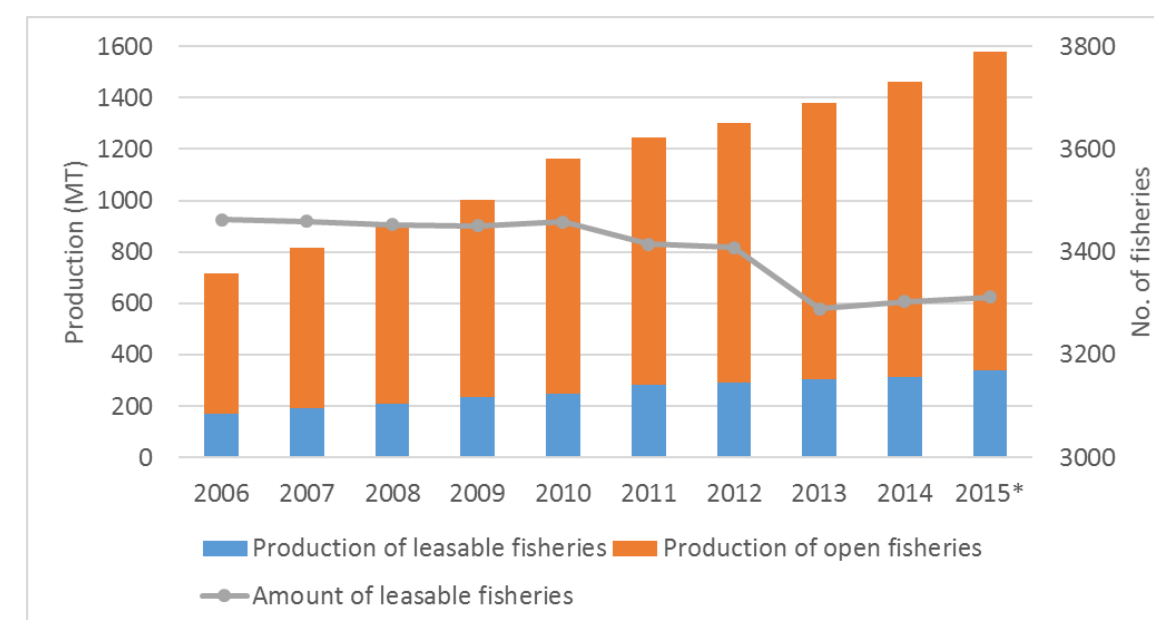


Figure 3-42: Production (million ton) of leasable and open fisheries¹⁴¹

¹⁴¹ Department of Fisheries (2016), Fishery Statistics 2016, Ministry of Agriculture, Livestock and Irrigation

¹⁴² Baran, E. and Myschowoda, C. (2009) Dams and fisheries in the Mekong Basin, Aquatic Ecosystem Health & Management, 12(3), 227-234

3.12.3 Ecological zones

The dynamic natural environment of the delta sustains many different habitats and ecosystems depending on the amount of fresh water. Three main ecological zones can be distinguished in the delta depending on the distance to the sea and the corresponding salinity level.¹⁴³

The first zone, the floodplain zone, is the most upstream zone in the delta and is characterised by mainly freshwater or a very low salinity maximum. In these zones, there is a large presence of freshwater fish species. This area consists of a complex of small rivers and creeks in between rice fields. In the rice fields, a small amount of crabs and shrimps are collected during the wet season. Some ponds are designed for the farming of carp and freshwater shrimp. Villages for trade are often connected well with each other and local markets by road and water transport.

Further downstream, an estuarine zone is situated, characterised by temporary brackish water, wide river reaches and further diverted into smaller creeks and canals. Some important commercial fish species are caught here; hilsa, nivea, pangasius, macro-brachium, penaid shrimp and mud crabs. Villages and markets have a good connection, although mainly by boat.

Reaching the coastal front, permanent brackish water is present and fishing activities are focused on the coastal and marine zones. Near the coastal front, the same commercial species are caught as in the estuarine zone. However, villages are often scattered and isolated. Commercial transport of the caught goods is to Yangon by boat. Large shrimp farms exist in the zone.

Some observation over time in the ecological zones are relevant.¹⁴⁴ In the upper floodplain area, there is an increasing loss of connectivity between the floodplains due to the extension of rice farming. Moreover, a reduction in biodiversity of catches is observed, although the fish species composition looks richer in this zone. The estuarine zone is more influenced by coastal and marine fisheries than by local fisheries. At last, the fishers of the coastal zone are among the poorest in the country and suffer from harsh natural conditions along the coast.

Not included in the ecological zones, but a high potential area of commercially interested species can be found in the in the small-scale inshore and offshore marine fisheries zones. Before 2014, the offshore fishing grounds were allocated to foreign vessels that have been granted a license. However, in 2014 this situation changed and fishing rights are not given to foreign vessels anymore. Where catches of marine fishes were first distribution to neighboring countries, the new situation will give a boost to the volume of marine fish in national market.



Figure 3-43: Ecological zones (MyFish, 2012)¹⁴⁵

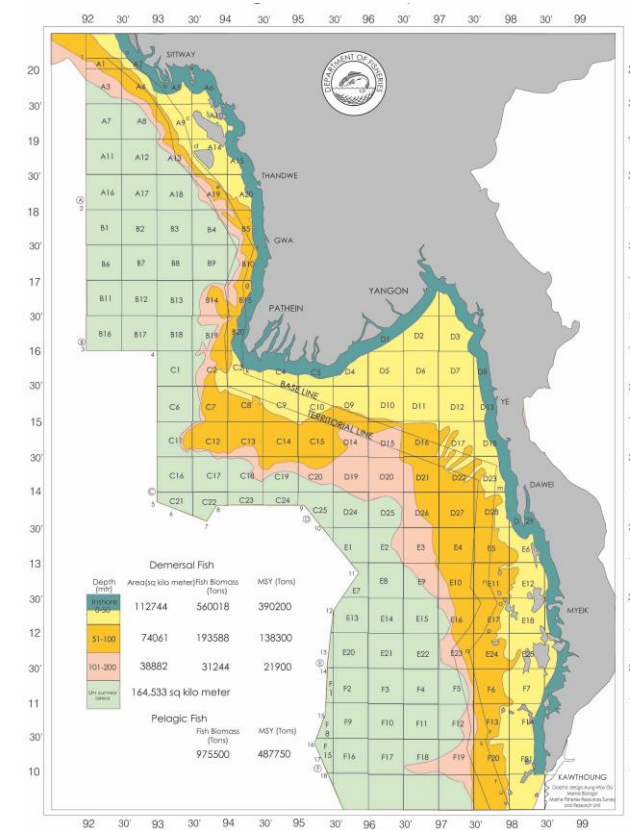


Figure 3-44 Fishing ground of Myanmar in the Andaman Sea (DOF, 2016)¹⁴¹

¹⁴³ Gregory & Saw La Paw Wah (2009), Participatory Rural Assessment of Delta Livelihoods and the Value of Fishing Assets

¹⁴⁴ MyFish (2012), Improving Research and Development of Myanmar's Inland and Coastal Fishery

¹⁴⁵ Delta Alliance (2015), Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar— Full assessment report, GWP/BOBLME

3.12.4 Fishing gear

The fishing near used in the delta is mainly a drift net. However, these numbers can deviate from the real numbers since a lot of fishers do not license their gear. The traditional boats are still very much used together with small powered boats. Offshore vessels are becoming increasingly popular to explore the offshore marine fishery grounds.

Table 3-12: Fishing gear in Ayeyarwady region between 2006 and 2015¹⁴⁶

Year	Trawl	Drift net	Long line	trap	total
2006		526			526
2007		464			464
2008		373			373
2009		544			544
2010		567			567
2011		503	2	3	508
2012	1	499	2	1	503
2013		411	1	1	413
2014		494		1	495
2015		498			498

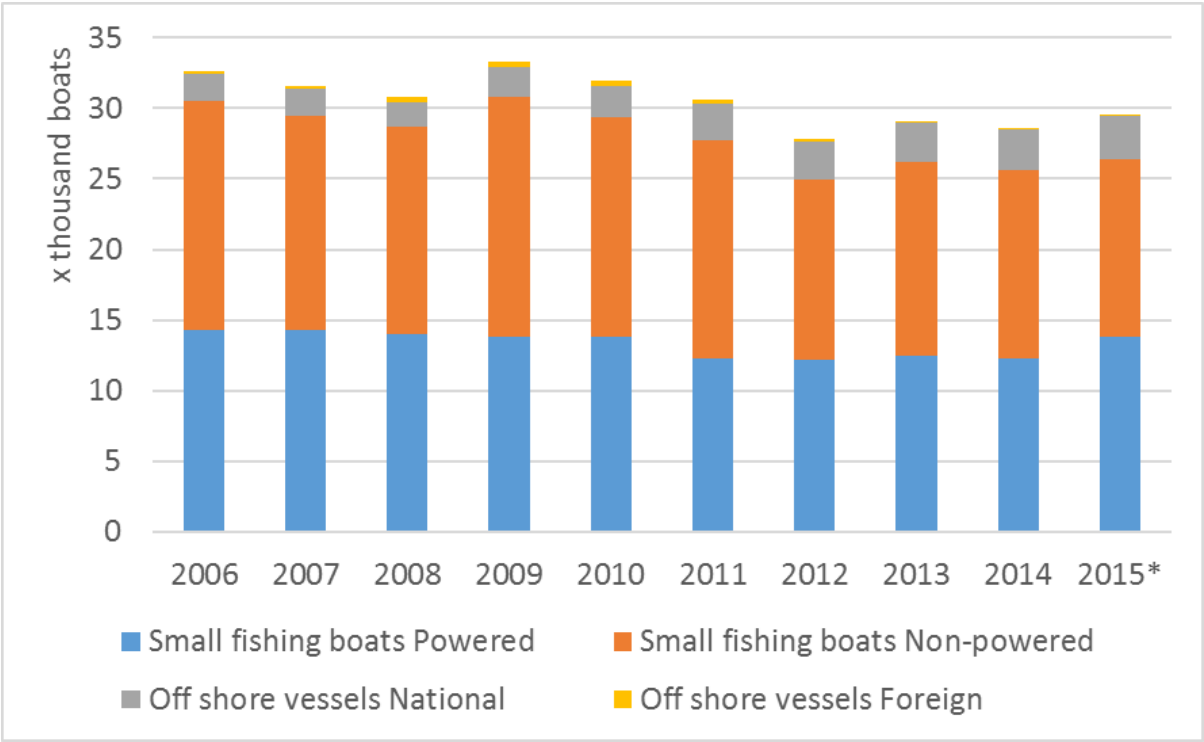


Figure 3-45: Number of fishing boats (DOF, 2016)¹⁴¹

3.12.5 Aquaculture

Fish farming is important for food security in Myanmar and developing at a high pace. In the Ayeyarwady Delta, 90% of the national aquaculture takes place. Only 20% of the aquaculture output is exported, whereas 80% is used for

domestic market. It is expected that export share will even decline with the expected growth of the urban market. Over the last decade, the fish farming output increased with about 250%, mainly because of the increase in pond area and yields. Very large farms account for well over half of total pond area. Furthermore, an estimated 210,000 backyard fish ponds are spread throughout the southern Ayeyarwady and Yangon.¹⁴⁹ Although the market is growing rapidly, there is little diversity in the species produced. Rohu fish is the most produced fish (Figure 3-47). Exotic species like pangasius catfish and tilapia are produced, although these fish types are major contributors for export in neighboring countries. It can therefore be expected that these exotic fish and other high value fish will become more important over time. Currently Pacific white shrimp and Giant freshwater prawn are two main species that are cultured in the Ayeyarwady and Yangon Regions. Giant freshwater prawn is mainly produced in polyculture systems with carp and other freshwater fish species. It is mainly exported to Japan, but there is also an increasing local demand for what is considered a luxury product.¹⁴⁷ Most of the fish is being produced in the west of Yangon in a 50 km radius (Figure 3-48). Yangon is the major trade city and connections to the city via water or road are good. Spreading of the fish ponds is for a large extent to the west and the north. Most of the fish ponds are created by conversion of paddy land to fish ponds. Although fish farming has a high potential, the high prices of fish feeding in Myanmar makes it still not fully exploited. There is only one big supplier of fish feed to the farmers. The costs of fish feed are 10-30% more than in neighboring countries, and therefore 80% of the farmers use by-products to grow their fish, resulting in lower level of production. Also, there is no credit available for small farmers, only some informal lenders against high interest rates per month.

The research of Belton, et al. (2017)¹⁴⁸ conceived some other results by surveys in the main aquaculture regions in the Ayeyarwady Delta. Aquaculture generates much higher earnings per hectare than crop farming, sometimes four times as much as crop farmers. It creates more on-farm employment, but pay higher wages to their employers. Yields of fish farms are still modest in the Ayeyarwady Delta, comparable with farms in Bangladesh, but half as much as well managed fish farms in for example India. Furthermore, limited fertilizers are used for fish growth.

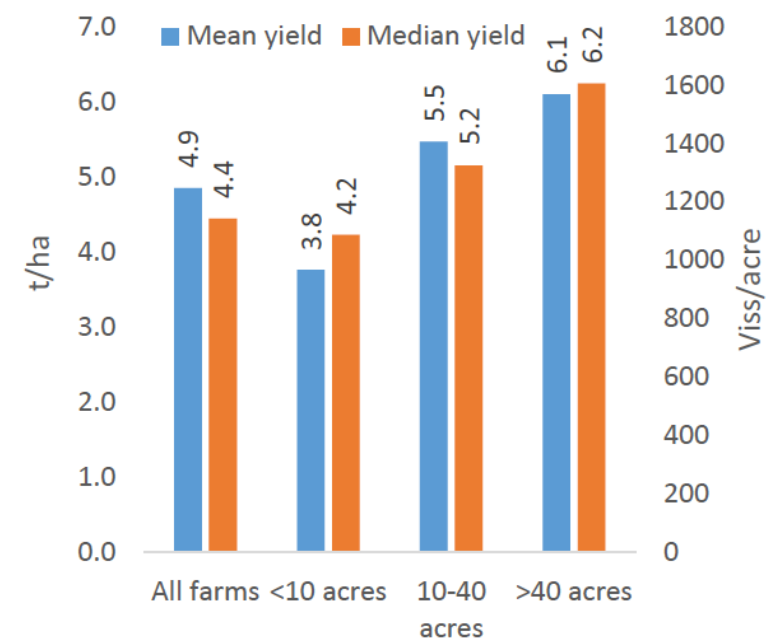


Figure 3-46: Average yield per farm size¹⁴⁸

¹⁴⁶ Department of Fisheries (2016), Fishery Statistics 2016, Ministry of Agriculture, Livestock and Irrigation

¹⁴⁷ van der Pijl, W. and van Duin, A.P. (2012) Myanmar seafood exports: Quick scan of the EU market potential, The Hague, CBI

¹⁴⁸Belton, B. and Filipski, M. and Hu, C. (2017) Aquaculture in Myanmar: Fish farm technology, production economics and management, Michigan State University and IFPRI

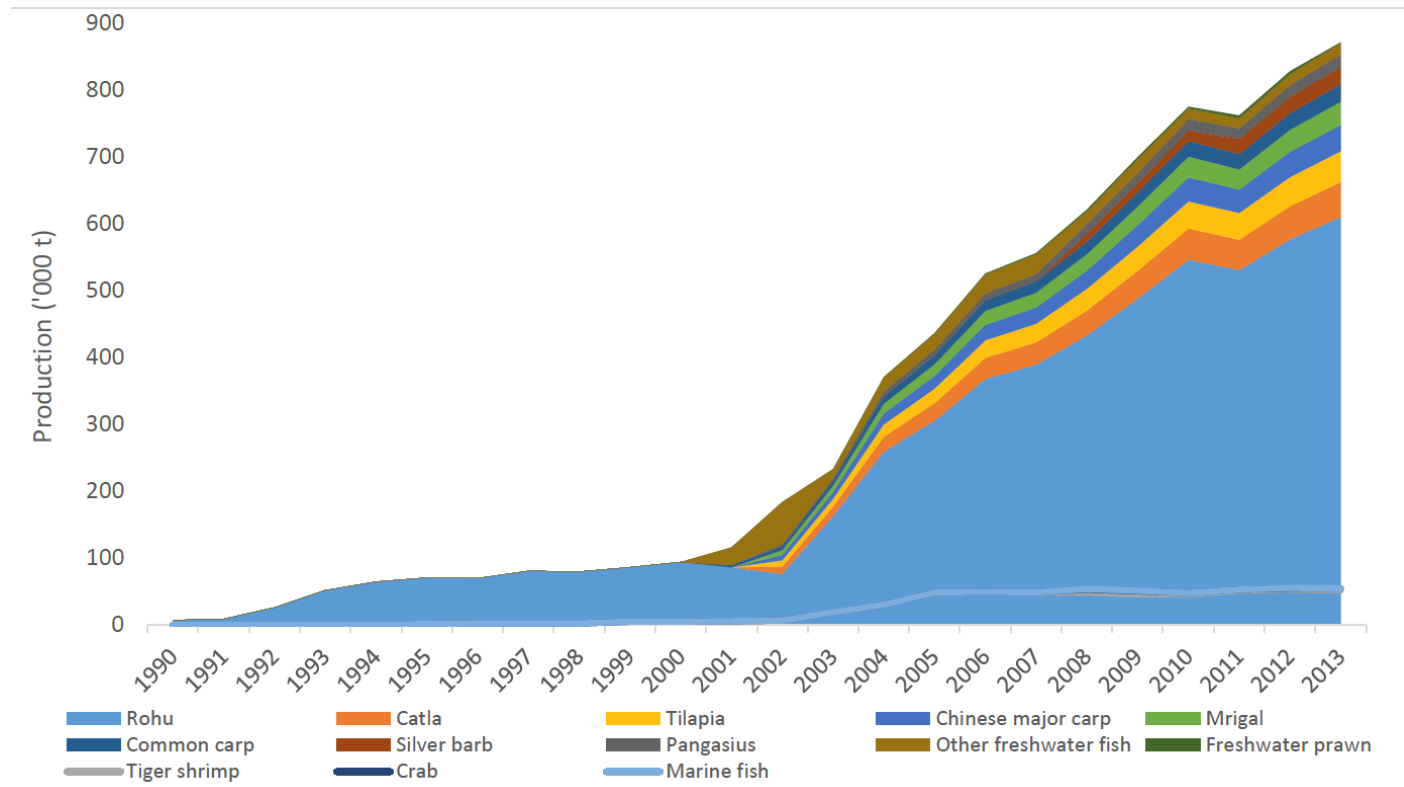


Figure 3-47 Fish production for different types of fish¹⁴⁹

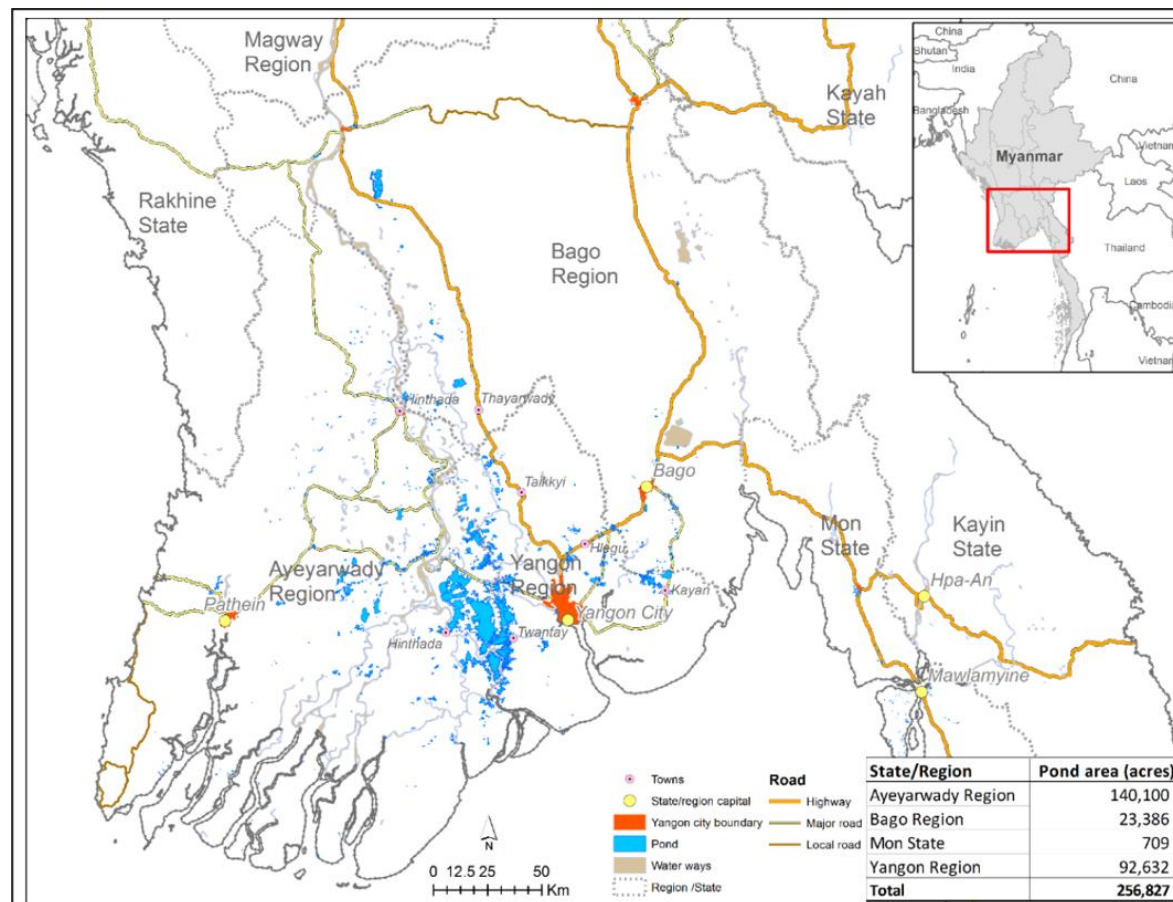


Figure 3-48 Fish ponds 2015 of Lower Myanmar by satellite analysis¹⁴⁹

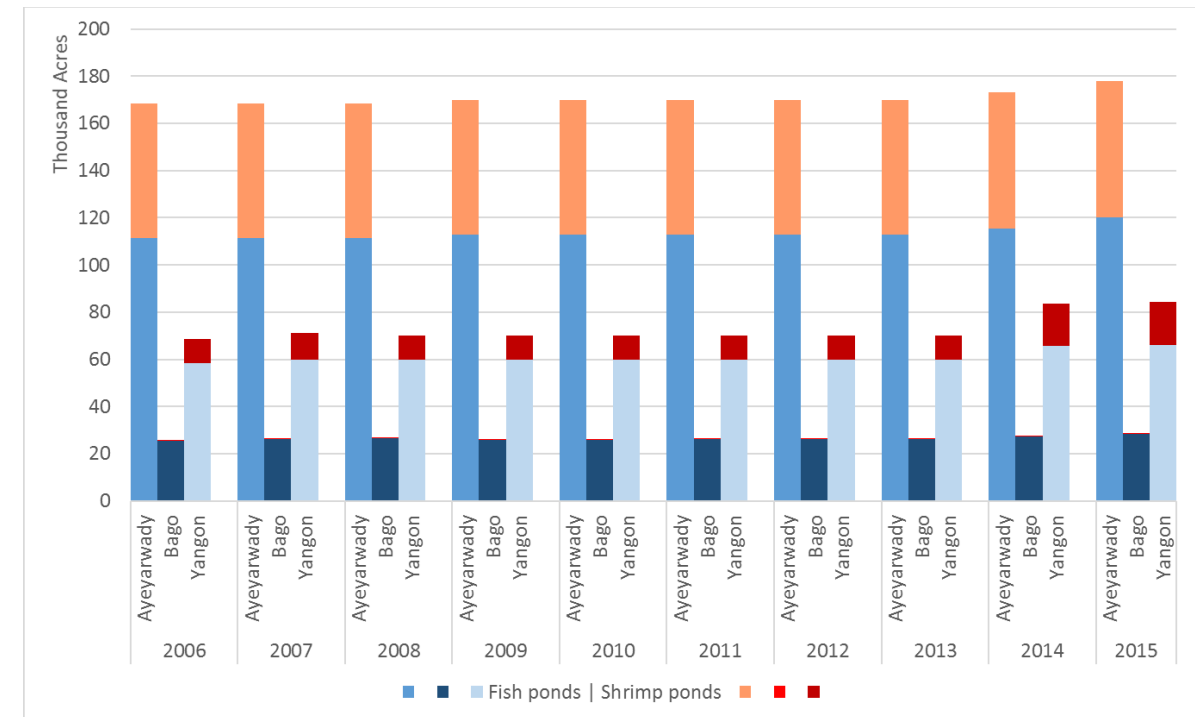


Figure 3-49: Area of fish ponds and shrimp ponds per region between 2006 and 2015 (DOF, 2016)

3.12.6 Export

The same trend as in agriculture is shown in the export value and amount of fish and prawns in Myanmar. Over the years, no increase can be distinguished. The main cause for trend is the upcoming inland fish and prawn market, as fish and fish products are becoming more popular. It is expected that national fish production will increase but that the share of export is even going to decrease.

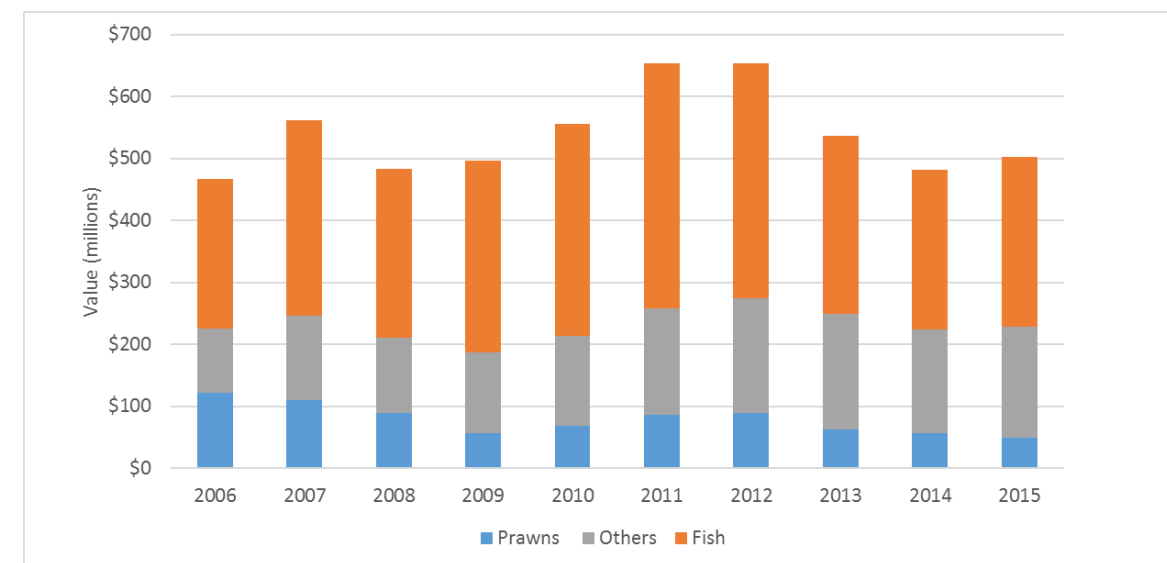


Figure 3-50: Fish exports of Myanmar (DOF, 2016)¹⁴¹

¹⁴⁹ Belton, B., et al. (2015), Aquaculture in transition: Value chain transformation, fish and food security in Myanmar, MSU, MDRI-CESD and IFPRI

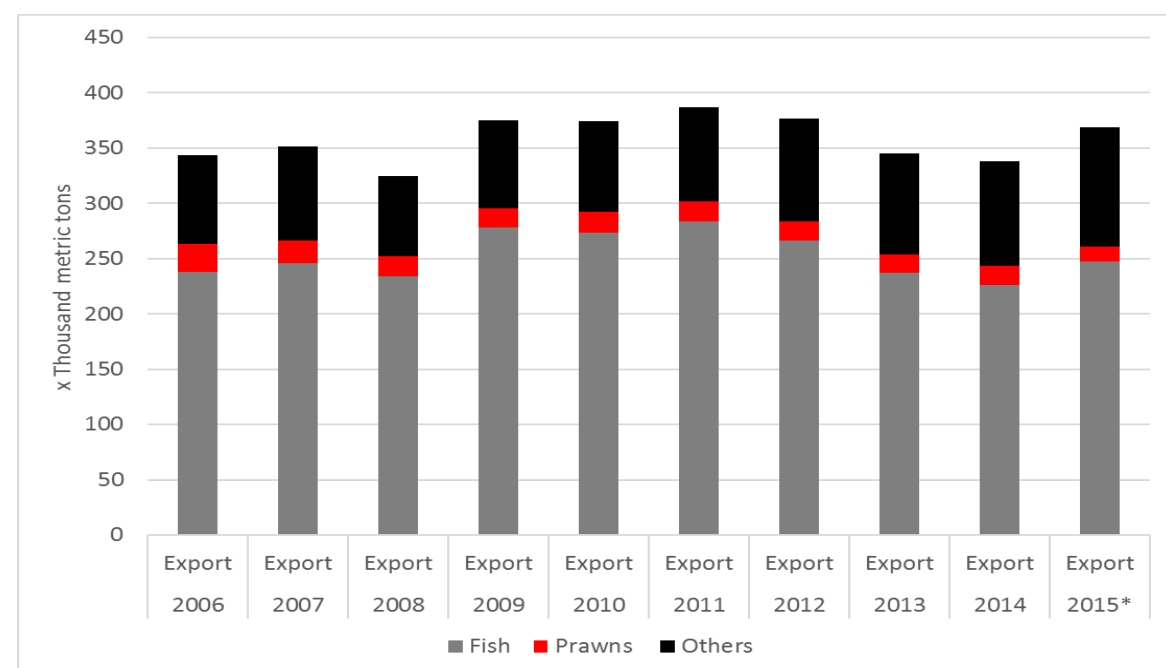


Figure 3-51: Fish and fishery product exported in Myanmar (2006-2007 to 2015-2016) (DOF, 2016) ¹⁴¹

3.13 Trends in Occupation

Population and urban development

In 2015 Myanmar had a population of approximately 53.9 million (World Bank, 2017). Myanmar is still an agricultural country, with about 70% of the population living in rural areas and 70% of the labour force being employed in agriculture (BTI, 2016; FAO, 2017). The largest share of the population is concentrated in the Delta and coastal zone, and the dry zone (Raitzer et al, 2015). According to the 2014 Population and Housing Census, the population of the Ayeyawady Region, covering a large part of the Ayeyarwady Delta, ranks second in size when compared with other States/Regions in Myanmar. Only the population of the Yangon Region is larger. The Ayeyarwady Delta is still a largely rural area dominated by a population living in low density village tracts, where land use is predominantly agriculture (Delta Alliance, 2015). In 2014 the Ayeyarwady Region had a population of 6.185 million on an area of 35,032 km² (DoP, 2015). A growing population in Ayeyarwady resulted in an increasing population density from about 142 inhabitants/km² in 1983 to approximately 177 inhabitants/km² in 2014 (Delta Alliance, 2015). As a result, it is the third most densely populated State/Region in Myanmar after the Yangon and Mandalay Regions (DoP, 2015). Nevertheless, the population density in Ayeyarwady is still relatively low compared to those of the Mekong (approx. 500 inhabitants/km², excluding Ho Chi Minh City) and the Ganges-Brahmaputra-Meghna Deltas (more than 1,200 inhabitants/km², including large urban agglomerations like Dhaka and Khulna) (Delta Alliance, 2015).

Livelihoods and domestic migration

Myanmar is still an agricultural country with the agriculture sector contributing 37.8% of gross domestic product (GDP) and with 70% of the population engaged directly or indirectly in agriculture (FAO, 2017). Rice dominates agriculture as measured by value of production and accounts for 43% of production value, nearly five times as high as the second highest value commodity, poultry (Raitzer et al, 2015). Myanmar’s agricultural production is concentrated largely in the Delta and coastal zone, and the dry zone. Rice and fish are predominantly produced in the Delta and coastal zone where monsoonal rainfall is plentiful and access to water easy (Raitzer et al, 2015). Agriculture, as the present dominant provider of employment and domestic output, is expected to continue to play an important role in the economy. However, with mechanisation and productivity increases, the number of jobs is expected to decline (OECD, 2013).

According to a UNDP report (2014b), in 2010 32% of the households in the Ayeyarwady Region lived below the poverty line. This was higher than the national average of 26%. Myanmar’s socioeconomic indicators appear to have halted their decline and in UNDP’s 2016 Human Development Index, it ranked 145th out of 188 states (150th in 2014), with the lowest value (0.556) in Southeast Asia (0.524 in 2014). In 2015-2016 real household incomes deteriorated as a result of widespread flooding (World Bank, 2016). Damages affected storage facilities with seed stocks; animals and livestock; aquaculture facilities and fisheries’ ponds; and fishing equipment. Losses were a result of a lower crop production, reduced output of meat and eggs, and a contraction in fisheries’ production. These losses had secondary effects downstream in the value chain in food processing, trading, and transportation services. Combinations of these factors had negative effects on household incomes (World Bank, 2016).

In recent years the Ayeyarwady Region has seen high levels of migration, especially since Myanmar’s economic transition started in 2011. One in five households in Ayeyarwady report having at least one household member currently migrating, while 60% of migrants are men (World Bank, 2016). This out-migration of people is visible in the population pyramid of Ayeyarwady that shows a considerable reduction in the proportion of persons aged 15–24 for both men and women (DoP, 2015). The majority of migrants move to Yangon (World Bank, 2016). People mostly migrate to create a diverse and potentially more reliable income stream as migration to Yangon provides greater certainty for year-round employment (World Bank, 2014). Despite the high rates of migration, the economic impacts are yet to be significant, as most migrants take up low-skilled employment in cities. Remittances are used primarily to supplement food expenses, smooth income and reduce debt (World Bank, 2016).

Economic development

Myanmar’s economy grew at a rate of 8.5% per year in 2013 and 2014. In 2015-2016 economic growth eased to 7% due to a supply shock from flooding in July 2015, which led to inflationary pressures and deteriorating real household incomes (World Bank, 2016). The agricultural sector is the backbone of Myanmar’s economy. It contributes 37.8% of GDP; accounts for 25 to 30% of total export earnings; and employs 70% of the labour force (FAO, 2017). In 2015-2016 agriculture growth declined to 2% compared to 5.6% the previous year due to the impact of heavy rains between July and September 2015 causing widespread flooding and landslides. Although the floods were geographically widespread, major agricultural producing areas like the Ayeyarwady Delta were particularly badly hit. This has also affected industrial output, as approximately 60% of industrial output comes from manufacturing and processing, about 70% of which is from food processing (World Bank, 2016). Food processing is dominated by rice milling, edible oils and snack foods (World Bank, 2016). Domestic food processors are facing growing competition from cheaper imports. Their productivity and competitiveness are affected by weak domestic supply chains and a lack of access to affordable finance. Furthermore, a large share of the inputs for domestically processed foods have to be imported (e.g. flour, preservatives, packaging material). Due to a weaker Kyat, nowadays these imports are more expensive (World Bank, 2016).

At present about 90% of the water use is utilized by agriculture. However, at the present time economic developments in Myanmar focus on a progressive shift from agriculture to industry. This shift has so far resulted in respectively a decreasing contribution of agriculture to GDP from 46.7%% in 2005 to 26.8% in 2015 and an increasing contribution of industry from 17.5% to 34.5% during the same period (MMSIS, 2017). The ongoing shift from agriculture to industry poses increasing pressures on the water system (Meel et al., 2014). The continuing industrial development makes the Ayeyarwady Delta a favourable investment area for domestic and foreign investment (MoNREC, 2016). Industries apart from fisheries and agriculture are not yet well developed in the delta. However, they are expected to become increasingly popular with a new stabilized government and the accompanying liberalization of the major industrial zones (Delta Alliance, 2015; UNDP, 2014). Out of a total of 18 Regional Industrial Zones three are located in the Ayeyarwady Region (Hinthada; Myaungmya; and Pathein) and four in Yangon (Eastern Township; Western Township; Northern Township; and Southern Township). These regional industrial zones were all designated in the 1990s. The development of a Special Economic Zone (SEZ) in Pathein has been led by Thai private investors. This SEZ will also be equipped with an international deep-sea port (OECD, 2014). The proximity of Ayeyarwady to the country’s commercial capital Yangon, which is just 4-5 hours by highway from Pathein, brings with it an opportunity to develop its potential as a major industrial zone (UNDP, 2014a). More industrial zones may be developed in Ayeyarwady in areas like for example Myaungmya Township (Eleven, 2017).

Land-use

The Irrigation Department classified about 52% of the land in the Ayeyarwady Region (2012-2013) as cultivatable, while approximately 21% was designated as forest and reserved forest. Less than 1% of the land in the region was still Virgin land. Land is largely used for paddy production and other land use is uncommon (Delta Alliance, 2015). Agriculture has been the principle driver of deforestation on the Delta (Webb et al, 2013).

The main types of land-use are irrigated (single, double and triple cropping annually), rain fed, flood plains and non-irrigated water managed areas (IWMI, 2014). Distinct differences exist in cropping patterns between the Lower, Middle and Upper Delta. These are mainly related to the availability of fresh water (Delta Alliance, 2015). In the Upper Delta, irrigated and rain fed areas can be found. Along the Pathein River, flood plain irrigation is found in the zone of seasonal flooding. The Lower Delta is predominantly irrigated and water managed (IWMI, 2014). Due to the ever-saline water in the Lower Delta, rain fed rice paddy during the monsoon season is the main crop that is grown. Besides, locally there are some possibilities for a second crop (e.g. beans) on residual water in soil and drainage canals. In the Upper Delta two or three crops can be grown. This is due to the fact that fresh water is available throughout the year (Delta Alliance, 2015).

Recently aquaculture is rapidly developing in the Ayeywarwady Delta. Very large farms (including several vertically integrated companies) account for well over half of total pond area (Belton et al, 2015). Furthermore, an estimated 210,000 backyard fish ponds are spread throughout southern Ayeyarwady and Yangon. Most ponds are transformed paddies and are small scale, (Belton et al., 2015). Aquaculture in Myanmar is highly concentrated spatially. The main fish farming area is within 50km of Yangon, with a big set of clusters to the West of Yangon. This pattern occurs because near

Yangon transport times are low, boats can use the river system to deliver fish and feed, energy grids exist, and water is neither too abundant nor too scarce (Belton et al, 2015). Approximate 55% and 36% of the total pond area are located in respectively the Ayeyarwady and the Yangon Region (Belton et al, 2015).

Agriculture

Agriculture is the most important sector in the country, both in terms of economic production as well as being the food source of livelihoods for 70% of the population (FAO, 2017). However, crop yields are still low. According to Raitzer et al. (2015) paddy yield was 3,83 MT/ha in 2011. Information obtained from the Irrigation Department in the Pyapon District indicates an average production of 55 baskets/acre (2,890 kg/ha) for rain fed monsoon paddy and 95 baskets/acre (4,990 kg/ha) for irrigated summer paddy (Delta Alliance, 2015). Despite massive water resources and favourable production conditions in the delta zone, Myanmar has Asia's second-lowest rice yields. Viet Nam and Bangladesh, which have similar productivity potential in their delta regions, have yields that are 114% and 66% higher, respectively (Raitzer et al., 2015).

There is considerable uncertainty regarding rice production statistics. Big differences have emerged between paddy production statistics of Myanmar's government and those of other sources. As a result, it is difficult to get a clear picture of agricultural performance. This distortion badly hampers planning of effective policy support and sharing of accurate market intelligence (Raitzer et al., 2015). Fertilizers are poorly documented, barely regulated, and not well understood by the farming population. Because of the high amount of imported fertilizers in the country, trends in fertilizer use are difficult to predict. Insecticides are still popular, but the use of herbicides and plant growth regulators is increasing (Raitzer et al, 2015). Because of one of the present problems is controlling the illegal pesticides crossing the border. Trends in pesticide use are also difficult to portray (Peters et al, 2015).

Capture fisheries and aquaculture

The fishery sector is another important sector in the delta, since fish is the main source of protein for the national diet and therefore important for food security of the country. A wide complexity of species can be found, because of the different ecological zones ranging from fully brackish, to estuarine, to fresh water.

Inland capture fisheries

The Ayeyarwaddy division, together with the Tanintharyi division, are by far largest the two largest fish producers in Myanmar (Kye Baroang 2013). According to the Department of Fisheries the number of fishing gear in the Ayeyarwady Region has remained stable of the last ten years (2006/2007-2015/2016) at around 500 drift nets (DOF, 2016). Besides these drift nets, a variety of fishing gear including push nets, stow/set bag nets and electric fishing have been observed in the Delta. Hydrological factors (i.e. flood level, duration and timing) play an important role in the sustainability in the sustainability of inland capture fisheries in the Ayeyarwady Delta (Baran & Myschowoda 2009). This particularly affects fisheries that depend on migratory species like Hilsa. Hilsa fishery is a very old livelihood for Myanmar local people. Hilsa occurs in inland, marine, and coastal waters (BOBLME, 2015). Fishermen in Kyaunggon Township and other parts of the Ayeyarwady Delta reported a declining catch (pers. com., 2015 & 2017). Anecdotal evidence from Wah et al. (unknown) supports this by suggesting an overall decline in the productivity of fisheries in the Ayeyarwady Delta over the last few decades. However, it is unclear whether this perception comes from a reduction in total yield or a reduction in catch per unit effort.

Aquaculture

Aquaculture is developing at a high pace in the delta. Fish grown in inland ponds account for close to 95% of Myanmar's reported aquaculture production and the Ayeyarwady Delta accounts for 90% of Myanmar's farmed fish production (Belton et al, 2015). The Ayeyarwady and Yangon regions account for almost 80% of Myanmar's inland fish ponds. Fish-farming output from the Delta went up about 250% over the past decade. This is due to a combination of growth in pond area and yields (Belton et al, 2015). According to the Department of Fisheries the number of fish ponds in the Ayeyarwady Region increased over the last ten years (2006/2007-2015/2016) from about 112,000 to around 120,000. Only 20% of farmed fish is exported and it is expected that this will decline with the expected growth of the urban

market and importance to the national diet (Belton et al, 2015). Nevertheless, there is little diversity in the species produced, with a single fish species (the indigenous carp, rohu) constituting roughly 70% of all farmed fish (Belton et al, 2015).

The Ayeyarwady (20%) and Yangon regions (5%) account for about 25% of Myanmar's shrimp ponds (Pijl & van Duijn, 2012). According to the Department of Fisheries the number of shrimp ponds in the Ayeyarwady Region increased over the last ten years (2006/2007-2015/2016) from approximately 57,000 to about 58,000 (DOF, 2016). Currently Pacific white shrimp and Giant freshwater prawn are two main species that are cultured in the Ayeyarwady and Yangon Regions. Giant freshwater prawn is mainly produced in polyculture systems with carp and other freshwater fish species. It is mainly exported to Japan, but there is also an increasing local demand for what is considered a luxury product (Pijl & van Duijn, 2012). In recent years other aquaculture products like crab have now become major export products (Pijl & van Duijn, 2012).

Rural electrification

The overall quality of in Myanmar's infrastructure, including rural roads, telecommunication systems, and the energy grid, was ranked 146th out of 148 in the World Economic Forum Global Competitiveness Report (2013). Myanmar has abundant energy resources, particularly hydropower and natural gas. However, the country's energy sector has been underdeveloped due to a lack of financial and technical capacity and global isolation (ADB, 2016). Most people use traditional biomass (mainly firewood and agricultural wastes), particularly for cooking and lighting. In 2014 in the Ayeyarwady Region firewood (88.4%) was reported as by far the most dominant source of energy for cooking (DoP, 2015). In the same year kerosene (30.8%) and batteries (30.7%) were the main sources of energy for lighting followed at some distance by candles (15.5%) and electricity (12%). The largest number of households using electricity for lighting were found in Patheingyi, Hinthada and Myaungmya townships (DoP, 2015).

The residential sector is the largest consumer of energy, with 75% of total consumption in 2012, followed by the industry sector (9%) (ADB, 2016). Together with the expansion of rice agriculture into mangrove areas, firewood extraction has been the dominant proximal driver of deforestation in the Delta (Webb et al, 2013). Energy consumption grew slowly at an annual average of 2.3% during 2000–2012 (ADB, 2016).

Electrical power generation and distribution is a major problem in Myanmar. While about half (49%) of the country's population has access to electricity, the rural electrification rate is considerably lower at 28% with the Ayeyarwady Region being in the lowest (26.4-40%) category (OECD, 2013). Only around 3,500 villages have access to grid electrification, while the rest (about 59,000 villages) are either have off-grid access or have no electricity (Tun et al, 2015).

Governance Layer



4 Governance layer

4.1 Stakeholders

4.1.1 Governmental stakeholders

According to the constitution of 2008, Myanmar has a decentralised governance system, with five government levels, the Union level, Regions (prior to 2010 known as divisions) and States, districts, townships, and village-tracts or -wards. The Union government is located in NayPyiTaw. The new government is led by President Htin Kyaw since the 15th of March 2016.¹⁵⁰

Ministries and departments

Relevant ministries and departments with regard to delta management from a water management perspective, but also including economic development, land-use and infrastructure (Table 4-1).

Table 4-1 List of ministries and departments

Ministry	Department (among others)
1 Ministry of Transportation and Communication	- Directorate Water Resources and Improvement of River systems - Department of Meteorology and Hydrology - Myanmar Port Authority - Department of Marine Administration - Inland Water Transport - Roads transport and administrative department
2 Ministry of Agriculture, Livestock and Irrigation	- Department Rural Development - Department of Fisheries - Department of Agriculture - Irrigation Water and Utilization Management Department - Department Agricultural Land Management and Statistics - Livestock Breeding and Veterinary department
3 Ministry of Natural Resources and Environmental Conservation	- Wildlife Department - Environmental Conservation Department - Survey Department - Forest Department - Mineral Affairs - National Environmental Conservation Committee
4 Ministry of Home Affairs	General Administration Department
5 Ministry of Education	
6 Ministry of Social Welfare, Relief and Resettlement	- Relief and Resettlement Department - Myanmar National Disaster Preparedness Working Committee (NDMWC)
7 Ministry of Planning and Finance	
8 Ministry of Construction	- Department of Human Settlement and Housing Development - Bridge Department - Highway Department
Ministry of Health	Department of Public Health
10 Ministry of Hotels and Tourism	
11 Ministry of Electric Power and Energy	- Power System Department - Power Transmission Project Department - Material Planning Department - Department of Hydropower Planning - Department of Hydropower Implementation
12 Ministry of Labour, Immigration and Population	
13 Ministry of Culture and Religious Affairs	
14 Ministry of Commerce	
15 Ministry of Industry	

Regions

¹⁵⁰ Gorp van, R. (2016) - Institutional Analysis of the Water Sector in Myanmar, As part of a study into perceptions of Integrated Water Resources Management in Myanmar, TU Delft, UNESCO-IHE

The Regional governments of Ayeyarwady Region, Yangon Region and Bago Region are part of the Ayeyarwady delta. With regard to water resources management, regions have the responsibility to manage dams, embankments, lakes, drains and irrigation works, and fresh water fisheries. A swell as small-scale electric power production and distribution that has no link with the national power grid.

General Administration Department (GAD)

The GAD under the Ministry of Home Affairs is the supplier of ‘government administrations’ at both, the district and township government levels. The GAD’s main responsibility is the countries public administration. GAD connects the villages and townships to the Union government level. Information and data collection at villages and townships is all gathered at the respective GAD’s offices and shared with the head office in Naypyitaw. At the district, township and village tract, the administrator is from the GAD’s office.

Districts

The districts are managed by a senior GAD official and work with several committees. The districts within the Ayeyarwady delta are shown on Figure 4-1.

Townships

Each township has a Township Administration who is responsible for tax collection, population and land registration, data collection and the supervision of the village administration. A township is managed by six committees with representatives from the GAD, partly elected villagers and partly prominent community people. Relevant data are collected at the GAD office, including data from ministry offices such as the irrigation departments at township levels.

- Township Development Affairs Committee - domestic water use
- Township Management Committee
- Township Farmland Management Body
- Township Development Support Committee
- Land Use Management Committee
- Rural Energy Development Committee

Wards and Village-tract

The lowest government administration is the Village-tract Administration in rural areas and the Ward Administration in urban areas.

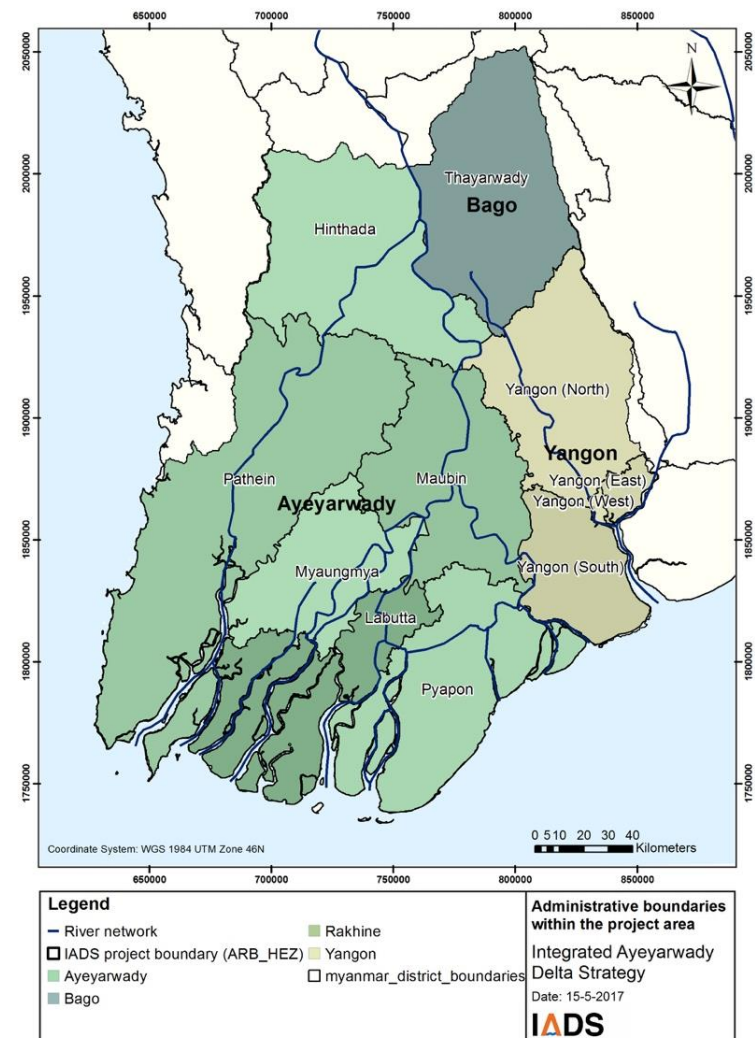


Figure 4-1 Regions and districts within the Ayeyarwady delta

Yangon City Development Committee (YCDC)

Yangon city is part of the delta because of its important role in the economic development and demographic developments. The future of the delta depends for a large part on the development of Yangon. With regard to water management in the city, the Water and Sanitation Department is responsible for drinking water and sanitation in Yangon. The city extracts ground water for drinking water purposes and measures the water quality of drinking water reservoirs.

Table 4-2 number of townships and wards per district

Region	District	Number of townships ¹⁵¹	Number of Wards ¹⁵²
Ayeyarwady Region	Patheingyi	7	48
	Maungmya	3	50
	Hinthada	6	
	Labutta	2	
	Maubin ¹⁵³	4	39
	Pyawbwe	4	35
Yangon Region	Yangon North	8	
	Yangon South	11	
	Yangon Western (Downtown)	13	
	Yangon Eastern	14	
Bago Region	Thayawady	8	

4.1.2 Stakeholder participation & platforms

Myanmar Climate Change Alliance (MCCA)¹⁵⁴

The Myanmar Climate Change Alliance was launched in 2013 with the support of the Global Climate Change Alliance (GCCA) and is being implemented by the United Nations Human Settlements Programme (UN-Habitat) and the United Nations Environment Programme (UNEP). The Programme works as a platform to mainstream climate change into the Myanmar policy development and reform agenda, but it also supports all on-going actions and activities on climate change from the National Government, Local Authorities, NGOs, Development partners, Civil Society and the Private Sector. MCCA is the key platform for climate change in Myanmar.



AIRBMP Multi Stakeholder Forum

The Multi-stakeholder Forum of the Ayeyarwady Integrated River Basin Management Project (AIRBMP) was established by the voluntary formulation of Core Group Members representing 29 organisations during the Multi-stakeholders Forum Establishment meeting on 18th October 2016 in Yangon. The Forum consists of a Virtual Forum, Thematic Working Groups, a Core Group and a Steering Committee. The Forum aims to share information and experience among stakeholders living in the Ayeyarwady River Basin, to create opportunities for all to share their opinions, to disseminate the accomplished tasks and progress of the AIRBMP planning process in IWRM in Myanmar and to ensure stakeholders engagement in sustainable development and management of the Ayeyarwady River Basin.

¹⁵¹ http://www.geohive.com/cntry/myanmar_ext.aspx

¹⁵² <http://www.mrtv3.net.mm/newpaper/69newsn.pdf>

¹⁵³ http://www.most.gov.mm/maubintu/index.php?option=com_content&task=view&id=23&Itemid=38

¹⁵⁴ Myanmar Climate Change Alliance, <http://myanmarccalliance.org/>



Global Water Partnership¹⁵⁵

The Mission of the Global Water Partnership Southeast Asia (GWP Southeast Asia) is to encourage, support, and facilitate member countries in achieving sustainable water for all through the Integrated Water Resources Management (IWRM) approach. GWP supports communities and countries to improve the way they manage water.

Delta Coalition¹⁵⁶

The Delta Coalition is world’s first international coalition of governments that have formed a partnership to deal with this problem and to get things done to make deltas more resilient. Fast, informal, and flexible, the coalition facilitates discussion, exchange, innovation and creativity between the participating members and observers. Government leads and multi-stakeholder initiatives aim to get things done to improve and protect lives in urban deltas. The coalition will facilitate a complete body of knowledge on deltas, adaptation, resilience and sustainable urban development. Most importantly, it will allow delta countries to join forces to stimulate best practice, innovation and to increase opportunities for financing in order to facilitate implementation of projects that will reduce vulnerability to climate change. Contact person for Myanmar is U Ko Ko Oo, Deputy Director General of Directorate of Water Resources and Improvement of River Systems (DWIR), Ministry of Transport and Communications (MoTC).



Delta Alliance¹⁵⁷

Delta Alliance is an international knowledge-driven network organization with the mission of improving the resilience of the world’s deltas. Delta Alliance with 16 network wings brings people together who live and work in deltas. They can benefit from each other’s experience and expertise and as such contribute to an increased resilience of their delta region. Myanmar is one of the 16 wings. One of the publications is the Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar. Delta Alliance report no. 10. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, the Netherlands. Driel, W.F. van & T.A. Nauta, Friday 27 February 2015. Contact person for Myanmar is Dr. Zaw Lwin Tun, Director at Irrigation and Water Utilisation Management Department (IWUMD), Ministry of Agriculture, Livestock and Irrigation.



¹⁵⁵ Global Water Partnership, <http://www.gwp.org/en/GWP-South-East-Asia/>

¹⁵⁶ Delta Coalition, <http://www.deltacoalition.net/>

¹⁵⁷ Delta Alliance, <http://www.delta-alliance.org/wings/myanmar-wing>

4.1.3 Community participation

Many projects in Myanmar take place on village and township level. The following maps indicate the number of projects in Bago, Yangon and Ayeyarwady Region, based on the data from MIMU (March 2017). The maps (Figure 4-2, Figure 4-3 and Figure 4-4) show that in particular in the lower delta, south of Yangon and western Bago many community and village projects are taking place. The complete list of projects can be found in Appendix 1: planned and ongoing projects in the delta.

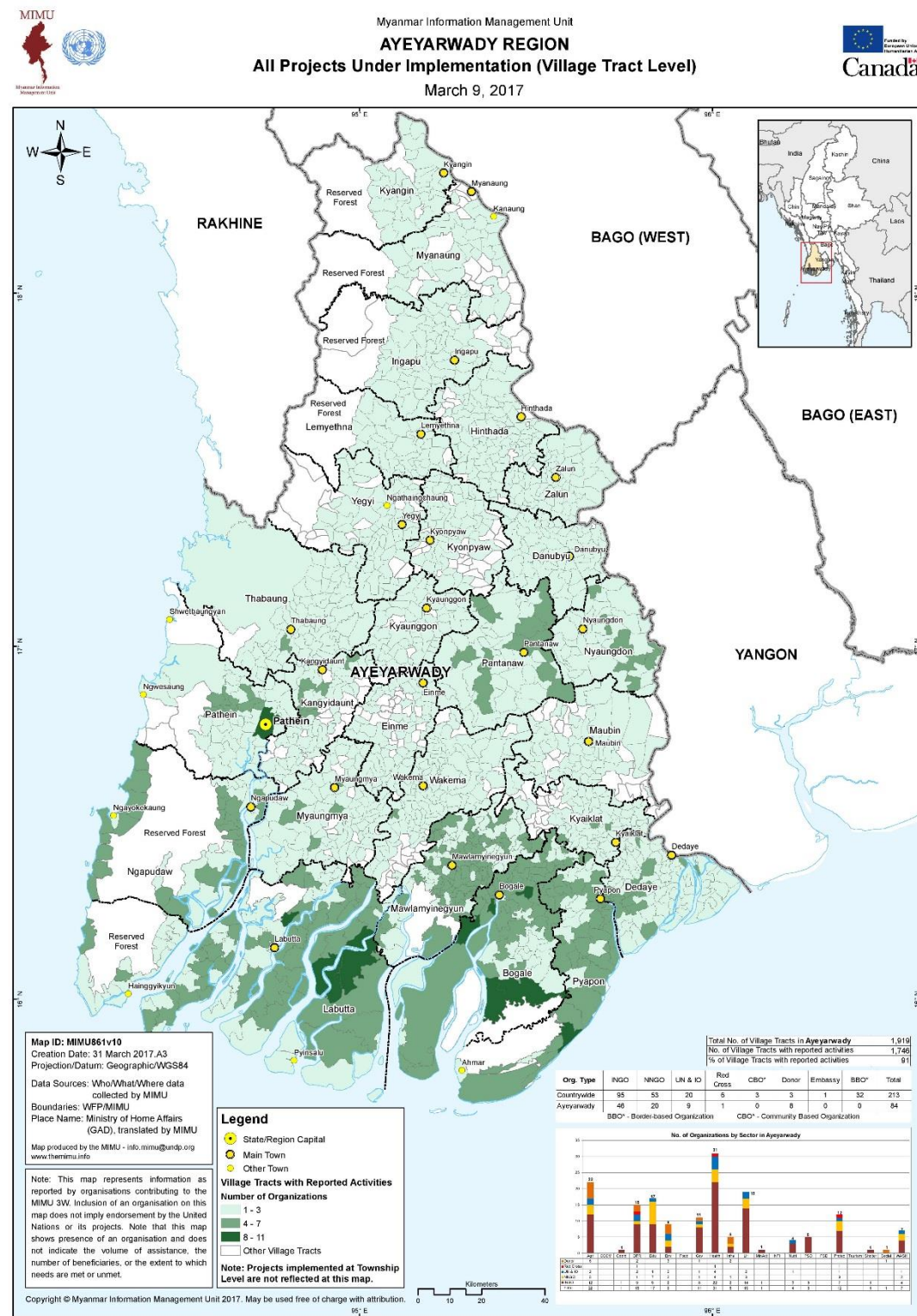


Figure 4-2: All projects under implementation in the Ayeyarwady Region (village tract level) MIMU

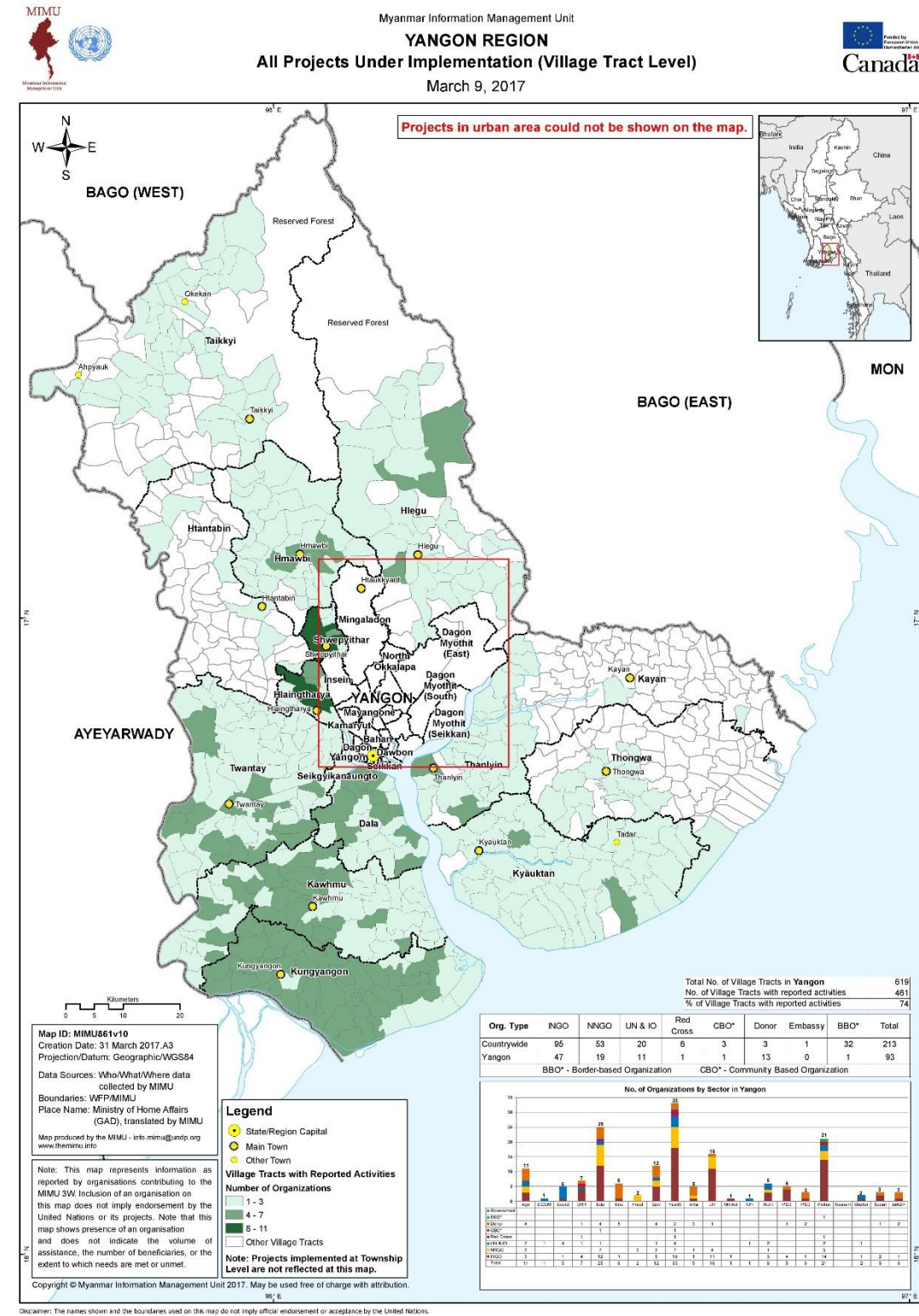


Figure 4-3: All projects under implementation in the Yangon Region (village tract level) MIMU

MIMU

The Myanmar Information Management Unit / MIMU is a service to the UN Country Team and Humanitarian Country Team. Its purpose is to improve the capacity for analysis and decision making by a wide variety of stakeholders - including the United Nations, the Humanitarian Country Team, non-governmental organizations, donors and other actors, both inside and outside of Myanmar, through strengthening the coordination, collection, processing, analysis and dissemination of information.



Universities

- Yangon Technological University
- Patheingyi University
- Yezin Agriculture University
- Myanmar Maritime University
- Yangon University
- Technical Universities

4.2 Governance

4.2.1 Roles and responsibilities

Currently in Myanmar, roles and mandates of each institution are not always as clear. Water management is scattered between ministries and departments resulting in missing or overlap of responsibilities in some sectors (OECD, 2014). A great example of this is the recent (March 2016) merger of several ministries and departments at the union level. Although these institutional reforms take time, the first steps towards a more efficient management of Myanmar's natural resources are taken. In Table 4-3, a brief description is given for each department.

Table 4-3 Tasks, responsibilities, activities and mandate of each relevant department in the Myanmar government

Ministry	Department (among others)	Tasks, responsibilities, activities and management
Ministry of Transportation and Communication (MOTC)	Directorate of Water Resources and Improvement of River systems (DWIR)	Dredging in river constraints to improve navigation, stabilize inland river ports, protect river bank erosion, river training and bank stabilization, assistance and coordination of demarcation of danger water levels, utilize river water for domestic and agriculture, observe long-term existence of cross river bridges, manage prevention of river water pollution, achieve adequate depth of maximum loading capacities, and hydrological/channel surveying and mapping.
	Department of Meteorology and Hydrology (DMH)	Meteorologic and hydrologic monitoring. Taking measures against and to minimize effects of natural disasters, promote safety of sea and inland water transportation, demarcation of danger water levels, promote agriculture and food production, support environmental protection and sustainable production of natural resources, research/public awareness of meteorology, hydrology, and seismology.
	Inland Water Transport (IWT)	Administrative department, Inspection Department, Transportation Department, Cargo Transportation Department, Engineering Department, Marine Department, and the Finance Department.
	Department of Marine Administration (DMA)	Measures and activities to maintain safety of ships. Activities: maritime accidents investigation ship registration, port state control implementation, check certifications, etc.
	Myanmar Port Authority (MPA)	Regulation and administration of the ports of Myanmar. Dredging activities at port areas.
Ministry of Agriculture, Livestock and Irrigation	Department of Rural Development	Construction and maintenance of rural feeder roads and bridges connecting villages to towns and districts, provision of rural safe drinking water, undertaking work for rural sanitation.

Ministry	Department (among others)	Tasks, responsibilities, activities and management
	Department of Fisheries	Conservation and rehabilitation of fisheries resources, promotion of fisheries researches and surveys, collection and compilation of fishery statistics and information, extension services, supervision of fishery sector, sustainability of fishery resources.
	Department of Agriculture	This department undertakes activities in farm mechanization, introduction of new technologies, and measures to increase yields.
	Irrigation and Water Utilization Management Department	Water supply for irrigation by pumping water from rivers and streams; Utilization of groundwater for crop production; safe drinking water supply for rural population Design, planning and implementation of irrigation projects, operation and maintenance of existing projects, flood protection embankments and polders, improving land reform process for establishment of mechanized farming, conducting water resources development plan especially in surface water management, providing adequate storage of water for irrigation
	Department of Agricultural Land Management and Statistics (DALMS)	Collecting, compiling and issuing the statistics of agriculture sector and land use in compliance with laws, procedures and instructions; Establishing database for an information system by using surveyed maps and Land Use Statistics, carrying out cadastral functions in accordance with cadastral manual; conducting socio-economic surveys and taking agricultural census in accordance with international norms to issue data on agriculture sector, carrying out deeds registration in accordance with the Registration Act, conducting training courses and workshops to enhance the personnel's capacity
	Livestock Breeding and Veterinary department	With regard to livestock breeding and veterinary specific Land ownership, agro-livestock production and opportunity policy, Financial and Material Needs Policy, Research, Technology, Inputs and Human Resources Policy, Environmental conservation Policy
	Ministry of Natural Resources and Environmental Conservation	Environmental Conservation Department
	Survey Department	topographic mapping throughout the whole country and jointly carries out boundary demarcation works with neighbouring countries
	Forest Department	Sustainably managing the forest, restoration of degraded forest, tree improvement and generic conservation of teak and other commercially important tree species, watershed management and soil conservation, climate change mitigation and bio-diversity conservation. Within this department they conduct all kinds of research for example the physical and chemical soil composition, effect of various fertilizers on tree growth, etc.
	National Environmental Conservation Committee	4 sub-committees: one aims at addressing the environmental problems in rivers and wetland areas. They advise the government on environmental policies, and act as a coordinating body for environmental affairs and promote environmentally sound sustainable development.
Ministry of Home Affairs	General Administration Department*	See explanation in text.
Ministry of Education		
Ministry of Social Welfare, Relief and Resettlement	Relief and Resettlement	To provide relief items for victims of natural disasters to ease their suffering and to take precautionary steps so as to minimize loss of lives and properties of the victims of natural disasters
	Myanmar Disaster Management Working Committee	This committee was constituted in 2016 under the chairmanship of the Union Minister of Social Welfare, Relief and Resettlement. This committee is the national focal point for planning, implementing, facilitating and coordinating disaster risk management and disaster risk reduction activities.
Ministry of Planning		Administers national monetary, fiscal policies and national planning.

Ministry	Department (among others)	Tasks, responsibilities, activities and management
Ministry of Construction	Department of Human Settlement and Housing Development	Preparing and implementing urban and regional plans, overseeing property development activities, managing government buildings and housing estates; planning and developing water and sanitation systems for new settlement areas. This department is currently working on a new ground water law. Under this department the Urban Research and Development Institute was established in 2012 to help strengthen policy formulation and provide urban planning and management training programs. Also construction of public buildings such as schools, hospitals, and government offices.
	Bridge Department	Main responsibilities are to construct and maintain public infrastructure such as bridges.
	Highway Department	Main responsibilities are to construct and maintain public infrastructure such as roads and high ways.
Ministry of Health	Department of Public Health	The Environmental Sanitation Division under this department is responsible for systematic latrine construction and utilization and for the provision of water supply activity for Health institutions and water quality development
Ministry of Hotels and Tourism		
Ministry of Electric Power and Energy	Power System Department / Electric Power	Operation and Planning of National Grid System and Power System Communication, operation and maintenance of transmission line and substation facilities above 66 kV, testing for Power System Equipment and Measuring Devices, writing Statistical research data
	Power Transmission Project Department	Transmission line and Substation facilities planning (above 66 kV), construction of transmission line and substation facilities (above 66 kV), construction of large-scale distribution system, repair of generators, turbines, transformers and other electric equipment
	Material Planning Department	Procurement Planning, storage, Logistic Movement, Fuel and Statistics
	Department of Hydropower Planning	Hydropower and coal fired power project planning for both the government and the private sector.
	Department of Hydropower Implementation	Four institutions responsible for the design of dams, feasibility studies, investigation works, and mechanical works. In addition there are seven engineering construction companies capable of construction and installation of large hydropower projects
Ministry of Labour, Immigration and Population		<i>To be added</i>
Ministry of Culture and Religious Affairs		<i>To be added</i>
Ministry of Commerce		<i>To be added</i>

4.2.2 Governance structures

New institutions such as the National Water Resources Committee (NWRC) and an advisory group have been established to bring the ministries with water management responsibilities together.

National Water Resources Committee (NWRC)

In 2013 the National Water Resources Committee was established, chaired by Vice-President II. The secretary is the minister of the Ministry of Transportation and Communication, via the Director General of the Directorate of Water Resources and Improvement of River Systems (DWIR). In 2014 an advisory group was established to advise the NWRC. In the previous years, the advisory group has advised the government on the national water policy as well as a national water law which is expected to pass the union government for approval this year.

National Commission for Environmental Affairs

The responsibilities of this commission are to ensure sustainable use of environmental resources and to promote environmentally sound practices in industry and in other economic activities. It formulates broad policies on natural resources management, prepares environmental legislation for pollution controls, and promotes environmental awareness.

National Committee for Coastal Resources Management (NCCRM)

The National Coastal Resources Management Committee has been designated on 30th November 2016 by the Government of the Republic of the Union of Myanmar. The objective of the meeting was to initiate the Integrated Coastal Management Approach for the sustainable management of the Coastal and Marine natural resources in the country.

First Meeting of National Committee for Coastal Resources Management (NCCRM) has been conducted in March 2017 in forest department. The meeting was chaired by HE Vice President of the government of the Union of Myanmar and attended by members comprising chief ministers of coastal related regional governments, union government ministers and high officials from government institutions.

National Wetland Committee

The National Wetland Committee is formed on the 30th of August 2016 in order to implement the work plan of the Conference of the Parties (COP) of the Ramsar Convention and to implement the strategies that relevant to relevant wetland activities those are stated in the National Biodiversity and Action Plan (2015-2020).

National Environment Conservation and Climate Change Committee

The National Environment Conservation and Climate Change Committee has been established on June 2, 2016 and is led by the Vice President. The Committee consists of working committees on:

- Policy, law, regulation, procedure and standards
- Industrial plans, urban, rural and waste management
- National resources, biodiversity, culture heritage conservation
- Climate Change Mitigation and Adaptation
- Environmental Capacity Building Development, Education and Awareness
- Environment and Climate Change Supervision Committee of Regions and States.

Other committees, for example on Agriculture and at the regional level have not yet been identified.

4.2.3 Governmental cooperation in delta management

On November 25, 2016, the Ayeyarwady Delta Working Committee has been established for jointly studying, discussing, negotiation and for supporting the decision-making process in capacity building activities (Figure 4-5). The committee

consists of representatives from many relevant Ministries and the regions Bago, Ayeyarwady and Yangon. The committee has the following tasks and responsibilities:

- To coordinate between Union Ministries and Regional Government;
- Sharing water resources data between Union Ministries and Regional Governments;
- Responsible for cooperation with international organisations;
- Responsible for cooperating with the Netherlands in planning other projects in relation to the Integrated Ayeyarwady Delta Strategy;
- To report to NWRC about the performing tasks on distinctive events and natural disasters;
- To report to NWRC about adding of members and/or improving the organization.

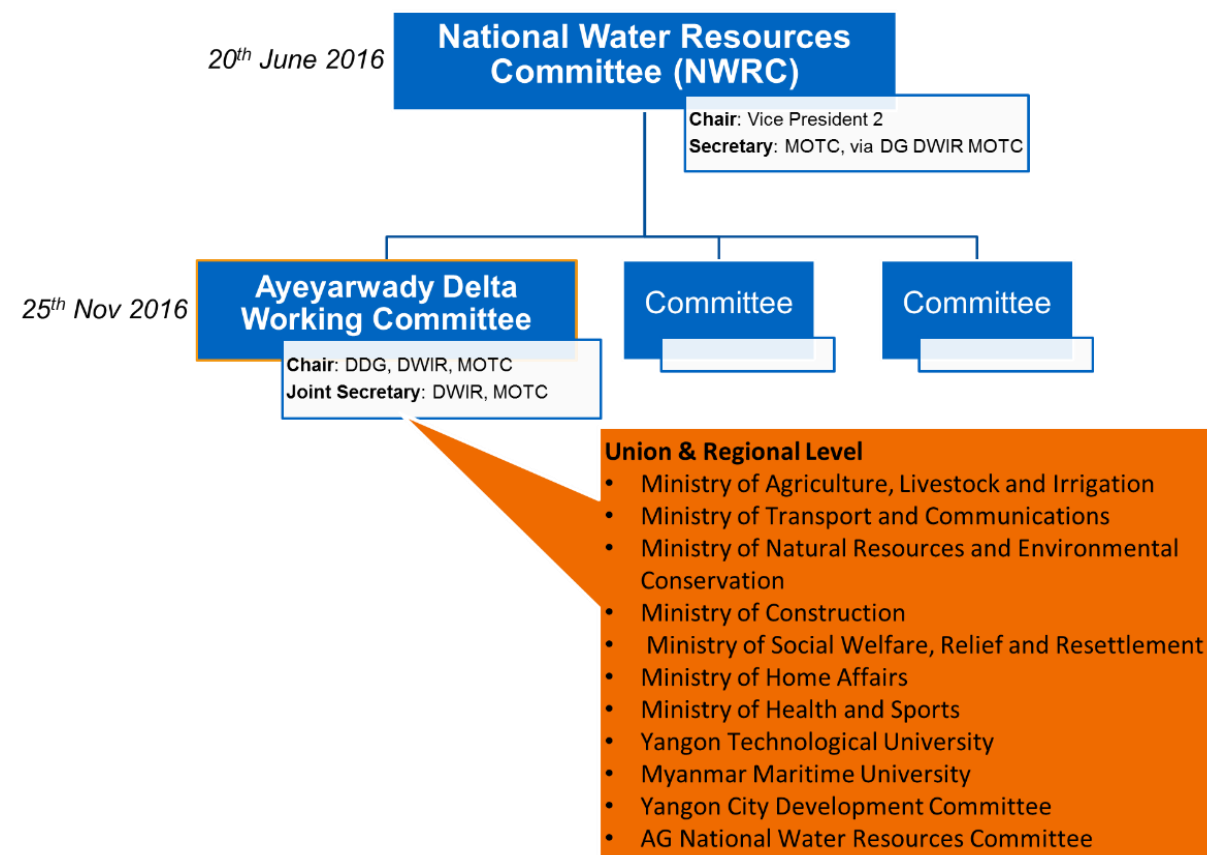


Figure 4-5 Ministries involved in the Ayeyarwady Delta Working Committee

4.3 Regulations, strategies, plans and policies

4.3.1 Relevant laws, acts and regulations

Gaps in Myanmar's institutional resources affect Myanmar's capacity to implement and enforce effective laws and regulations (SEI, 2015). In some sectors there are no mechanisms, or political will to enforce laws and policies resulting in deforestation and environmental degradation. In addition, there is a need to raise awareness of existing laws and regulations. The national water policy, adopted by the government in 2015, advocates for an integrated approach for future water management in Myanmar (NWP, 2014).

Currently, the laws that exist on water management in Myanmar are almost ancient (Figure 1-38). Although the NWRC has put a lot of effort in the formulation of a new national water law, finalizing the process is expected in 2017. The existing water utilization laws, most of which had been drafted in the 19th century or the beginning of the 20th century, have not been enacted since the second half of the 20th century with exception of the City Development Committee laws. Regional laws with regard to fisheries, fertilizers etc. have not be addressed in detail.

Myanmar Water Framework Directive (approved May 2015)

Essential legislation on water governance in every region and state of the Union under the national legal framework of general principle. The Myanmar Water Framework Directive aims to establish "a framework for all walks of life in the field of water policy", which commits all local governments (States and Divisional Governments) to achieve good qualitative and quantitative status of all Water Bodies within Myanmar (including marine waters up to one nautical mile from shore). Myanmar Water Framework Directive (MWFD) is approved in May 2015.

Table 4-4 List of acts per discipline

Water Utilization¹⁵⁸	Irrigation
The Rangoon Water Works Act (1885)	Land Improvement Act
The Burma Municipal Act (1898)	Canal Act (1905), amendment Canal Act in 1998
The Burma Canal Act (1905), amended by Burma Act of 1914, 1924, 1928 and 1934 Amended Canal Act (1998)	Myanmar Embankment Act (1909), amendment Embankment Act in 1998
The Burma Embankment Act (1909), amended by Burma Act of 1923 and 1931	Myanmar Irrigation Manual (1945), revised
City of Yangon Municipal Act (1991).	Livestock and Fisheries
The Underground Water Act (1930) Burma Act IV 1930	Law relating to Aquaculture (1989)
The Burma Water Power Rules (1932)	Fishing Rights of Foreign Fishing Vessels, (1989), amended in 1993
The Rangoon Municipal Act (1932)	The Myanmar Marine Fisheries Law, (1990) (Amending Law, 1993)
The City of Yangon Development Law, 16th May (1990) Law No. 11/90	The Freshwater Fisheries Law, (1992)
City of Yangon Development Law 17th December (1999) Law No. 6/99	
Groundwater Law in preparation by Ministry of Construction - Department of Human Settlement and Housing Development	River, Navigation, and Ports
Forestry	The Burma Ports Act (1908)
The Forest Law (1992)	The Yangon Port Act (1905)
Myanmar Forest Policy (1995)	Port Authority Law (2015)
The Protection of Wild life and Wild plants and conservation of Natural Areas Law, (1994)	Rangoon / Yangon Port Act (2015)
Environment	The Myanmar Lighthouse Act (1937)
Environmental Conservation Law (2012) Environmental Conservation Rules (2014)	The Obstruction in Fairways Act (India Act) (2013)
The Tax Law (1992)	The Conservation of Water Resources and Rivers Law (2006)
Agriculture	Economic developments
Farm Land Law (2012)	
Agricultural Land Act (2012)	Tourism and hotels law (1993, under amendment)
Health & Pollution	Myanmar Special Economic Zone Law (2014)
Water quality standards (draft)	Foreign Investment Rules (2013)
Pesticides law (1990)	Foreign Investment Law (2012)
Fertilizer law (2002)	The State Owned Economic Enterprises law (1989)
Public Health Law (1972)	Land Management
Private industrial Enterprise Law (1990)	The Land Acquisition Act (1894)
Promotion of Cottage Industries Law (1991)	Land Nationalization Act (1953)
Mines Law (1994)	Tenancy Law (1963)
Pearl Law (1995)	Vacant, Fallow, and Virgin Land Management law (2012)
Prevention and Control of communicable Diseases Law (1995, revised 2011)	

4.3.2 Relevant policies

The following policies have been mentioned in several studies as relevant with regard to water management:

- Environmental policy (1994)
- Forest Policy (1995)
- Community Forestry Instructions
- Watershed protection policy
- Myanmar Responsible Tourism Policy (2012)
- Tourism Master Plan (2013)
- National Water Policy (2014)
- National Energy Policy (2014)
- National Land Use Policy (draft, 2015)
- Overall waste Management strategy (2015)

4.3.3 Relevant strategies and plans

- Regional Development Plans
- National Sustainable Development Strategy and National Biodiversity Strategic Action Plan (1996)
- Myanmar Agenda 21 (1997)
- National Forestry Management Master Plan (2001-2030)
- National Sustainable Development Strategy (2009)
- National Biodiversity Strategic Action Plan (2011)
- National restoration and rehabilitation program in Myanmar (NRRPM)
- 30 years Agricultural Master Plan (2000)
- Agriculture strategy (status unknown)
- National Adaption Programs of Action (NAPA)
- Myanmar Climate Change Strategy & Action Plan (MCCSAP) (2017)
- WASH Strategy and investment plan
- 20 years National Planning Master Plan
- Myanmar 2nd 5 year National Development Plan (Nov 2016)
- Expected: Agriculture Master Plan for the delta via KOICA

¹⁵⁸ NIVA (2016), Framework notes and recommendations for Integrated Water Resource Management in Myanmar, RAPPORT L.NR. 7027-2016

4.4 Trends in Governance

Decision making process

Before the regime change, due to the strong hierarchical system, there were clear and strict decision structures, and an absolute top-down type of governance. Tasks and responsibilities of the various ministries, departments, as well as regional and state organizations were defined by the central government.

After the regime change this stiff type of control is gradually disappearing. The result seems to be a bit more competition and overlap between ministries. They all try to find their place within, for instance, the water (sub) sector with regard to activities, responsibilities and mandates. This may lead to overlaps and inefficient use of resources.

Decentralization

From the strongly centralized system before the regime change, a trend of decentralization seems to be occurring. Regional and state organizations are getting more responsibilities and tasks. This is relevant with regard to development of the Ayeyarwady Delta and the strategic planning of economic activities within the area.

Financing options

Due to the fact that Myanmar was 'closed' for about 20 to 25 years, urban services, infrastructure, social development etc. have been left behind and came to more or less a standstill. However, since 5 to 10 years, even before the regime change, Myanmar has been opening up for international cooperation and trade. This has also improved and opened options for financial support from international donors, financing organizations as well as bi-lateral partners. World Bank, ADB, ADF, Netherlands, JICA and various other parties are willing to help Myanmar in their development and finance projects in the field of infrastructure, urban services, social development, water resources development etc. In this respect also the interest of the new Asian (Chinese) AIIB bank should be mentioned.

Social development

Similarly, to the increasing interest and participation of (international) donors, the presence and activities of national and international NGO's has strongly increased in the last years. They mainly focus on assistance in the field of social development but also execute activities in the field of agricultural development, environmental conservation, WASH (Water Supply, Sanitation and Health), etc. Since they are generally in close contact with the people, i.e. the actual stakeholders, they are interesting partners for development, specifically for a project like IADS.

Legislation

Laws, Rules and Regulations, together with the new democratic movement and the new government since 2015, a new framework for legislation is on its way as well. A draft water framework directive has been developed in cooperation with NIVA (2014, approved in May 2015) and currently institutional review is taking place under the Integrated Ayeyarwady River Basin Management Project (AIRBMP). Also, the development of a new water law is on-going.

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Appendix 1: planned and ongoing projects in the delta

Appendix 1A: Ayeyarwady Region

Implementing INGO/NGO/companies	Projects in Ayeyarwady Region
Action Aid Myanmar	Active Citizenship for accountable governance Adolescent Engagement in Myanmar Agriculture loan Project Building Local capacities for a Livelihood systems approach in the Ayeyarwady Delta Building Local Capacities for Livelihood Systems Approach in Ayeyarwady Delta Building Resilience and Adaptation to Climate Extremes and Disasters Citizens for Accountability in Public Service Financing (CAPSF) Community Led Development Programme (1) Community Led Development Programme (3) Comprehensive Development Plan (Village Book) Installation of WASH facilities in Schools Latrine Construction Promoting Just and Democratic Governance in the Reform Process in Myanmar Promoting justice towards a violence free environment for women and girls Promoting women’s empowerment and political participation in Myanmar Ready for Anything Safer Coastal and Urban Communities through Disaster Risk Reduction in Myanmar- DIPECHO IX The Civil Society Led Community Based Livelihood Resources Development in Dry Zone BRACED Alliance Myanmar – Building Resilience and Adaptation to Climate Extremes and Disasters
Adventist Development and Relief Agency	Myanmar Monsoon Flooding Response
Ar Yone Oo Social Development Association	Linking Labutta to Markets Increasing Incomes through Agriculture, Skills & Employment
arche noVa - Initiative for People in Need	Community based disaster preparedness, disaster management improvement of food security and water supply in the Delta-Ayeyarwady Community-based disaster preparedness and disaster management and improvement of food security and water supply in the Delta, Ayeyarwady Region
Asian Development Bank	Enhancing Rural Livelihoods and Incomes Maubin Pyapon Road Rehabilitation Project Transformation of Urban Management
Association for Aid and Relief, Japan	Community Based Rehabilitation Project for PWDs in Yangon and Ayeywarwady Division Emergency Assistance Project for cyclone affected people in Yangon and Ayeyarwady Division in Myanmar Livelihood Assistance in Ayeyarwady Division
Association François-Xavier Bagnoud	Community-led Development through Theatre Project/ Human Drama Project Partnership approach for Continuum Care, Treatment, Support and Prevent HIV transmission Skills for Rural Livelihoods Development
AVSI Foundation	Stress Tolerant Rice in Vulnerable Environment (STRIVE): Support to quality Education
Bridge Asia Japan	Books and Toys Project Community's School Construction/ Renovation
CARE International in Myanmar	Community Home-Based Care Project
Charity Oriented Myanmar	Gender equality and health service equity
Christian AID	Reduction of Gender Based Violence (GBV) Supporting Participation, Accountability, and Civil Society Empowerment (SPACE)
Community Development Association	Sustainable SDC infrastructure in Ayeyarwady Region
Community Partners International	Swiss Agency for Development and Cooperation SDC
Cord	SPEED
Danish Church Aid	Assimilating Environmental Governance Integrating Sustainability Empowering landmine survivor, victims and persons with disabilities in Myanmar to cope with the negative impacts of physical handicap Rights Based Empowerment Project
Diakonia	Community Management Course Empowering Community Managed Development Project Preparing CSO Report on CEDAW by CAM RIDPCM Thriving Resilience Empowering Community Project
Eden Centre for Disabled children	Early Intervention for Disabled Children
European Union	Realisation of Disability Rights in Myanmar SMART Myanmar II - SMEs for Environmental Accountability, Responsibility and Transparency
Food & Agriculture Organization	Facilitate the process of formation and strengthening of Smallholder producer groups into Township Level Producers Association in the forest landscapes Post-Harvest losses along the rice supply chain in Myanmar Support to the development of Hybrid Rice in Myanmar Sustainable Cropland and Forest Management in Priority Agroecosystems of Myanmar Sustainable Cropland and Forest Management in Priority Agroecosystems of Myanmar

Implementing INGO/NGO/companies	Projects in Ayeyarwady Region
Gender and Development Institute	Women in Political Leadership
Good Neighbors International	Community Development Project
Government of Germany	Community Based Disaster Preparedness and Disaster Management and Improvement of Food Security and Water Supply in the Ayeyarwady Delta (2015.1812.5)
Government of Norway	Climate-smart Products and Services for Rural Myanmar
Groupe de Recherche et d'Echanges Technologiques	Delta RISE Farmers Innovating towards Agroecology FIDEL Financial Inclusion in Delta for all villages, 4 projects My Culture Promoting innovative techniques for poor family farmers
Groupe Energies Renouvelables, Environnement et Solidarités	Upscaling Dissemination of Improved Cooking stoves in Myanmar Through Replication of Best Practice From The Region
HelpAge International	Building Community Organization to Reduce Poverty and Vulnerability amongst Older People their Families in Myanmar Disaster Risk Reduction Supporting older people self-help group
Helping The Burmese Delta	Emergency Food Supply Programme High School Programme Pig Farm Project School construction TBA Educational Programme Tube Well Project
ICCO Cooperation	Livelihood enhancement and food security initiatives Social protection and livelihoods for people with disability Story of Friendship
ICEM	Developing a Strategic Environmental Assessment (SEA) of the Hydropower Sector in Myanmar (2016-2017) Ayeyarwady Healthy Rivers Project (2015-2017) State of the Basin Economic development - Integrated Ayeyarwady River Basin Management Project (2017)
IMWI	Ayeyarwady Healthy Rivers Project (2015-2017) State of the Basin groundwater and data management Integrated Ayeyarwady River Basin Management Project (2017)
International Fertilizer Development Center	Fertilizer Sector Improvement Project
International Organization for Migration	3MDG-MNCH Capitalizing human mobility for poverty alleviation and inclusive development in Myanmar (CHIME) Migration as Livelihood Diversification Strategy (MILDAS)
Ipas	Improving Quality of Post Abortion Care Services in Myanmar
Japan	Project for Improvement of Road Technology in Disaster Affected Area Project for Mangrove Rehabilitation Plan for Enhancement of Disaster Prevention in Ayeyawady Delta
Japan Heart	Providing Health Care Service to Local People Project
Japanese Org for Intl Cooperation in Family Planning	Improving Maternal Health through Enhancement of Community Capacity in Rural Areas of Myanmar Program for Improving Female Personal Hygiene through School Health Education among Young Girls in Myanmar
Jhpiego - an affiliate of Johns Hopkins University	Improved Midwifery for Maternal, Newborn, and Child Health Services
Karuna Mission Social Solidarity	Civil Society Strengthening &Pro Poor Market Climate Resilient Agriculture Community Based Disaster Risk Reduction / MF - 3 DREAM Enhancing capacity of 50 ECCD caregivers. Enhancing capacity of 9 FLE farmers Ensure Community Access to Livelihood Development Farmer Fighting Poverty Fertilizer Sector Improvement (FSI) Flood Emergency Response and Recovery Improve Sustainable Agriculture and Saving Practices then strengthen farmers association Inclusive Education for Children With Disabilities Life Skill and Mother Tongue Non Formal Primary Education (NFPE) Protection of children in Emergency and against violation Strengthening community basic health care services and credit union Strengthening Farmers Association through financial supports
Kayin Baptist Convention	Early Childhood Care and Development
Korea International Cooperation Agency	Establishment of Photovoltaic Power System for School and Public Facilities in Myanmar Formulation of Comprehensive Agriculture and Irrigation Development Master Plan in the Ayeyarwady Delta Region, Myanmar
KT Care Foundation	Cleft Lip and Cleft Palate Operation Project

Implementing INGO/NGO/companies	Projects in Ayeyarwady Region
	Emergency Relief Emergency Relief Project Mobile Clinic Scholarship
Lutheran World Federation Myanmar	Integrated Rural Development Project Project for Improved Women Livelihood
Management Sciences for Health	Regional Supply Chain Strengthening (RSCS)
Marie Stopes International	HIV prevention and care Reproductive Health Reproductive Health for Young People Youth, HIV and ARH
Médecins du Monde	Strengthening community health systems
Mercy Corps	Linking Laputta to Markets National Community Driven Development Project
Monastic Education Development Group	Educate A Child
Myanmar Environment Rehabilitation-conservation Network	A Gap Analysis for the Conservation of Freshwater Biodiversity in the Upper Ayeyarwady Basin Building Capacity and Strengthening Voice of Local NGOs for Improved Environmental Governance in Myanmar Building Capacity and Strengthening Voice of Local NGOs for Improved Environmental Governance in Myanmar(Enhancing Fish Stocks and Biodiversity in Inle Lake) Building Comprehensive Chelonian Conservation Program Developing policies for sustainable tourism in the Upper Ayeyarwady River Corridor,Myanmar Forest and Farm Facility Small Grant programme by the Asean Centre for Biodiversity co-financed by the federal republic of Germany through KfW
Myanmar Health Assistant Association	Integrated Health and Nutrition Interventions For Flood Affected Communities in Ayeyarwaddy Region and Chin State (2016) Sanitation and Hygiene Promotion Project
Myanmar Institute for Integrated Development	Myanmar Healthy River Initiative Participatory River Management
Myanmar Medical Association	Public Private Mix TB Project QDSTM
Myanmar Red Cross Society	Child Protection Community Base Health TB Myanmar Consortium for Capacity Development on Disaster Management Resilience in Myanmar 2016-2017 Project Sexual and Reproductive Health Project (SRH)
Nan Oo Teaching & National Youth Development Organization	Building Local Capacities for a livelihood Systems Approach in Ayeyarwaddy Delta
Network Activities Group	Enhancing Rural Livelihoods & Incomes Project Improving Fishery Governance System Project
Norwegian People's Aid	Amendment of the Ward and Village Tract Administration Law Emergency Flood Response Grassroots Human Rights Education in Burma Human Rights, Democracy Promotion and Public Awareness Project Voter Education & Observation Trainings and Observation for General Election 2015
OXFAM International	Strengthening civil society DipECHO
Pact Global Microfinance Fund	Pact Global Microfinance Fund(PGMF)
PATH	Introducing fortified rice to Myanmar
Plan International	CB-ECCD DipECHO
Population Services International	Control of Communicable Diseases
Premiere Urgence-Aide Medicale Internationale	Creation of an enabling environment for better engagement of key population to the HV program supported by the Global fund in Myanmar
Proximity Designs	Farm Advisory Service Irrigation Proximity Finance
Pyi Gyi Khin	Enabling Environment to access to HIV prevention and treatment/care services through promotion of law and policies in State and Region Enhance the quality of life of PLHA through ART provision, psychosocial support and increase the access to prevention services among key populations. Approach with Key Population Services Centre (KPSC) Strengthening of M&E System at township level for HIV,TB and Malaria Program under Health System Strengthening (HSS) in Myanmar Support ART Centers and Decentralized Sites for ART access, logistic, data management
Pyin Nyaw Daya	Quality Basic Education/Formal Education

Implementing INGO/NGO/companies	Projects in Ayeyarwady Region
Radanar Ayar Rural Development Association	IARD Project STRIVE Project
Ratana Metta Organization	Community mobilization for the rights and protection for street working children Drop in Centre for street working children Protecting Children in Emergencies and Against Grave Violations in conflict project Protecting vulnerable children through Inter religious cooperation in Myanmar
Relief International	Strengthening Dedaye Township Health System through the Coordinated Township Health Plan
Religions for Peace-Myanmar	Capacity Building of RfP-M Women of Faith Network Strengthening Religious Collaboration in Myanmar
Sandhi Governance Institute	Women Leadership Program
Save the Children in Myanmar	3MDG MNCH Project Bright SUN Case Management Demobilization
Social Vision Services	Implementing Community Base Forest Management Development Promotion of Sanitation and Hygiene practices through CLTS approach
Stromme Foundation	DREAM-Development and Rehabilitation of the Economy of the poor through Alternative Means
Swiss Agency for Development and Cooperation	Myanmar: Improve School Infrastructures in the Ayerawady,Delta.
Swisscontact - Swiss Foundation for Technical Cooperation	Linking Laputta to Markets (LLM)
Terre des hommes - lausanne	Child Protection
The Leprosy Mission Myanmar	GPAF Integrated Rehabilitation and Improve Access
The National Young Women's Christian Association of Myanmar	Capacity building through financial and business literacy Gender Base Violence and Men Engagement Young Women Empowerment Group Young Women leadership training institute
U.S. Agency for International Development	Stress Tolerant Rice in Vulnerable Environments
United Nations Childrens Fund	2016 August Flood Operation Awareness, mine victims support BEGE/CFS BEGE/KG BEGE/Life-skill BEGE/TEIP Birth Registration Child protection case management Child Protection System Township Community based newborn care DRR Youth Volunteer Programme HIV and Children (including PMTCT) Hospital-based treatment for under-five children with severe acute malnutrition Integrated Humanitarian Health & Nutrition Intervention for flood affected people in Ayeyarwaddy and Chin State (2016_2017) MNCH Quality Care Promotion of Sanitation and Hygiene practices through CLTS approach Promotion of Sanitation and Hygiene practices through CLTS approach in Bogalay Township, Ayeyarwaddy Protection of Vulnerable Children and Women Through Strengthened Child Protection Systems Strengthening Community-based Child Protection System Support to the Anti-Trafficking in Persons Division WASH Early Recovery Responses to Flood affected Communities
United Nations Development Programme	Democratic Governance Programme Local Governance Programme Myanmar Disaster Loss and Damage Database / Data Collection
United Nations Educational, Scientific and Cultural Organization	Communication for Sustained Livelihoods and Food Security
United Nations Human Settlements Programme	BRACED Alliance Coordinator Disaster Responses & Preparedness Resilient Coastal Communities and Myanmar Climate Change Initiative (MCCA) Myanmar Consortium for Capacity Development on Disaster Management (MCCDDM) Transformation of Urban Management in Myanmar- Capacity Building for Urban Management
United Nations Population Fund	Programme for RHCS & Capacity Development in Myanmar Sexual and Reproductive Health Youth and ARH
United Nations World Health Organization	Health System Strengthening in Myanmar Prevention and control of HIV/AIDS Prevention and Control of Malaria

Implementing INGO/NGO/companies	Projects in Ayeyarwady Region
	Prevention and control of Tuberculosis Routine immunization programme
World Child Cancer	Beazley Insurance company Nutrition Project City Love & Hope Foundation Project DFID-Global Poverty Action Fund (GPAF) Dignitas Business Limousines Please Take Me There Project Twinning Programme
World Concern Myanmar	Labutta Water, Sanitation and Nutrition Project
World Vision	Bogale Child Development Project Bogale Economic Development Project Bogale Education Project Bogale Livestock Project Bogale Maternal, Newborn, Child Health and Nutrition Project Cookstove Kyangin Child Development Project Kyangin Child Protection and Advocacy Project Kyangin Economic Development Project Kyangin Education Project Kyangin Health Project Kyangin Income and Economic Development Project Pathein Child Development Project Pathein Education Project Pathein Health Project Pathein Livelihood Project Thabaung ENRICH project Thabaung Health Project Thabung Economic Development Project
World view International Foundation	Community-based mangroves e.g. Mangrove restoration - sustainable community development in adaptation to climate change (to 2020) MoU with the Forest Department of MoNREC.
WorldFish	Promoting Sustainable Growth Of Aquaculture In Myanmar To Improve Food Security And Income For Communities In The Ayeyarwady Delta And Central Dry Zone (myfish-culture-myfc) State of the Basin fisheries - Integrated Ayeyarwady River Basin Management Project (2017)
WWF	State of the Basin Economic development - Integrated Ayeyarwady River Basin Management Project (2017) Myanmar national ecosystem service assessment technical report, May 2016, Natural Capital Project

Appendix 1B: Yangon Region

Implementing INGO/NGO/companies	Projects in Yangon
ACTED	Support Vocational training centers for unemployed youth in Myanmar
Action Aid Myanmar	Promoting women’s empowerment and political participation in Myanmar
Africa Asia Development And Relief Foundation	Brighter future Library Project Mushroom Farming project New Hope Class Project
Agence Française de Développement	ECOMORE - ECONomic Development, ECOsystem Modifications and Emerging Infectious Diseases Risk Evaluation
Alinntaw (The Light)	Agro Training Cash Grants Food Distribution
Asian Development Bank	Power Distribution Improvement Project Power Transmission and Distribution Improvement Project Power Transmission Improvement Project Pro-Poor Community Infrastructure and Basic Services
Association for Aid and Relief, Japan	Community Based Rehabilitation Project for PWDs in Yangon and Ayeywarwady Division Disability Development Emergency Assistance Project for cyclone affected people in Yangon and Ayeyarwady Division in Myanmar Empowerment of SHGs of Eden Centre for Disabled Children Myanmar Foster Children Program Promotion of Employment and Schooling for Persons with Disabilities in Yangon Strengthening Employment Support for Persons with Disabilities in Myanmar Vocational Training for Persons with Disabilities
Association François-Xavier Bagnoud	Community-led Development through Theatre Project/ Human Drama Project Livelihood assistance to access education for sustainable socio economic development Partnership approach for Continuum Care, Treatment, Support and Prevent HIV transmission Promoting Access to ARH Information by young people Promoting GBV Policy Dialogue for the Development of Gender/GBV Policy, SOP, Action Plan and Laws Skills for Rural Livelihoods Development
Better and Undisruptive Delivery Support	HIV/AIDS Programme
BRAC Myanmar	Microfinance
Bridge Asia Japan	Books and Toys Project
British Council	English for Education System
Burnet Institute Myanmar	AAMI Study (Accelerating HIV Testing and ART Initiation Among Infants Study) Comprehensive community-based prevention and care for drug-resistant tuberculosis Enhancing education and health services to reduce harms related to drug use Improving community demand for timely maternal and child health services Pathways to Post-abortion Care in Myanmar Working with men to address HIV (GF)
CARE International in Myanmar	Gender Equality & Women Empowerment Programme Improving Access to Safe Employment for Migrant Women in Urban Myanmar Personal Advancement & Career Enhancement (P.A.C.E) for Women in Factories
Center for Vocational Training	CVT-Certified Instructors Post Graduated Program for Young Entrepreneurs/ YE4M Training Companies Instructors
CESVI Foundation	Sustainable Urban Mobility Planning
Charity Oriented Myanmar	Democratic Governance Program
ChildFund Myanmar	Enhancing the effectiveness of Case Management System in the community Protection and Empowering Children and Youth Yangon Monastic Education Training Centre
CHINA FOUNDATION FOR POVERTY ALLEVIATION(CFPA)	Paukphaw Scholarship Project
Christian AID	Reduction of Gender Based Violence (GBV)
Danish Church Aid	Empowering landmine survivor, victims and persons with disabilities in Myanmar to cope with the negative impacts of physical handicap Ethnic Peace Resource Project Improving Civil Society Capacity to Combat Gender Based Violence in Myanmar Promoting Gender Equality in the Faith-Based Institutions Rights Based Empowerment Project Strengthening Access to Justice for Women and Girls Project
Danish International Development Agency	Establishment of a Bachelor Programme in Business Administration
Diakonia	Combating Violence Against Women through Economic Empowerment Community Management Course Empowering Community Managed Development Project Gender Based Violence Reduction in Myanmar Preparing CSO Report on CEDAW by CAM Thriving Resilience Empowering Community Project
Eden Centre for Disabled children	Child Development Program

Implementing INGO/NGO/companies	Projects in Yangon
	Early Intervention for Disabled Children Education For All Project Sponsorship with Children with disabilities Supporting CWDs for their needed services
European Union	Realisation of Disability Rights in Myanmar SMART Myanmar II - SMEs for Environmental Accountability, Responsibility and Transparency Supporting Reconciliation between Key Actors and Working Towards Security Sector Reform in the Myanmar Peace Process
Food & Agriculture Organization	Improvement of data collection on Fisheries and Aquaculture; pilot system for the Yangon Region Promoting an Integrated Home Garden and School Garden approach for food and nutrition security in Myanmar Support for animal feeding strategies for improved livestock production in Myanmar
Forever Humanitarian & Develoment Projects	Saving Group Street Children Integration Project
Golden Plain Livelihood Development Services Co-op Ltd	Fertilizer Sector Improvement
Good Neighbors International	Community Development Project
Government of France	Creation of the Myanmar Journalism Institute
Government of Germany	Support of a Network for Social Security and for Relevant Counseling on the Community Level in Htan Tabin, Yangon Region (2014.5521.1)
Government of Italy	Development of Rural Aquaculture through Entrepreneurship in Women in Myanmar Environmental Protection and Sustainable Development: Building Local Capacities on Solid Waste Management in Myanmar Small scale fishery and aquaculture in Myanmar Institutional support for dissemination of European Regulations and Best Mediterranean Practices Support to Yangon Animal Upgrading Centre
Groupe de Recherche et d'Echanges Technologiques	LIFT-LAND
HelpAge International	Building Community Organization o Reduce Poverty and Vulnerability amongst Older People their Families in Myanmar Supporting older people selfhelp group
Helping The Burmese Delta	Scholarship Programme
ICCO Cooperation	Conflict sensitive economic governance program Social protection and livelihoods for people with disability Understanding women's issues in achieving food security Women and youth empowerment program
International Alert	Conflict-Sensitive and Social Cohesion Responsive Local Development Conflict-Sensitive Forest Governance in Myanmar Supporting Safer Communities: Community Driven Sexual and Gender Based Violence Reduction Understanding masculinities and critically engaging male champions for peacebuilding in Myanmar
International Fertilizer Development Center	Fertilizer Sector Improvement Project
International HIV/AIDS Alliance	CAHR Global Fund
International Organization for Migration	Community-based TB awareness, detection, diagnosis and treatment in mobility impacted communities in Mon & Kayin State
International Union Against Tuberculosis and Lung Disease/The Union	Integrated HIV Care Program (IHC)
Ipas	Improving Quality of Post Abortion Care Services in Myanmar
Japan	Adviser on Water Supply and Sanitation Improvement Advisor for improvement of the capacity of Thilawa SEZ Management Committee in Myanmar ASEAN University Network / Southeast Asia Engineering Education Development Network Project Phase III Communication Network Improvement Project Greater Yangon Water Supply Improvement Project Greater Yangon Water Supply Improvement Project (Phase II) (I)Infrastructure Development Project in Thilawa Area Phase 1 Infrastructure Development Project in Thilawa Area Phase 1 & 2 National Power Transmission Network Development Project Phase I 7 II Power Distribution Improvement Project in Yangon Phase 1 Project for Construction of New Thaketa Bridge Project for Development of ICT System for Central Bank of Myanmar Project for Enhancing Technological Universities in Myanmar Project for Improvement of Medical Equipment in General Hospitals in Yangon Project for Improvement of Water Supply Management of YCDC Project for Installation of Operation Control Center System and Safety Equipment The Project for Improvement of Foot-and-Mouth Disease Control The Project for Improvement of Malaria Control Equipment

Implementing INGO/NGO/companies	Projects in Yangon
	Yangon Circular Railway Line Upgrading Project Yangon-Mandalay Railway Improvement Project Phase 1
Japan Heart	Medical Massage Project Providing Health Care Service to Local People Project Scholarship Programme Supporting to Dream Train Child Development Centre Project Supporting to School Children Project
Japan International Co-operation Agency	The Project for Improvement of Nationwide Airport Safety and Security The Project for Reduction of Non-Revenue Water in Mayangone Township in Yangon City
Jhpiego - an affiliate of Johns Hopkins University	“Improving Maternal Health in Myanmar: A Scalable Model” Maternal and Child Survival Program same as above
Kayin Baptist Convention	Early Childhood Care and Development
Korea EximBank	Korea-Myanmar Friendship Bridge
Korea International Cooperation Agency	Project for Establishment of Master Plans for Yangon-Hanthawaddy-Bago Corridor and Yangon South-western Regional Development in Myanmar Project for Establishment of Technical Teacher's Training Institute in Myanmar
KT Care Foundation	Health Education
Lutheran World Federation Myanmar	Integrated Rural Development Project
Marie Stopes International	HIV prevention and care Maternal and Child Health Reproductive Health Reproductive Health for Young People Sexual and Reproductive Health Youth, HIV and ARH
Médecins du Monde	HIV/AIDS prevention and care targeting most at risk groups TB/HIV collaborative activities
Monastic Education Development Group	Educate A Child
Mote Oo Education	Educational service
Myanmar Anti-Narcotics Association	HIV Prevention among Most at Risk population (MARPs)
Myanmar Health Assistant Association	Patient-centered Community-based MDR-TB care Project
Myanmar Medical Association	Public Private Mix TB Project
Myanmar Red Cross Society	Child Protection Children Associated with Armed Conflicts (Armed Forces and Armed Groups) Community Based Health and First Aid Community Safety and Resilience Program Community Based TB Care/ Global Fund Enhancing Disaster Safety in Vulnerable Communities and School in Myanmar Myanmar Consortium for Capacity Development on Disaster Management
Network Activities Group	Community Driven Development Project
Norwegian People's Aid	Amendment of the Ward and Village Tract Administration Law Civic Education for Just Peace Democracy Enhancement Program Election Observation Mission (Bi election) Election Observation Project for 2015 General Election Grassroots Human Rights Education in Burma Human Rights and Democracy Promotion Human Rights, Democracy Promotion and Public Awareness Project Strengthen Democracy through Electoral Reform Women Can Do It Programme - Phase – 3, Phase - 4 Women Transforming Political Spaces for Peace and Democratic Governance in Myanmar Youth Empowerment through Student Unions Leadership
Pact Global Microfinance Fund	Pact Global Microfinance Fund(PGMF)
PACT-Myanmar	Shae Thot Strengthening Abilities for Women's Economic Empowerment Swan Yi
Partners Myanmar	Améliorer l'accès aux infrastructures Watsan dans 10 écoles Une nouvelle école pour un meilleur future au Myanmar W 18, un village aux conditions précaires Water in school for a better education
Partnership for Change	Civic Education for Youth Entrepreneurial Support Vocational Training for Hospitality
PATH	Introducing fortified rice to Myanmar
Phoenix Association	Care Support & Treatment Educational Support Hospitalize Care Support

Implementing INGO/NGO/companies	Projects in Yangon
	Promoting Rule of Law Project Sexual Reproductive Health
Plan International	ASEAN Safe School Initiative Building Disaster Resilience of Children, Communities and Institutions in Myanmar DIPECHO
Population Services International	Control of Communicable Diseases
Premiere Urgence-Aide Medicale Internationale	Creation of an enabling environment for better engagement of key population to the HIV program supported by the Global fund in Myanmar HIV mobile testing and referral to DC, HIV Prevention HIV prevention, care and treatment towards a safe motherhood in Myanmar
Proximity Designs	Farm Advisory Service Irrigation Proximity Finance
Pyi Gyi Khin	Building Awareness of Civil Society in Right to Information Coordination Office Enabling Environment to access to HIV prevention and treatment/care services through promotion of law and policies in State and Region MDR-TB Patient-Centered Community Based MDRTB Care Model Strengthening of M&E System at township level for HIV,TB and Malaria Program under Health System Strengthening (HSS) in Myanmar Support ART Centers and Decentralized Sites for ART access, logistic, data management
Ratana Metta Organization	Community mobilization for the rights and protection for street working children Direct beneficiaries Monitoring System FOC Clinic Justice access and raising legal awareness for children and women in Haling Thar Yar Protecting Children in Emergencies and Against Grave Violations in conflict project
Relief International	National Community Driven Development Project (NCDD) for Htantabin Township
Religions for Peace-Myanmar	Capacity Building of RfP-M Women of Faith Network Peaceful Living in Harmony/Interreligious Development Activities for Peace Strengthening Religious Collaboration in Myanmar
Sandhi Governance Institute	Women Leadership Program
Save the Children in Myanmar	Case Management Demobilization MMR Supporting Victims of Trafficking in the Criminal Justice Process Support the development of a strong and knowledgeable local civil society that are able to demand child rights in Myanmar
Swiss Agency for Development and Cooperation	Institutional support to the Centre for Vocational Training School Reconstruction
Swisscontact - Swiss Foundation for Technical Cooperation	Vocational Skills Development Program (VSDP)
Terre des hommes - lausanne	Child Protection Juvenile Justice MNCH Project
Terre des hommes Italia	Children Sponsorship program
The Border Consortium (Burmese Women's Union)	Women's gathering for Gender Justice and Ethnic Reconciliation
The Border Consortium (Ethnic Nationalities Affairs Center)	Policy Consultation with United Nationalities Alliance
The Border Consortium (Kawthoolei Land Committee)	Farmers' Land Conference
The Leprosy Mission Myanmar	CBR Main CBR Outreach GPAF Integrated Rehabilitation and Improve Access
The National Young Women's Christian Association of Myanmar	Adolescent girls, health awareness Capacity building through financial and business literacy Meal for needy in-patients Vocational training Resource Center Volunteered based Health Services for Aged People Young Women Empowerment Group Young Women leadership training institute
Thingaha Gender Organization	Gender Education
Trocaire	Connecting national land initiatives Evidence based advocacy through land disputes database website Gender Programme Myanmar Alumni Professional Land Rights Fellowship Program Supporting Growth of the Land Core Groups advocacy to secure land tenure rights for small holder farmers in Myanmar
U.S. Agency for International	Stress Tolerant Rice in Vulnerable Environments

Implementing INGO/NGO/companies	Projects in Yangon
Development	
United Nations Childrens Fund	2016 August Flood Operation Awareness, mine victims support BEGE/CFS - BEGE/EXCEL - BEGE/KG - BEGE/Life-skill - BEGE/TEIP Child protection case management Child Protection System Township F4C Project (Faith for Children) HIV and Children (including PMTCT) Hospital-based treatment for under-five children with severe acute malnutrition Protection of Vulnerable Children and Women Through Strengthened Child Protection Systems Strengthening Community-based Child Protection System Support to the Anti-Trafficking in Persons Division WASH in School
United Nations Development Programme	Democratic Governance Programme
United Nations High Commissioner for Refugees	Capacity building on HLP CCCM Coordination Cross border meetings (Quarterly Myanmar/Thailand) General IM Support for the UNHCR operation in Myanmar Legal research on citizenship in Myanmar Legal support for stateless persons Maintain the protection incident monitoring mechanism NFI Cluster Coordination Protection Sector coordination Shelter Cluster Coordination Support to obtain civil documentation
United Nations Human Settlements Programme	BRACED Alliance Coordinator Disaster Responses & Preparedness Resilient Coastal Communities and Mapping Yangon- The Untapped Communities (Cities Alliance) Strengthening Community and Institutional Resilience to natural hazards in Myanmar Transformation of Urban Management in Myanmar- Capacity Building for Urban Management
United Nations Industrial Development Organisation	Fostering Pro-Poor and inclusive SME Development in Myanmar Pilot National Resource Efficient and Cleaner Production (RECP) Programme, Myanmar Strengthening the National Quality Infrastructure for Trade in the Republic of the Union of Myanmar
United Nations Office for the Coordination of Humanitarian Affairs	OCHA Yangon Office
United Nations Population Fund	Programme for RHCS & Capacity Development in Myanmar Sexual and Reproductive Health Youth and ARH
United Nations World Health Organization	Health System Strengthening in Myanmar Prevention and control of HIV/AIDS, Malaria, Tuberculosis Routine immunization programme
World Child Cancer	Beazley Insurance company Nutrition Project City Love & Hope Foundation Project DFID-Global Poverty Action Fund (GPAF) Dignitas Business Limousines Please Take Me There Project Twinning Programme
World Vision	Child Development Project Dagon Seikkan BRACED Project, Child Development Project, Economic Development Project, Hlegu Child Development Project, Education Project, Health Project, Livelihood Project

Appendix 1C: Bago (west) Region

Implementing INGO/NGO/companies	Projects in Bago (West)
Burnet Institute Myanmar	Working with men to address HIV (GF)
CARE International in Myanmar	Community Home-Based Care Project
Danish Church Aid	Promoting Gender Equality in the Faith-Based Institutions
Diakonia	Community Management Course Empowering Community Managed Development Project Preparing CSO Report on CEDAW by CAM RIDPCM Thriving Resilience Empowering Community Project
European Union	Realisation of Disability Rights in Myanmar SMART Myanmar II - SMEs for Environmental Accountability, Responsibility and Transparency
Family Health International	Challenge TB
ICCO Cooperation	Cooperation of Livelihoods in Agricultural Business Project (CLAP) Empowering farmers to market Improved Livelihood Opportunities Through Sustainable Agriculture Trainings Project Social protection and livelihoods for people with disability

Implementing INGO/NGO/companies	Projects in Bago (West)
International Fertilizer Development Center	Fertilizer Sector Improvement Project
International HIV/AIDS Alliance	Global Fund UNFPA
Japan	Communication Network Improvement Project Project for Profitable Irrigated Agriculture in Western Bago Region The Project for Improvement of Malaria Control Equipment Yangon-Mandalay Railway Improvement Project Phase 1
Japanese Org for Intl Cooperation in Family Planning	Program for Improving Female Personal Hygiene through School Health Education among Young Girls in Myanmar
Jhpiego - an affiliate of Johns Hopkins University	Maternal and Child Health
Karuna Mission Social Solidarity	Farmer Led Sustainable Livelihood Project HIV and AIDS Prevention, Care and Support Programme Promoting Forest Governance, Customary Land Tenure & Indigenous Rights for 30 Ethnic Minorities in East & west Bago region Protecting of Children in Conflicts and against violation
Kayin Baptist Convention	Early Childhood Care and Development Mother and Child Health Improvement
KfW Entwicklungsbank	Vocational Training Programme - Industrial Training Center Sinde
Management Sciences for Health	Regional Supply Chain Strengthening (RSCS)
Marie Stopes International	HIV prevention and care Reproductive Health
Mercy Corps	National Community Driven Development Project
Monastic Education Development Group	Educate A Child
Myanmar Medical Association	Public Private Mix TB Project
Myanmar Red Cross Society	Child Protection Children Associated with Armed Conflicts (Armed Forces and Armed Groups) Community Based Health and First Aid Sexual and Reproductive Health Project (SRH)
Norwegian People's Aid	Amendment of the Ward and Village Tract Administration Law Civic Education for Just Peace Emergence Flood Response Grassroots Human Rights Education in Burma Human Rights, Democracy Promotion and Public Awareness Project
Population Services International	Control of Communicable Diseases
Proximity Designs	Irrigation
Pyi Gyi Khin	Support ART Centers and Decentralized Sites for ART access, logistic, data management
Radanar Ayar Rural Development Association	CLAP Food Safety Project
Ratana Metta Organization	Child Labour Elimination through community participation Protecting Children in Emergencies and Against Grave Violations in conflict project
Religions for Peace-Myanmar	Capacity Building of RfP-M Women of Faith Network Strengthening Religious Collaboration in Myanmar
Sandhi Governance Institute	Women Leadership Program
Save the Children in Myanmar	Case Management
Social Development Initiative	Linking Farmer Community with Market & Household Income Development
Swiss Agency for Development and Cooperation	Community-led Coastal Management In the Gulf of Mottama
Terre des hommes - lausanne	Child Protection
The National Young Women's Christian Association of Myanmar	Capacity building through financial and business literacy Young Women Empowerment Group
U.S. Agency for International Development	Stress Tolerant Rice in Vulnerable Environments
United Nations Childrens Fund	2016 August Flood Operation BEGE/EXCEL BEGE/KG BEGE/Life-skill Child protection case management Child Protection System Township Community based newborn care HIV and Children (including PMTCT) Hospital-based treatment for under-five children with severe acute malnutrition Protection of Vulnerable Children and Women Through Strengthened Child Protection Systems
United Nations Educational, Scientific	Capacity Building for Safeguarding Cultural Heritage in Myanmar - Phase II

Implementing INGO/NGO/companies	Projects in Bago (West)
and Cultural Organization	
United Nations Population Fund	Sexual and Reproductive Health Youth and ARH
United Nations World Health Organization	Health System Strengthening in Myanmar Prevention and control of HIV/AIDS Prevention and control of Malaria
World Bank	Myanmar Agricultural Development Support Project
World Child Cancer	Beazley Insurance company Nutrition Project City Love & Hope Foundation Project DFID-Global Poverty Action Fund (GPAF) Dignitas Business Limousines Please Take Me There Project Twinning Programme