Myanmar Integrated Water Resources Management

Strategic Study

Research and Analysis,
Strategies and Measures

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December 2014

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1. Introduction to IWRM in Myanmar

Setting the right strategy before master planning

The Myanmar IWRM Strategic Study aims to contribute in a participative manner to the development of a national strategy for integrated water resources management (IWRM) in Myanmar[1]. The fullest possible use has been made of insights into delta management, IWRM and adaptive water management as developed in the Dutch delta programme and elsewhere in the world. The strategic study assists in responding to the national IWRM challenges and opportunities in Myanmar. It provides options and recommendations as building blocks for a Myanmar National Water Master Plan. It does not go into detail as may be expected from a comprehensive *master plan*. This study is at a strategic level; it presents an overview of the most important challenges and anticipated changes in water resources management, what measures could be taken and the expected impact of these measures as well as their economic and financial aspects. The building blocks, recommendations, proposed strategies and measures may be used by the Government of the Republic of the Union of Myanmar for initial decision making, taking into consideration their priorities. Eventually, the preferred strategy can then be further detailed in a future IWRM Master plan.

Opportunity to coordinate towards sustainable development

When looking at present day Myanmar, it can be observed that the country is to a large extent still unspoiled. With its abundance in natural resources, including water, the country has great opportunities to achieve a balanced and sustainable development. However, it is crucial to do this wisely. Mistakes visible in neighbouring countries with respect to depleting natural resources and degradation of the environment can well be avoided. Similarly, the international community has another chance to support and assist a developing country without falling into old patterns of uncoordinated actions.

The Netherlands and Myanmar collaborate in water resources management

The Dutch Ministry of Infrastructure and Environment has offered to support the Government of Myanmar in the development of an Integrated Water Resources Management (IWRM) Strategy for Myanmar, and in May 2013 has signed a Memorandum of Understanding (MoU) with the Myanmar Ministry of Transport, in name of the Myanmar National Water Resources Committee (NWRC).

The Expert Group of the NWRC, as senior advising group to the NWRC, has been the immediate counterpart for a Dutch High Level Expert Group, headed by former Minister of Agriculture, Mr. Cees Veerman. The secretariats of both the NWRC and its Expert Group have been the liaison between expert groups, the relevant Ministries and Departments of Myanmar and the Dutch Study Team who all gave guidance in the preparation of the Myanmar Integrated Water Resources Strategic Study.

[1] As used in this document, the terms integral water management and Integrated Water Resources Management (IWRM) are synonymous with each other.

Two reports

The study team has prepared two reports. This report "Research and Analysis, Strategies and Measures" gives a comprehensive account of the research and analysis results as well as the elaboration of possible Myanmar development scenarios and applicable strategies to cope with these possible futures from an IWRM point of view. Myanmar is in urgent need to actually start development and leap "From Vision to Action". The report also contains a (long) list of no-regret and quick-win projects for short-term implementation. The Dutch Study Team has based its Strategic Study, with 'building blocks' for future policy development, capacity building and legal framework elements, on intensive stakeholder participation and discussions with experts in Myanmar.

The second document constitutes the "Executive Report" and, apart from being a shorter version of this document "Research and Analysis, Strategies and Measures", focuses on 'thoughts for future development' and translating "vision into action".

We stress that the assessment should not be considered fully comprehensive in view of the limited time the study team has been able to spend in Myanmar and the vastness of the country and the related issues on water resources management.

In preparation of these reports the Study Team has used the IWRM data collection of Deltares and Delft University of Technology (December 2013). See also Appendix 12.

2. Water Policy Framework

2.1 Water Policy Development

The National Water Policy (NWP) is the first integrated water policy for the watersheds, rivers, lakes and reservoirs, groundwater aquifers and coastal and marine waters of all of Myanmar. The objective of the National Water Policy is to take cognisance of the existing situation, to propose a framework for creation of a system of laws and institutions and for a plan of action with a unified national perspective including the Myanmar Water Framework Directive (MWFD). This Myanmar Water Framework Directive is to be an umbrella statement of general principles governing the exercise of legislative and/or executive (or devolved) powers by the Union, the States and Regions, and the local governing bodies[2].

The Expert Group of the National Water Resources Committee prepared the NWP, after which it was approved by the National Water Resources Committee on 13 March 2014. The NWP was formalised by the approval of the National Water Resources Committee. As a consequence to this formalisation, the NWP can and should be used as an umbrella and as guidance for:

- All further policy development on water resources or subjects that relate to or have an impact on Myanmar's water resources;
- Further development of legal instruments and a system of institutions to protect and manage Myanmar's water resources;
- Strategies, master plans, development plans and projects that relate to or have an impact on Myanmar's water resources.

The Expert Group of the National Water Resources Committee aims to prepare a Plan of Action based on the National Water Policy. This Plan of Action needs to be approved by the National Water Resources Committee and its implementation needs to be regularly monitored. The NWP will also be used for the development of the Myanmar Water Framework Directive, which, in turn, is the framework for the development of legal instruments (starting with a Water Law). Both developments are planned to start in 2014.

[2] (The term directive as used for the MWFD is different from when used in relation to the European Union Water Framework Directive (EU WFD) which applies also to legal instruments in relation to water management).

Figure 2-1 Word cloud Water Policy visualises word frequencies in water policy. It shows e.g. that Water Policy emphasises on management of water resources and that floods, pollution and climate change are important concerns. *[developed through website: Tagcrowd.com]*

2.2 From National Water Policy to IWRM Strategic Study

The goal of the NWP is adopted for the IWRM Strategic Study. The goal is:

To develop, share and manage the water resources of Myanmar in an integrated, holistic and socially inclusive manner, to contribute significantly to the poverty alleviation, to the green growth and sustainable development of the nation, by providing access to water of equitable quantity and safe quality for all social, environmental and economic needs of the present and future generations.

This goal is reflected into the approach of the IWRM Strategic Study.

The main issues from the NWP were recognised, verified and elaborated upon in this IWRM Strategy. Since Myanmar is facing rapid socio-economic development, the guiding principles of the NWP are crucial to support the desired green and sustainable development.

The NWP already points out a great variety of needs and measures. The study team took these measures as a starting point for further development, prioritisation and structuring in this report. The most important and specific measures are structured in Appendix 1.

Finally the vision of the NWP was adopted as the long-term vision for the IWRM Strategy development. This vision is:

By 2020 Myanmar has become a water efficient nation with well-developed and sustainable water resources based on fully functional integrated water resources management system.

2.3 From Vision to Implementation

There is a great sense of urgency to take the step from vision to implementation. This study envisions its most important steps as follows.

- Considering the existing water stress conditions in Myanmar and the likelihood of a further worsening situation due to climate change and other factors, water resources projects should be planned as per the efficiency benchmarks to be prescribed for various situations.
- Being inter-disciplinary in nature, water resources projects should be planned considering social and environmental aspects also in addition to techno-economic considerations in consultation with project affected and beneficiary families.
- Local governing bodies like water resources authorities, municipalities, corporations, etc., and water users associations, wherever applicable, should be involved in planning of the projects.
- All water resources projects should be planned as multi-purpose projects with provision of storage to derive maximum benefit from available topology and water resources.
- Big infrastructure projects should establish an "Ecosystem Compensation Fund" (see 6.3.4 and 9.3), in addition to social compensations.

3. Approach to the study

3.1 General overview and study framework

As stated before, this strategic study provides building blocks for a Myanmar National Water Master Plan. It will not go into details as may be expected from a comprehensive master plan, but will give an overview, with respect to water resources management, of:

- challenges and anticipated changes
- measures
- economic and financial consequences of measures.

In master planning, and building on present conditions as a starting point, the time frame for the plan is to be set. Most of the short-term planning is developed for 2014-2015. The present planning horizon in Myanmar is 2030. The Minister of planning suggest for the study 2040. In accordance with the National Planning of Myanmar a Fiscal Year starts from 1st April and ends on 31st March of the next year.

In this strategic study we emphasise on the current situation and the near future (short-term) (2015 and 2020). Taking into account Myanmar's fast changing conditions and expected fast development as compared to the previous decades, for all practical purposes the long-term planning horizon has been set at 2040. Actually changing climate conditions, of the recent past as well as for the farther future, should be taken into account.

Next when looking at a possible future a long-term vision on what is to be achieved in the longer future is to be formulated. As discussed in Chapter 2, for Myanmar such a vision is already in place and formulated in the recently approved National Water Policy: **"**A water efficient nation in 2020 with well-developed and sustainable water resources". To achieve this by 2020 will be a challenge and is to be done gradually and for this proper steps need to be taken publicly and privately. It will be a great achievement to sustain this in a later future.

President U Thein Sein has also expressed his vision for Myanmar "to strive for a green economy and green growth". He has reiterated this vision in his address on the occasion of the of World Environment Day on 5th June, 2014.

The present situation as starting point, the long-term vision for Myanmar as a whole and its water resources in particular with a horizon set at 2040 and the Myanmar Water Policy are the basic presumptions for the overall framework of the IWRM Strategic Study.

The framework is presented in the figure below.

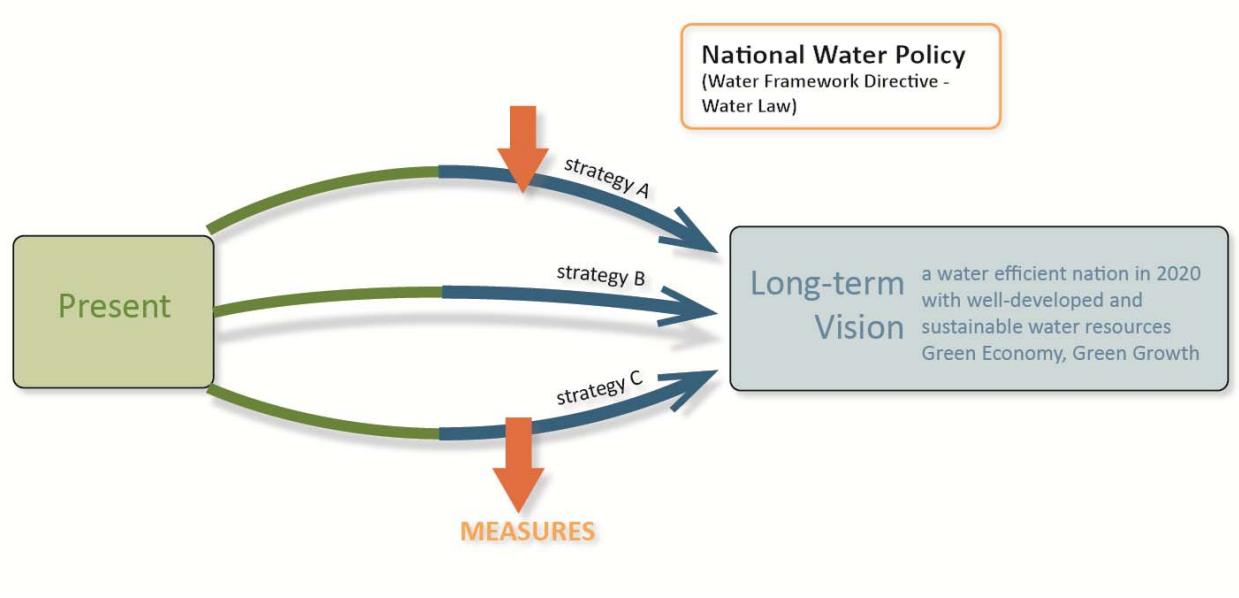


Figure 3-1 Framework for Strategic Study Team.

Before strategies can be developed to achieve the long-term vision, various scenarios for future development have to be considered. The demand and supply of water resources have large uncertainties. The demand will be influenced mostly by demographic, socio-economic and spatial planning developments.

Different development scenarios will, to some extent, require different strategies to achieve the long-term goal. In developing these scenarios the National Water Policy offers specific criteria for implementation of the strategies.

To realise the strategies concrete measures will need to be taken. These measures can be 'hard' measures such as river training works or irrigation schemes but also 'soft' measures related to aspects of good water resources governance such as data collection and monitoring to allow realistic adherence and enforcement of water legislation and rules.

A vision on long-term developments is important to know the direction of measures, but Myanmar is in dire need of short-term, concrete measures. These must be measures that are suitable in any long-term development (no-regret measures) and it must be possible to realise them in the short term with clear definitions of the expected results (quick-wins).

Finally in identifying the required measures, based on the strategies, this may again give a feedback on the realism and practicability of the water policy presently approved.

In the scenario development in first instance future socio-economic developments including population growth and land use changes are considered as overruling exogenous developments in relation to Myanmar's water resources.

Climate change is another aspect to be taken into account which for each strategy may require specific measures in both the near as well as the longer future.

The actual future socio-economic, population growth and climatic change impacts on then available water resources and demands are not known yet. Over time adaptive IWRM will be needed to adjust to the ever changing circumstances.

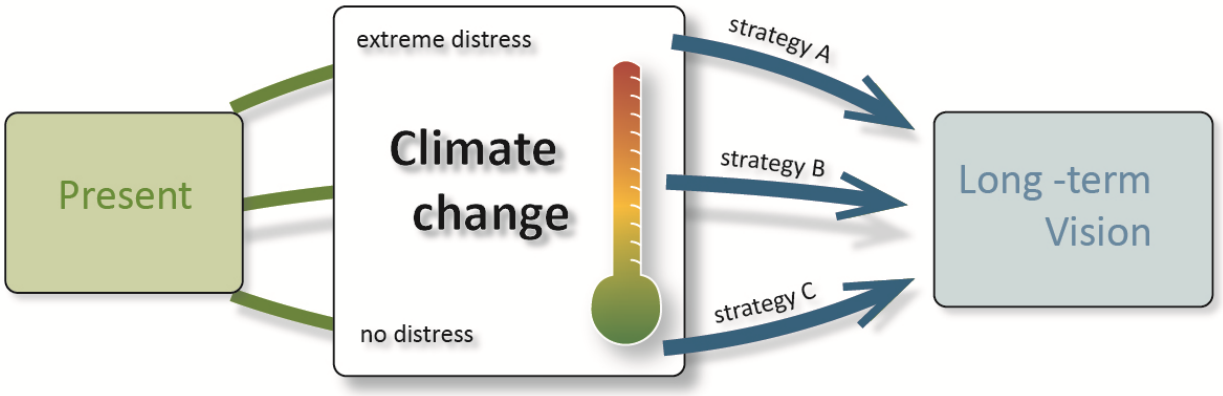


Figure 3-2 Apart from the socio-economic scenarios, also the physical systems changes. Climate change is one important issue.

3.2 Working approach

Below the study's working approach and the underlying principles are further clarified.

Integrated approach

The essence of *integrated* water resource management is that it integrates:

- different kinds of water uses, for example irrigation and drinking water;
- water and other socio-economical fields, for example water and agriculture, industry, forestry;
- 'hard' technical measures and 'soft' measures like social economic developments and water governance.

It is important to understand that measures have their own effects, but also directly and indirectly affect the outcome of other measures. That is why measures have to be assessed not only by their own effects but also in the combination of measures in strategies. Only this integrated assessment will provide the required information on whether strategies are sustainable.

People-centred

It is the people of Myanmar who have to benefit from the results of the strategic study. This can only be reached when strategies are developed and implemented in close cooperation with the involved stakeholders.

Ambition with realism

Myanmar changes rapidly and the direction of political and socio-economic changes will change the country even more. The GoM's ambition for a people centred development aiming at a stable livelihood and a green economy will need to be implemented within the prevailing socio-economic conditions. The international community may play an important role to facilitate in matching ambition with realism.

Adaptive water management

In developing IWRM strategies the combination of measures will be judged against their combined effectiveness under changing circumstances in time. The change can be due to climate change but more likely due to changes in socio-economic development. For the

planning horizon considered, 2040, it is expected that socio-economic development will be the overruling factor.

Participative approach

A clear and well thought through approach does not always mean it is automatically accepted. To find acceptance by the stakeholders involved, the study team has adopted an intensive participative approach with the stakeholders as from the early stages of the study and will continue to do so till the end. Stakeholder groups are governmental authorities (national, regional and local), NGO's, private companies, investors and Myanmar people in both the urban and rural areas.

3.3 Future scenario development methodology

To be able to plan IWRM measures properly it is necessary to have a clear view on what future developments might bring for Myanmar. How the country will develop cannot be fully prognosticated. Different visions, projections and goals exist, however, the Green Economy Green Growth (GEGG) development path is leading in the President's public communications. The Framework for Economic and Social Development (FESD) and the expected National Comprehensive Development Program (NCDP) provide guidance but leave room for differentiating development paths. That is why it is important to establish the range of potential socio and economic developments for Myanmar to prepare IWRM strategies that will facilitate the developments induced by the Government and the people of Myanmar. By developing different scenarios for Myanmar's socio-economic future it is possible to anticipate on whichever path is followed and facilitate achieving the goals of the National Water Policy. For this reason in chapter 5 future development scenarios are described which then further on are used to design the strategies to reach 'A water efficient nation in 2020 with well-developed and sustainable water resources'.

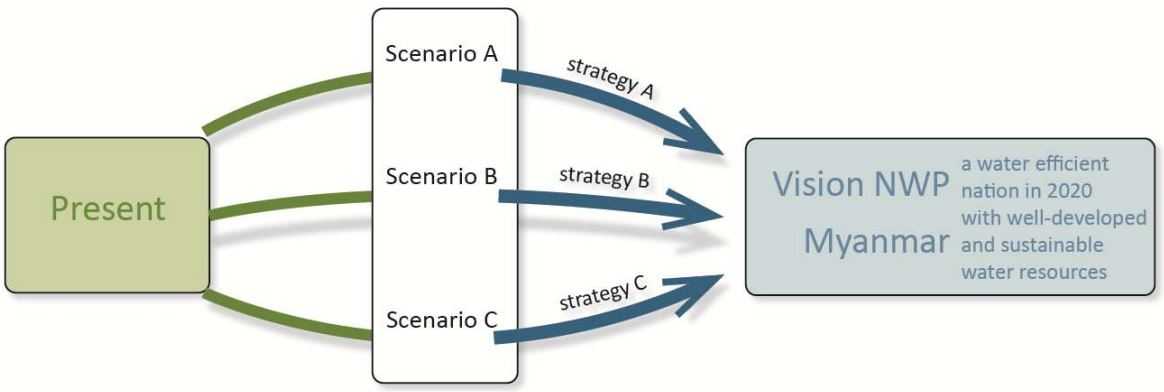


Figure 3-3 In order to achieve the preferred situation, strive for the vision, Myanmar will need to follow a strategy that depends on the development path that the country (or region within the country) will eventually go through as a result of the mix of socio-economic and climate developments.

The Study Team has established descriptions for three different potential scenarios using an analysis of the present situation as the starting point. These scenarios were developed with the input delivered by Myanmar officials (interviews) and a multiday workshop in May 2014 in

Myanmar. During this workshop a distinction was made between exogenous and endogenous aspects. Exogenous aspects cannot be influenced from within the *scope* of the study, but will have an impact on water resources. These are 'explicit' exogenous developments like climate change, but are also choices in the other policy domains like industry and land use that will affect the pressure on the water resources. Endogenous are those aspects that can be directly influenced by this study, these are considered to be part of the array of measures (e.g. water treatment, multipurpose operational protocols for reservoirs, groundwater management, etc.). To facilitate the developments under a scenario and at the same time assure the achievement of the NWP, different strategies have been developed.

3.4 Development of strategies and measures

In the process of the water strategy study numerous different actors affected by or depending on water resources or directly involved in water management took part in workshops or have been interviewed. These actors raised and discussed the challenges that Myanmar faces to attain sustainable management of the nation's water resources. During these workshops, group discussions and bilateral meetings, the development of Myanmar in the next 20 - 30 years was discussed and an inventory was made of the possible measures that might be required in the near, mid-term and long-term future. These measures have been included in a long list of projects (Appendix 1). This list we have used for different purposes. Firstly the list is the basis for the development of the strategies that are to be implemented to facilitate the different development paths and, at the same time, assure the achievement of the NWP objectives. Secondly, this list we used to identify no-regret measures. These are the measures that will be carried out under each one of the strategies. Hence, the selection of no-regret measures does not influence the strategy to be followed. Thirdly we have used this list of no-regret measures to identify those that can be carried out in the short term and can lead to quick results. Quick results are needed to counter short-term negative effects, to start building a truly integrated approach to water management and also to increase broad awareness in relation to the necessity of IWRM.

To identify and asses the measures we have used the triple bottom line as leading approach. This means that the no-regret measures have been selected by assessing the projects on:

- social acceptability;
- environmental sustainability;
- economic viability.

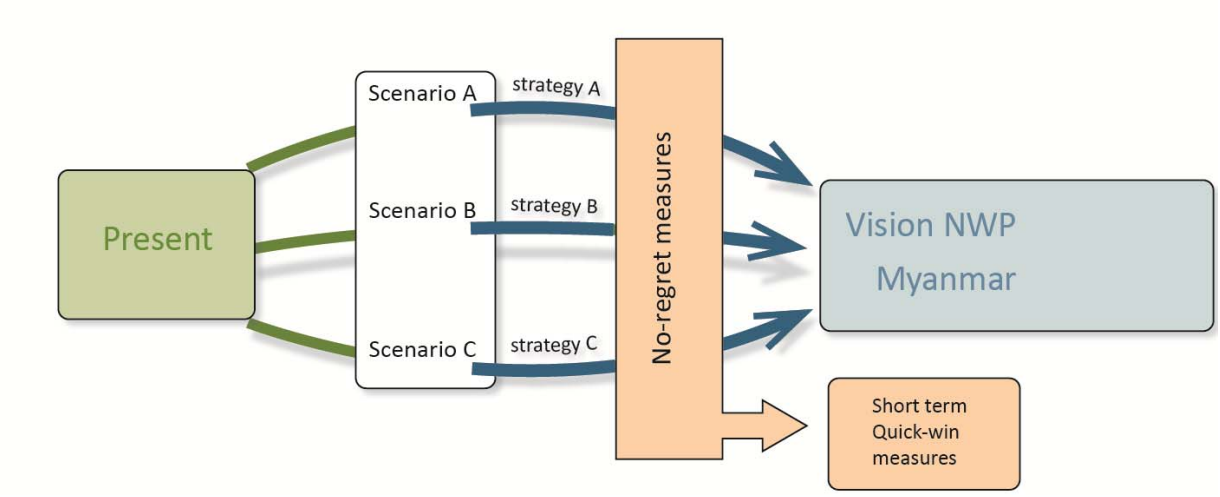


Figure 3-4 Having identified the different strategies a selection of measures will come up that fits either all strategies or that can be assumed to be a first step that is flexible enough to be adapted, adjusted for a range of diverse, yet uncertain developments.

4. Current situation of water resources in Myanmar

4.1 Overview of water resources

4.1.1 Available information

In order to be able to establish recommendations for integrated water resources management for Myanmar familiarisation with facts of Myanmar's water and land resources is required first as well as an assessment of the strong and weak points. Having made this assessment and looking at the needs of the country the challenges, opportunities for the country can be defined, not losing out of sight the threats that may have a negative impact.

The purpose of this chapter is to give a general description and analysis of the physical setting of Myanmar's water resources in relation to integrated water and land resources management.

It is based on the first findings from documentation and information received during visits and interviews with government officials and various experts and during workshops with stakeholders as well as from reading of background information.

With respect to the description of the physical setting Appendix 4 is referred to as well as for a number of references [2], [3], [4], [5].

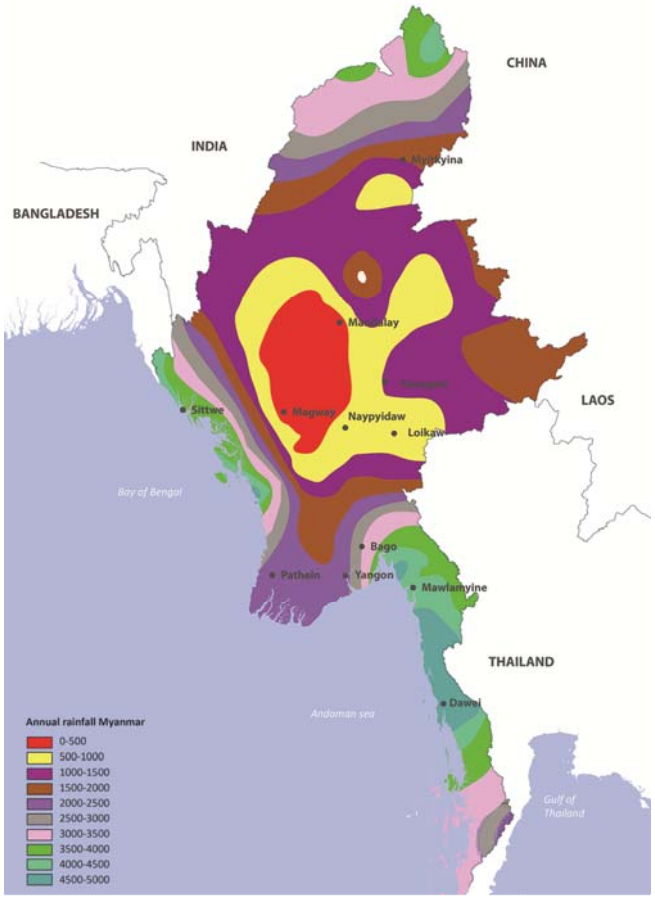


Figure 4-1 Annual Rainfall in Myanmar, *source MoT, DMH*

4.1.2 Water in Myanmar

Myanmar is a country in a more or less favourable situation with respect to water resources. Generally spoken, virtually all main water resources are within the national borders. There are however a number of transboundary and border rivers. Collaboration with the neighbouring countries on these rivers is of high importance in the context of proper IWRM.

A low number of 5%[3] is being stated as the actual utilisation rate of available fresh water. This implies ample availability, where the demand for water use is expected to grow with economic development and population increase. However, rainfall is unevenly distributed over the country and over the seasons (see Figure 4-1 for a general impression) leading to floods, flash floods and also very important, to water shortages and droughts. Very, if not most important is to trap, transport and store fresh water for later use. Storage of water is common from large public to small individual scale: reservoirs for hydropower, irrigation and urban water supply, (fenced) community ponds for domestic and drinking water supply, big jars for collection of rainwater for home use. With regard to water, especially the Ayeyarwady and the Chindwin, running north-south, are the main arteries. The rivers are an important source for – pumped – irrigation water. Navigation is important, but complicated and limited in times of shallow water.

Salt water near the coast is available for aquaculture; its development is still limited.

Groundwater is increasingly being used and will need further study based on reliable data collection and analysis for proper groundwater management throughout the country. Irreversible depletion is to be avoided as well as excessive land subsidence. Natural diffused arsenic contamination of groundwater is a widespread problem. In this report the groundwater aspect has not been researched in depth, but will need to be taken up for future IWRM planning for Myanmar. This may lead to sustained use of groundwater through strict regulation on groundwater extraction.

[3] Different sources cite each other on this number of 5%. This figure refers mostly to agriculture, domestic and industrial *use*: the water does not return directly (clean) into the water system. Water utilisation for hydropower, navigation etc. is utilised in a different manner and remains in the system.

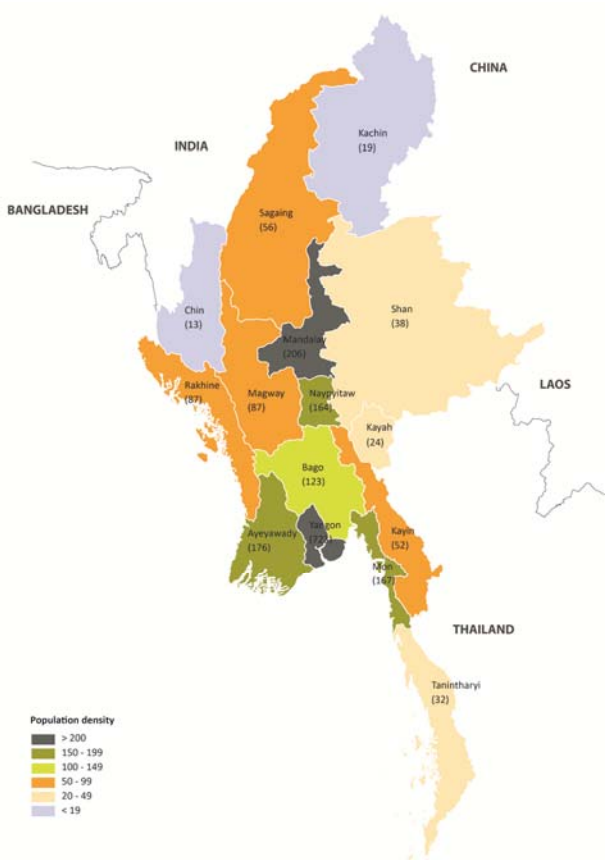


Figure 4-2 Population density per region *[source: Population and Housing Census of Myanmar, 2014, provisional results]*

Figure 4-3 Characteristic regions for water resources

4.1.3 Water resources distinguished by region

Myanmar can be divided in a number of regions with specific characteristics with respect to water resources. This chapter gives a general analysis of the physical setting in relation to integrated water resources management with both focus on land and water. This section includes relevant data and maps for easy reference and understanding of the issues discussed. Commonly Myanmar, and hence also for this overview, the country is divided into the mountainous area, the central dry zone and the Ayeyarwady delta and the coastal zone. On Figure 4-4 a more detailed rainfall map is presented (FAO) together with the average data of the main rainfall stations. Reportedly the annual rainfall pattern is changing with a gradual decreasing trend in some parts of the country. Accurate data collection and analysis is imperative to monitor changes. The river system of mainly the Ayeyarwady and its tributary Chindwin is described separately.

Mountainous region

The high mountains are located in the Northern part of Kachin State, Chin State and the Sagaing Region and form the link with the Himalayan mountain ranges of China and India. The mountains and hills in Shan State in the East are bordering China, Laos and Thailand. Hilly areas are found throughout the country and particular in the South East bordering

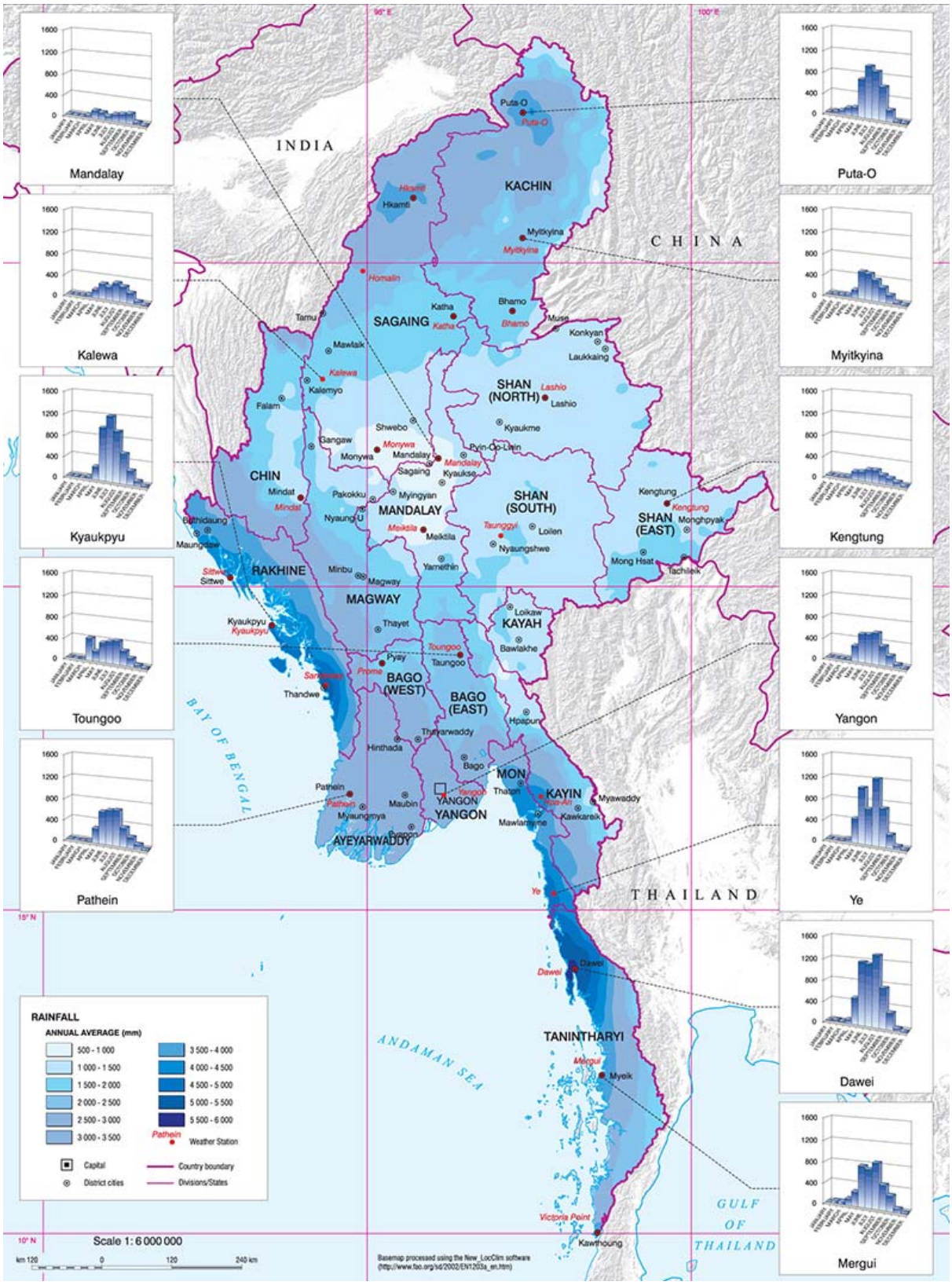


Figure 4-4 Detailed rainfall map with selected monitoring stations [FAO, 2002]

Thailand. See also the topographic map of Myanmar (Figure 4-3). The mountains and hills take up the larger part of the Myanmar territory. With most of the rainfall falling in the mountainous area, they constitute the largest water resource in the country. Main issues are deforestation, hydropower and mining through inadequate watershed management.

Central Dry Zone

The Central Dry Zone region, straddling large parts of Mandalay, Magway and lower Sagaing divisions, along with Rakhine Region and Shan State is one of the most food insecure, water-stressed, climate sensitive and natural resource poor regions in Myanmar. This region has the second highest population density in Myanmar but remains one of the least developed.

Access and availability of water resources are key determinants of rural poverty with livelihoods largely dependent on the southwest monsoon.

Principal crops consist of oil seeds and legumes, chillies, and vegetables grown as rain fed, upland crops during the wet season. Rice cultivation depends on irrigation, even during the monsoon season. Seasonal water shortages caused by low and erratic annual rainfall patterns and sandy and fragile soils that are at high risk of water and wind erosion limit paddy rice cultivation, render rain fed agriculture a high risk endeavour, and contribute to low agricultural production.

Under such uncertain climatic and rainfall conditions, the provision of functional canal irrigation systems is critical to safeguarding crops [*Source ADB 2013*].

The main issue in this region is the availability of water. This is a problem for agriculture (irrigation), drinking and domestic water and energy need through (small scale)hydropower, all in the water-food-energy nexus. Deforestation, erosion and sedimentation add to the problems. Short heavy rainfall causes flash floods. Urbanisation and industrialisation are growing issues.

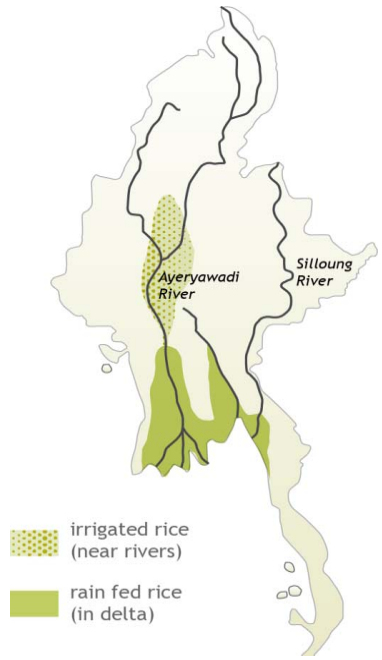


Figure 4-5 Rain fed rice in the delta, irrigated rice in the dry zone near river [source MoAI]

Ayeyarwady Delta

The apex of the Ayeyarwady delta area is located near Monyo, North of Hinthada, where the Ayeyarwady River starts branching off into 9 or 10 branches discharging into the Andaman Sea where the delta builds itself out on average 50 metre per year. With improved watershed management and trapping of sediment in present and future reservoirs this rate may decrease in the future.

The delta is very fertile. Most of Myanmar's paddy fields can be found in the delta. The Central Dry Zone needs irrigation (Figure 4-5). About 60 percent of the delta region, including the Ayeyarwady, Bago and Yangon region of Lower Myanmar, is cultivated with rain fed paddy. Alternative crops are often vegetables: pulses (black and green gram, pigeon pea) and oil seed nuts (ground nuts, sesame, sunflower). Reference is made to A8.1.2. Aquaculture,

breeding of fresh water fish and shrimp farming is growing.

There is a great deal of salt intrusion in the ground water aquifers. Due to lower discharges of the river also sea water intrusion into the Ayeyarwady branches reaches more and more upstream endangering the tidal irrigation fresh water supply.

The delta is hazard prone. It is very low, high river floods in the upper delta and cyclones and storms from the Bay of Bengal cause floods. The Nargis cyclone destroyed large parts of the delta and caused almost 140.000 deaths in 2008, which makes it a disaster that is comparable to the 2004 Indian Ocean Tsunami.

Deterioration of the mangrove forest along the coast has reduced protection against storm surges. This is due to cutting of mangrove trees for fuel of the local people and occupation of the natural habitat by agriculture and aquaculture.

Main water resources management issues of the delta are cyclone hazard, agriculture and aquaculture in view of fresh water availability and salinisation. Valuable mangroves disappear rapidly. In the rural areas rainwater harvesting (either individual or communal in open, fenced, ponds) is *the* method for drinking water supply.

Coastal Zone and special economic zones

Myanmar has approximately 2832 kilometres of coastline on the Andaman Sea. The coastline can be divided into three areas; the west coast (Rakhine State), the Ayeyarwady Delta and the south coast along the Mon State and Tanintharyi Region.

The coastline used to have large mangrove forests (Myanmar is the third mangrove covered country in the world), but with reference to 80/90 years ago, only 50% of the mangroves remain in the north, 14% in the Delta, and 95% in the south in Tanintharyi [see also section Mangroves on page 33]. Especially in the Delta this deterioration of the mangroves is problematic; cyclone Nargis (2008) clearly showed in its' destruction path the natural protection mangroves offer against storm surges.

Along the west coast of Rakhine State several developments are important. A special economic zone is planned at Kyauk Phyu, which has prospects as a deep sea harbour near Myanmar's energy reserves in the Bay of Bengal and hinterland connections (road, rail, energy) to important destinations in Myanmar (Mandalay) and China (Kunming). The beach resort town Ngapali, the main beach destination of Myanmar, is currently experiencing a construction boom. Ngapali is supplied with fresh water by large pipelines. The Rakhine coast has suffered from severe mangrove deterioration.

Figure 4-6 Special Economic Zones in Myanmar with their respective hinterland potentials

The mangroves at the south coast are still fairly pristine. Most notably of the south coast is the plan near Dawei for a special economic zone and a deep water sea harbour. The port would allow ships to avoid the Strait of Malacca. Development of the Dawei region is being reconsidered in view of changing insights in its economic, environmental and social aspects.

In the far south of the Tanintharyi coast are the Islands of the Myeik Archipelago. This area has a Marine National Park status, which is managed by the Department of Forestry. This area is also known for the Moken (or Sea Gipsies), a nomadic people living at sea. This area has

expansive rubber plantations, pearl farming, swiftnests harvesting, but most notably, also a huge potential for development of (eco-)tourism and diving.

Offshore there are plans for oil and gas exploration. Fisheries are an important source of food for Myanmar and many communities depend heavily on fishing. However, the amount of fish seems to be reducing, but the cause is not clear. Natural Myanmar pearls have become extremely rare and pearls are now farmed.

4.2 Water resources issues

4.2.1 Public health and sanitation

Wide variations in access to basic services such as housing, water, and sanitation exist across Myanmar's states and rural and urban areas. From 2005–2010, overall access to safe drinking water increased from 63% to 69%. This is in line with rates of Asian nations with similar income levels, such as 64% in Cambodia and 67% in the Lao PDR. The poor continue to benefit less from access than the rich. In urban areas 81% of the urban population had access to safe drinking water in 2010, versus only 65% of rural dwellers (MNPED et al. 2011). Access to sanitation and electricity also varies along economic and geographical lines. About 77% of rural and 84% of urban residents have access to sanitation. Access to sanitation is particularly low (54%) in Rakhine state. The gaps in access to electricity between income groups and across states are large. About 34% of rural residents have access to electricity versus 89% of urban residents (MNPED et al. 2011). However, according to the government sources, electrification ratios are much lower. In 2011, Yangon City had the highest electrification ratio (67%), followed by Nay Pyi Taw (54%), Kayar (37%), and Mandalay (31%).

These figures hide the actual quality of sanitation. In many places solid waste management, and sewage remain 'individual responsibility', where a collective community effort would generate a more skilled and effective approach.

Access to safe drinking water is not necessarily equal to the availability of a piped supply system and even at places with piped supply systems the intake water is not necessarily clean.

The report 'Drinking Water Quality Surveillance and Monitoring; Analysis and Assessment of Drinking Water Quality in Selected Areas of Myanmar', written by Water Resources Utilisation Department (WRUD), Ministry of Agriculture and Irrigation in Collaboration with UNICEF in 2002, revealed a serious health threat by Arsenic, Fluoride and Faecal Coliform in various drinking water sources. The study covered Chin, Kayah, Shan and Rakhine States and Sagaing, Mandalay, Bago, Ayeyerwaddy and Yangon Divisions from which 4969 samples from 6 different sources were collected. The results revealed a serious health risk from Arsenic in Ayeyarwady, Rakhine, Bago and Shan (shallow tube wells, deep tube wells, dug wells). The study also found that 33% of all sources were contaminated with Faecal Coliform. Bago, Mandalay, Sagaing Kayah and Ayeyarwady were affected by Fluoride. Although these studies do provide a full picture of the drinking water quality in Myanmar, they do give an indication of the seriousness of the water quality problem.

4.2.2 Agriculture and irrigation

In the water-food-energy nexus water for food plays an important role, especially where Myanmar is still predominantly an agricultural country. The country is to a great extent self-

sufficient in food; there is very little import or export of agricultural products. Two third of the labour force is one way or another employed in the agricultural sector (see Table 4-1 Evolution of population and labour force size in millions).

Table 4-1 Evolution of population and labour force size in millions

	1998	2003	2008	2013
Total population	47.32	49.58	51.17	53.26[1]
Total labour force	25.21	27.51	29.43	31.67
Labour force in agriculture percentage of total population of labour force	17.90 38% 71%	19.10 39% 69%	19.95 39% 68%	20.93 39% 66%
Source: FAOSTAT, FAO of the UN Accessed on January 24, 2014. http://faostat.fao.org/site/550/default.aspx#ancor				

[1]The preliminary result of the census of March 2014 arrives at 51.4 million

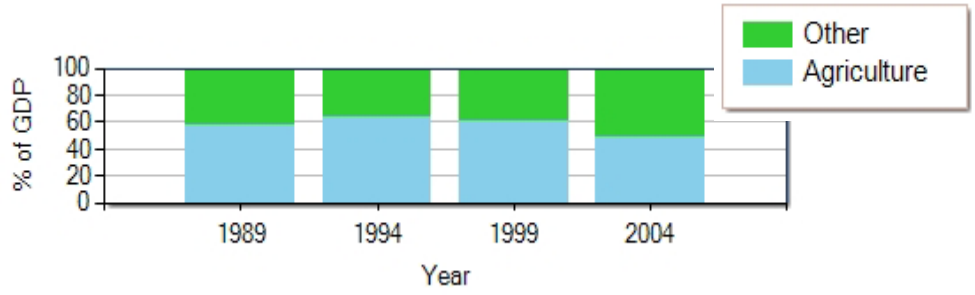


Figure 4-7 Share of agricultural value in GDP Myanmar, *source World Bank 2012*

Products are predominantly rice, a profitable second, or third crop is found in vegetables like beans and pulses (see Table 4-2).

Table 4-2 Production of Myanmar top ten commodities

MyanmarTop Ten commoditiesProduction quantity2012		
	Commodity	Quantity [t]
1	Rice, paddy	33,000,000
2	Sugar cane	10,000,000
3	Vegetables, fresh	4,000,000
4	Beans, dry	3,900,000
5	Maize	1,500,000
6	Fruit, fresh	1,425,000
7	Groundnuts, with shell	1,371,500
8	Milk, whole fresh cow	1,300,000
9	Onions, dry	1,140,000
10	Meat indigenous, chicken	1,079,726
Source: FAOSTAT, FAO of the UN, Accessed on February 7, 2014. http://faostat.fao.org/site/567/default.aspx#ancor		

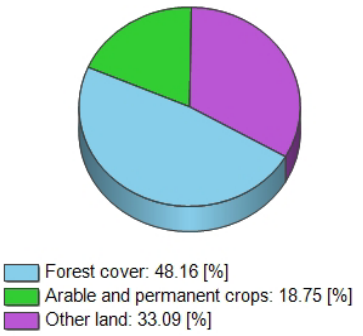


Figure 4-8
Land use in Myanmar 2011 [source FAOSTAT 2013]

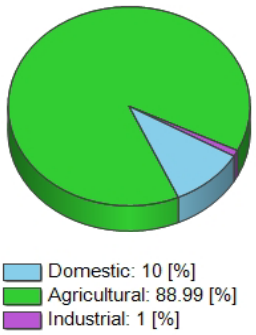


Figure 4-9
Water use in Myanmar 2002 [source AquaSTAT, FAO, 2011]

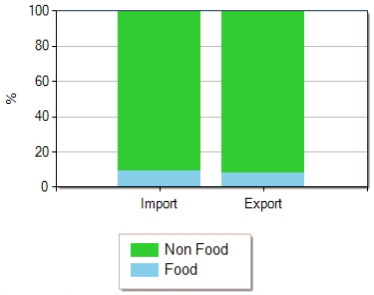


Figure 4-10
Food trade 2011 Myanmar [source FAOSTAT, 2013]

Of the total amount of utilised water in 2002 almost 90% was for agricultural use and 10% for domestic use. There will be more pressure on water resources from other sectors with growing development. Rice production is exemplary for agricultural water management in Myanmar. The availability of fresh water in dry zones and the prolongation of the growing season determine the ways of irrigation. Due to possibly changing rainfall patterns cropping patterns and crop calendars may need to be adjusted to adapt to climate change. Adjustment may also be required for more efficient and economic attractive agriculture.

Several ways of water supply for rice production may be distinguished:

1. irrigation systems based on pumped water (electricity, diesel) from nearby rivers;
2. spate irrigation systems to catch water from scarce – heavy – rainfall during short periods in the dry zone;
3. irrigation systems with water storage in reservoirs all over the country;
4. river water level setup though weirs for gravity irrigation possibly in combination with (5);
5. rain fed rice production, often in dyked polders (see Figure 10-5), possibly combined with (4).
6. groundwater irrigation using tube wells (see Figure 4-11)

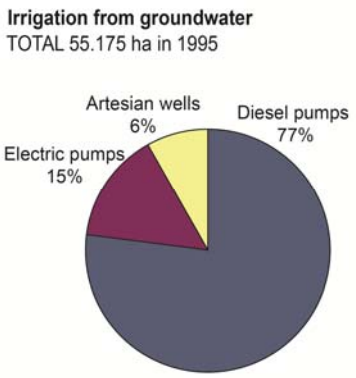


Figure 4-11 Also groundwater is being used for irrigation. Old (1995) FAO figures refer to 3000 tube wells being drilled yearly by MoAI, Water Resources Utilisation Department, but 9000 in the private sector.

The well-functioning of the irrigation systems is under pressure. In its base the systems are technically designed to the standards of their time. Especially the state-owned systems are

highly subsidised. The construction of reservoirs and irrigation system is expensive and cannot be borne by farmers alone, but in terms of food security, availability these systems are of national importance. But also the operation and maintenance is not in financial balance: farmers pay a very small lump sum only (order 10 US$ per crop per acre) for a whole season of fresh water availability, which by far does not cover the costs and which lacks the incentive of saving water. The operation and maintenance costs of e.g. pumping stations are often high: electricity and diesel, dredging of sedimented and continuously sedimenting access channels, adjacent river bank protection. Sedimentation of reservoirs is generally high, reducing the capacity and lifetime and posing challenges for major rehabilitation investments.

Polders are common in the lower delta of the Ayeyarwady. Nargis has destroyed a significant amount of these polders. MoAI, often with help of JICA, puts great effort in rehabilitation and upgrading of these polder systems.

There is great importance in maintaining and (re)development the food production system. The country's self-sufficiency in food, the safeguarding of employment in this – rural – sector and the potential for future export is both a great challenge and opportunity.

4.2.3 Hydropower

Myanmar has abundant energy resources, particularly hydropower and natural gas. The hydropower *potential* of the country's rivers, which drain the four main basins of Ayeyarwady, Chindwin, Thanlwin, and Sittaung, is estimated to be more than 100,000 megawatts (MW) [*source Myanmar, Energy Sector Initial Assessment, Asian Development Bank, October 2012*]. The actually installed hydropower capacity is at the moment less than 2,000 MW. The Ministry of Electric Power is drafting a "Master Plan Electric Power" to increase the installed capacity to around 20,000 MW in 2030, which will be in a generation mix of water, oil and gas.

Larger hydropower dams

The Ministry of Electric Power reported in January 2014 that the potential of hydropower dams under study amounts more than 45,000 MW. Some 300 MW are actually planned, excluding one large dam presently being developed in collaboration with China: 1400 MW on almost 50-50% basis. See Table 4-4. The details of the existing major hydropower dams and construction of hydropower dams and planned dams are listed.

Table 4-3 Existing hydropower projects in Myanmar *[source: Ministry of Electric Power]*

Station	Installed Capacity (MW)	Annual Energy Generation (GWh)
Baluchaung 2	168	1190
Kinda	56	165
Sedawgyi	25	134
Baluchaung-1	28	200
Zawgyi-1	18	35
Zawgyi-2	12	30
Zaunghu	20	76
Thapanzeik	30	117.2
Mone	75	330
Paunglaung	280	911
Yenwe	25	123
Kabaung	30	120
Kengtawng	54	377.6
Shweli-1	600	4022
Yeywa	395/790	1775/3550

Table 4-4 Existing dams
[source Ministry of Electric Power]

	Installed capacity (MW)	Annual energy generation (GWh)
Existing	1,816	9,606
Planned	305	1,600
In study	45,752	235,896

Small scale hydropower

In recent year's environmental and socio-economic impacts due to construction of large hydropower dam schemes have become increasingly important. This has resulted in delay or cancellation of some of the larger hydropower schemes. The majority of these larger dams is financed and constructed by Chinese developers, which conflicts with the Myanmar Government's policy to become more independent in development of Myanmar's hydropower potential.

This development and the search for adequate and fit power supply have resulted in increased interest in *small scale hydropower*. Over the past 5 years, some 26 micro and 9 mini-hydropower power projects have been developed by MEPE, with installed capacities ranging from 24 kilowatts (kW) to 5,000 kW. These projects have included border areas, aimed at improving the social and economic conditions of poor rural households and remote communities. These mini-hydropower projects also facilitate cottage industries and enhance agricultural productivity through improved irrigation.

Table 4-5 provides the list of the planned micro-hydropower power projects in border areas. Village-scale hydropower projects range from primitive wooden wheel types to a variety of small modern turbine systems. Research on micro-hydropower plants, led by MOST, includes the design and construction of different types of turbines and synchronous generators for micro-hydropower plants. [source: to Myanmar, Energy Sector Initial Assessment, Asian Development Bank, October 2012].

Table 4-5 Installed capacity small scale hydropower

Project	Installed capacity [kW]
Mepan Chaung	1,200
Tumpang Hka Chaung	6,000
Kang Hkawang	1,200
Kyu Hkak Chuang	320
Nam Mae Sai	6,000

source: www.aseanenergy.org

4.2.4 Deforestation and decline of mangroves

Mountain and hill forests

Over the years, heavy deforestation has taken place in various parts of the mountain area. Reasons for deforestation are:

1. slash and burn methods in agriculture;
2. cutting for local timber and domestic use (fuel);
3. cutting for export, teak and other valuable wood species.

Where adequate watershed management is lacking, this deforestation keeps on being a problem.

Still, the agro-ecological map (Figure 4-12) shows that large parts of the mountain ranges part are still covered with intact forest. This is in contrast with the mountainous area across the border in China.

Further deterioration of the vegetation cover of the mountain slopes will have the effect that rainwater runoff has become more direct whilst taking along large amounts of sediment towards streams and rivers. This is instead of the water being absorbed by the thick forests and forest soils and subsequently fed to the groundwater.

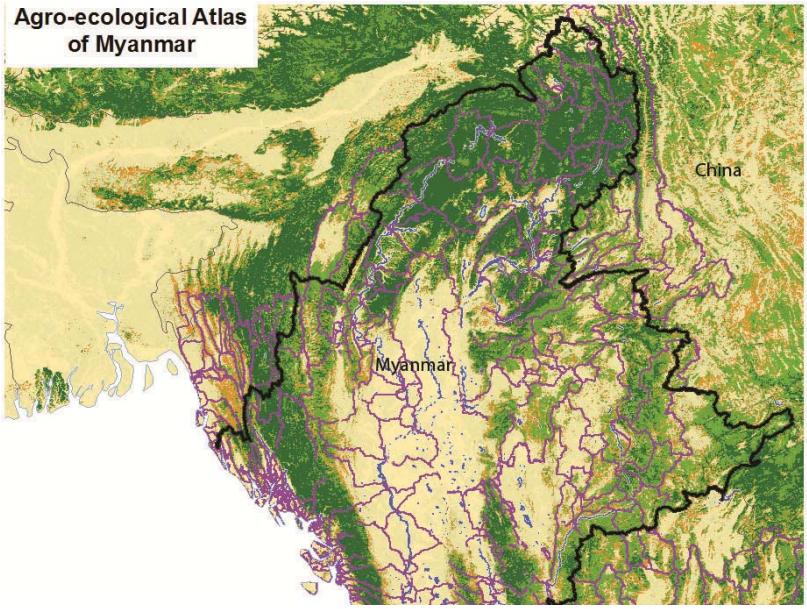


Figure 4-12 Forest in Myanmar border zones, source Earl Saxon, Forest Inform.

The increase in the rainfall-runoff relation has resulted in higher floods with shorter duration and increase in sedimentation in the lower reaches of rivers. This again has already shown negative effects on the operational life of hydropower and irrigation supply reservoirs (rapid increase of dead storage), flood safety, navigability of the rivers and bio-diversity. From an IWRM point of view, land and water conservation in the mountains and hills is to be considered core to Myanmar's water resources management.

Mangroves

Mangroves have an important function in the coastal zone of Rakhine State in the west and Tanintharyi in the south and estuaries of the Ayeyarwady delta.

Their function is, at large, twofold:

1. birthplace, breeding ground for brackish and salt water relater flora and fauna
2. coastal protection

The state of the mangrove system in Myanmar is under heavy pressure. Early reference points of 1924 show that 80% of the mangroves have disappeared already and the deterioration has not stopped (Figure 4-14 and Figure 4-15). In this respect the country is not

different from many other countries in Asia (Indonesia, Vietnam, Bangladesh, India). This is caused predominantly by human activity:

- too little knowledge about function and vulnerability of the mangrove system;
- unplanned and excessive cutting of mangroves for fuel and charcoal production;
- unsustainable land and water management depriving the mangrove system from its habitat for rice fields and shrimp ponds.

Parts of mangrove area are directly being used for these purposes or e.g. dykes are being built too far out on the tidal flats that are so important in the biological, ecological survival system of the mangroves (see Figure 4-13).

Figure 4-13 Polder dyke in the background built very close to the mangrove shore, the mangroves lose their required size of habitat and will eventually perish.

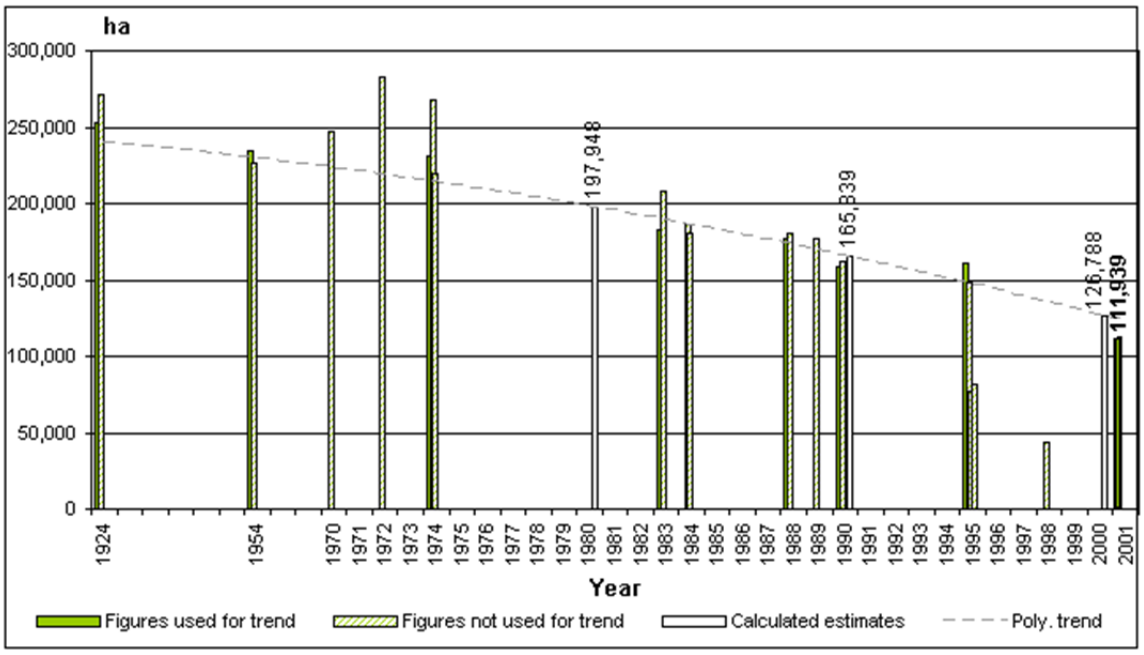
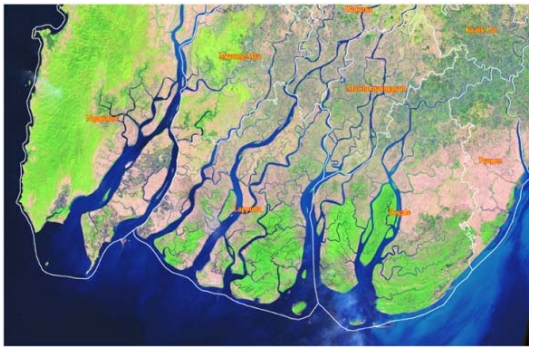


Figure 4-14 Mangroves decline in a span of 80 year in the Ayeyarwady Delta, source FAO 2007

1991

2001



2005

2008 after Nargis

Figure 4-15 Decreasing mangrove cover, *source MoECaF*

The Ministry of Environmental Conservation and Forestry has set high stakes on conservation and restoration of mangroves. This includes integrated projects in which communities are being offered livelihood improvement in order to enable restoration *and* sustainable conservation of the mangroves.

Figure 4-16 Mangrove restoration in combination with nursery and shelter, *MoECaF 2007-2013*

4.2.5 Flood hazards, cyclones, earthquakes and tsunamis

Myanmar's main natural hazards are floods, flash floods, cyclones and earthquakes. Tsunamis could also hit; the 2004 Aceh tsunami in the Indian Ocean did not really hit the Myanmar coast. Myanmar vulnerability to disasters is combined with wide-spread poverty and poor infrastructure. This combination makes Myanmar the 'most at risk country' in the Asia-Pacific according to the UN Risk Model [*source*: Ministry of Social Welfare, Relief and Resettlement].

Disaster management is the responsibility of the National Disaster Preparedness Central Committee and its working committee, the Ministry of Social Welfare, Relief and Resettlement and many NGO's like UNDP, JICA, UN Habitat, Action Aid, etc. In 2013 the Myanmar Disaster Management Law was enacted. The Myanmar Action Plan on Disaster Risk Reduction (MAPDRR, 2012) contains projects to make Myanmar safer and more resilient. The implementation of this MAPDRR is still weak (lack of budget and staff); townships must have a 'Township reduction plan" which should be interlinked with spatial development plans.

Flood hazards

The mountain areas, and especially also the Central Dry Zone suffer from flash floods. Along the rivers, floods also occur regularly (see

Table 4-6). Flash floods belong to rainfall pattern with intensive, relatively local rainfall. It occurs in steep areas, comes fast; deforestation, inadequate agricultural practices contribute to the impact in terms of seepd, force and consequently the damage.

River floods come slower and prediction and flood warning by DMH is fairly well possible, although the number of reliable measuring gauges is limited. DMH is putting great effort in improving the measurement grid throughout the country.

Table 4-6 Recorded floods of Ayeyarwady and Chindwin, [*source MOT – DMH*]

Stations	DangerLevel (cm)	Max. WL (cm)	Flood Duration	above DL (m)	Year
Ayeyarwady					
Myitkyina	1200	1411	4 days 12 Hrs	2.11	1979
Bhamo	1150	1338	8 days 2 Hrs	2.38	2004
Katha	1040	1154	7 days 6 Hrs	1.14	1979
Mandalay	1260	1382	16 Days	1.22	2004
Sagaing	1150	1274	17 Days 6 Hrs	1.24	2004
Nyaung Oo	2120	2263	16 Days 12 Hrs	1.43	2004
Chauk	1450	1532	12 Days 12 Hrs	0.82	1974
Minbu	1700	1982	17 Days 12 Hrs	2.82	1974
Aunglan	2550	2737	15 Days	1.87	1974
Pyay	2900	3025	13 Days	1.25	1974
Hinthada	1342	1582	23 Days 12 Hrs	2.40	1966
Chindwin					
Hkamti	1360	1771	18 Days 6 Hrs	4.11	1991
Homalin	2900	3107	18 Days 6 Hrs	2.07	1968
Mawlaik	1230	1608	15 Days 12 Hrs	3.78	1976
Kalewa	1550	1920	10 Day 12 Hrs	3.70	2002
Monywa	1000	1099	9 Days 6 Hrs	0.99	2002

Cyclone hazards

In fact Nargis says it all. Cyclones may hit Myanmar and the may hit hard. Protection against the surge and the wind is difficult in area where there is no defence and hardly any shelter.

Box 4-1 Cyclone Nargis Overview

On 2 and 3 May 2008, Cyclone Nargis (category 3) swept in from the Bay of Bengal and struck Myanmar's Yangon and Ayeyarwady Divisions, resulting in unprecedented large-scale loss of life and destruction of infrastructure, property and livelihoods. Approximately 140,000 people were killed or unaccounted for following the cyclone. 2.4 million people – one third of the population of Ayeyarwady and Yangon Divisions – were affected by the cyclone in 37 townships covering an area of 23,500 square kilometres.

Fast Nargis Facts

The 8th deadliest cyclone ever recorded and by far the worst natural disaster in the history of Myanmar.

It hit both urban and rural areas, the Ayeyarwady and Yangon Divisions. The townships of Labutta, Pyapon and Bogale were the hardest hit.

Winds during the cyclone reached up to an estimated 200 kilometres per hour, which destroyed houses, tore down trees, power cables and severed communication systems including land line and mobile phone service.

It had a significant, long-term impact on people's livelihoods and resulted in enormous physical losses, including the destruction of homes and critical infrastructure such as roads, jetties, electricity, water and fuel supplies and sanitation systems

A large proportion of water supplies were contaminated and food stocks damaged or destroyed. This damage was most severe in the Delta region, often referred to as the country's rice bowl, where the effects of extreme winds were compounded by a 3-4 metre storm surge, which inundated broad areas of the fertile land and submerged countless villages.

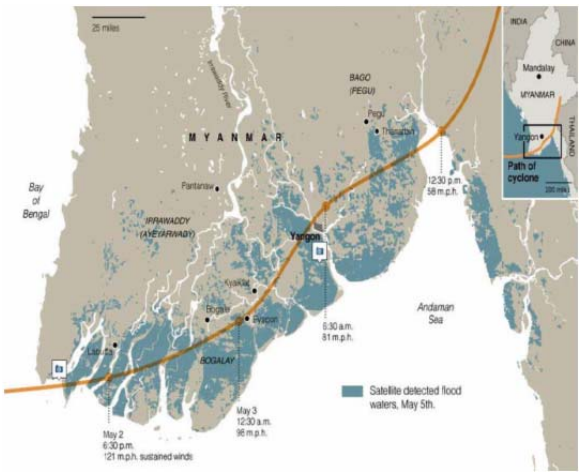
Nargis struck just as the Delta's paddy farmers were at the very last stage of harvesting the so-called “dry season” crop, which accounts for 25 per cent of the annual production in the affected areas, and destroyed several rice warehouses and their stocks. The total damage and losses estimated for the agricultural sector ranged from K570,000 million to almost K700,000 million.

Loss and damage

Overview of loss and damage resulting from Cyclone Nargis, based on the Post-Nargis Joint Assessment (PONJA)

- Damage from the cyclone was estimated at USD 4 billion, with USD 1 billion needed for recovery until 2012.
- Total economic losses amounted to approximately 2.7 per cent of Myanmar's projected GDP in 2008.
- Affected households were extremely vulnerable – 55 per cent reported having only one day of food stocks or less. Reliance on the steady flow of relief supplies was widespread.
- The scale of the impact was similar to that inflicted on Indonesia following the Indian Ocean Tsunami in 2004.
- Over 90 per cent of needs were at the community level and could be addressed through community based approaches.

Nargis is being presented as once in a very long time event. It is true that there is hardly any record of cyclones that made landfall in Myanmar that would, or rather could be considered as a warning for heavier cyclones, let alone one of a devastating capacity as Nargis. Still some investigation is available (see Figure 5-7). Coping with future cyclones is still difficult. Myanmar works hard on flood early warning systems and on shelters in the delta, where people cannot seek refuge elsewhere in the vastness of the low-lying protection-less delta.



Cyclones in North Indian Ocean, death toll		
1970	Bangladesh	500,000
1737	India	300,000
1876	Bangladesh	200,000
1897	Bangladesh	175,000
1991	Bangladesh	140,000
2008	Myanmar	138,000
1833	India	50,000
1864	India	50,000
1822	Bangladesh	40,000
1965	Bangladesh	19,279
1999	India	10,000
1963	Bangladesh	11,520
1961	Bangladesh	11,466
1985	Bangladesh	11,069
1971	India	10,000
1977	India	10,000
1960	Bangladesh	5,149
1972	India	5,000

Figure 4-17 Path of cyclone Nargis and death toll of cyclones in the Bay of Bengal region.

Earthquakes

Earthquakes do occur in Myanmar. The intensity depends very much on the region. In this report no further research was carried out. However when coming to design of infrastructural works, risk of earthquakes will need to be taken into consideration within the design criteria of the respective works to ensure earthquake-safe designs. This will also apply to works to prevent landslides which may endanger hill-side communities.

Figure 4-18 Vulnerability of Myanmar to hazards [source: UN Office for the Coordination of Humanitarian Affairs *(OCHA), 22 March 2011]*

4.2.6 Water availability, droughts and water shortages

Although Myanmar uses only 5% of its total water availability, the exploration of the remaining 95% for growth is not so obvious, rather a major challenge. The actual availability of water depends very much on the capacity of the country and, in various intensity and form, of each region to retain the abundant precipitation amounts of the wet monsoon and make them available in the rest of the year. The country has taken many measures to retain and store water: reservoirs for hydropower, drinking water and irrigation water, smart irrigation systems to prolong the growing and cropping seasons, communal ponds for drinking water supply and domestic storage for household water. Over time, many of these measures lose – parts of – their capacity: sedimentation in reservoirs decreases the storage volume, pollution is also a threat for especially drinking water storage. In the irrigation systems and domestic water supply there are few incentives to save on the actual use of water.

Figure 4-19 Catching rain in in the wet monsoon and store for the dry season in numerous reservoirs throughout the dry zone (left), in irrigation canals in de Delta (middle) and in communal ponds with concentrated tap point at the low end of the dam (right).

Climate change [section 5.5] adds to this problem, especially in terms of later start of the wet monsoon, thus prolonging the dry season.

4.2.7 Urban and industrial development

The dry zone also sees an intense urbanisation in the area of the new capital Nay Pyi Taw (NPT) and more particularly around the city of Mandalay. Mandalay located at the cross roads of the Asian Highway connecting China, Thailand, India and the world through the deep sea harbour of Sittwe, aims to become an important logistical and industrial hub. As an example, apart from existing industrial zones, it has the ambitious Mandalay Myotha Industrial Development ongoing. Both urban and industrial developments will increasingly draw on the available local water resources, groundwater and surface water, and will pose particular concern on water quality aspects. Currently there are 18 Industrial Zones and 7 new planned Industrial Zones and strategically located within the entire transportation system.

Unrestrained land development has several, sometimes severe consequences:

1. changing water demand in both quantity and quality;
2. loss of flood plains, room for river;
3. loss of agricultural land, forest and ecologic zones;
4. environmental consequences: water, air and soil pollution;
5. high social impact;
6. drainage problems.

Where developments seen to be in *nodes* (towns, industrial zones), the connecting highways often lead to *corridor* development: urbanisation and industrialisation in a long stretch along the highways. This leads to spreading of the above mentioned problems caused by these developments and more troublesome, expensive solutions.

4.2.8 Ports and navigation

River transport

The Ayeyarwady and Chindwin Rivers are the main navigable rivers of Myanmar and maintained and monitored by DWIR. Other rivers like Thanlwin and Sittaung are also used for shipping but only for short distances by small vessels and boats (typically less than 10 DWT). During recent years the inland waterway navigable length has become shorter and shorter. In Table 4-7 an overview is given of the rivers and associated navigable length.

Table 4-7 Navigable length of inland waterways, *source MoT-DWIR 2014*

River	navigable length [km]
Ayeyarwady	1,534
Chindwin	730
Thanlwin, rivers in Mon State	380
Delta Region	2,404
Rivers in Rakhaing State	1,602
total length (km)	6,650

There is one government agency, namely Inland Water Transport (IWT), under the management of the Ministry of Transport. IWT is responsible for both long haul passenger and freight services, and cross-river ferry services in various places along the rivers. Statistics in 2011 show IWT could carry about 5 million tons of freight along the main rivers. It is about 1.5 times the volume carried by Myanmar Railways. Additionally, there are some private barges which carry bulk cargo (such as fuels, crops, stones for road construction, fertiliser) along the rivers. The total volume of shipments handled in all the domestic shipping services was about 6.687 million tons.

During the low water season, from November to May, many of the inland water transport routes do not provide sufficient water depth for inland waterway vessels to operate safely. Improving river channels and navigation aids would benefit all providers of inland water transport services, IWT vessels and private vessels as well.

The Waterways Department was organised and founded in 1972 by combining the Dredging and River Conservancy sections of Department of Marine Administration, Ministry of Transport and Communication and parts of Hydrographic Surveying section of Port Corporation, Ministry of Transport and Communications [*http://www.mot.gov.mm/dwir*]. In 1999, the Department was extended and reorganised as the Directorate of Water Resources and Improvement of River Systems (DWIR). The main responsibilities of DWIR are to:

- improve the navigation channel and to stabilise the inland river ports.
- protect the river bank erosion.
- cooperate with other organisations in demarcation of danger water level.
- utilise the river water for domestic and agriculture all the year round.
- protect bank erosion of border rivers.
- observe the long-term existence of the cross river bridges by river engineering points of views.
- manage the prevention of the river water pollution.
- achieve adequate depth for maximum loading capacity of the vessels.

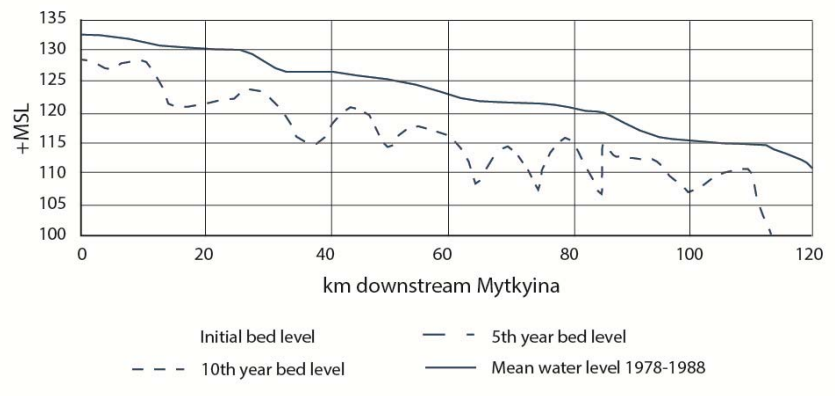


Figure 4-20 Navigable depths *[source: MoT, DWIR]*

Sea ports and railways

The current rail network is very run-down due to under-investment and insufficient maintenance over past decades. The 5 768 km network runs north to south with branch lines to east and west, but does not connect with neighbouring countries. There are plans to integrate the rail network into the Trans-Asia Railway, a project that will create an integrated freight railway network across Europe and Asia. China plans to construct a major rail line to connect Kunming, Yunnan province with the Kyaukpyu deep sea port on the west coast of Myanmar. This port would also be the landing place for a gas pipeline to China.

More railways from China could be constructed from Kunming through Shan State to Thailand and to Yangon and further south to the Dawei port. Dawei port seems the most promising for relatively short-term development, since it has a strong hinterland in Thailand. Rotterdam Harbour has shown interest in this development.

Figure 4-21 Potential sea ports Myanmar

4.2.9 Pollution

Waste water treatment facilities are rare in Myanmar. Most sewage and other waste water discharges directly into ditches, streams, lakes and rivers. Sceptic tanks are widely used, but also these are not discharged into a treatment facility.

Currently, the use of fertilisers is by Ministry of Agriculture guidance based on soil condition and crop type. Current use of fertilisers is likely to be low, because of the high costs. With socio-economic growth the use of fertilisers, pesticides and insecticides is expected to increase.

Figure 4-22 Use of pesticides and fertilisers in Myanmar, *source FAO*

Figure 4-23 Solid waste collection is still not community based in many locations

Solid waste is an obvious and wide-spread pollution problem. There is no organised waste collection. Bagan shows a good example combining 'do not litter' awareness campaign with organised waste collection keeping Bagan fairly clean. Waste poses a problem for water quality; at many places it is either dumped directly into waters or it flushes into waters during heavy rains or floods.

Growing industrialisation is a threat to the water quality of all water bodies in Myanmar. In the past the licencing system was poor and not transparent, partly because the law was inadequate. This has resulted in industries discharging their waste water without or with poor waste water treatment facilities into water bodies. Even at the moment of writing this report, there is little pressure or reward for industries to treat their waste water responsibly. There are some good examples that can be showcases, such as the new Heineken Beer factory that has installed a state of the art waste water treatment complying with its own corporate policy standards. Many industries have some kind of waste water treatment, but are not transparent about the water quality of their effluents. There is for example a large textile factory in Meiktila [see section 10.3.2 and Appendix 7] that is said (but unconfirmed) to have a treatment facility, but does not provide monitoring data. Transparency is the first step in a step by step approach to improve these current facilities with more effective treatment technologies.

The issue regarding law and enforcement is discussed further in Chapter 6 on Water governance.

4.3 Context socio economic status and development

There are numerous sources that can be cited where general information on the socio economic development of Myanmar is concerned. These sources include publications of the government of Myanmar (e.g. national plans like the Framework for Economic and Social Reforms), international organisations (e.g. FAO, UNDP, OECD), IFI's (e.g. WB, ADB) and international consultancy firms (e.g. McKinsey). The table below cites a few of the sources on GDP growth (past, present and future).

Box 4-2 GDP Growth rates Myanmar

McKinsey:	4.7% from 1990-2010
ADB:	1.8%(1980s), 5.5%(1990's), 4.7%(2000's), 5.3%(2010), 5.9%(2011), 6.5%(2012), 6.8% (2013)
World bank:	9.7% ('00-'09), 5.3% (2010), 5.9% (2011), 6.5% (2012), 6.8% (2013)

Most hindsight and information related to actual development is congruent. However, estimates or foresights for future development are sparsely available and figures diverge. The

National Comprehensive Development Plan (NCDP) is still under preparation and it is to be expected that this plan will provide better insight in socio economic development for the period until 2031. This document is expected to offer information on the choices that will be made and the priority that will be given to economic developments. These priorities will be the basis for an assessment of the pressure that these developments will pose on the country's resources including water. As noted already, from President U Thein Sein public communications it can be concluded that Myanmar will be seeking a path of a green economy and green development.

The preliminary result of the March 2014 Population and Housing census arrives at 51.4 million people in Myanmar in 10.9 million households. In 2000 28% of the total population lived in large urban centres. In 2010 it was already 33,9% (ADB, 2012) and it is to be expected that urbanisation process will continue (according to index mundi at a rate of 2.49%). In the biggest cities Yangon and Mandalay live 5.2 and 1.2 million people respectively (census 2014).

Agriculture (including crop production, livestock, fisheries and forestry) is the most important sector in the country's economy. It is the main source of livelihood for about 70 per cent of the population, who live in the rural areas, it accounts for about 64 per cent of the labour force and it contributed about 42 per cent of the gross domestic product (GDP) in 2011. Agricultural production differs from the mountainous areas to the Delta region. Different irrigation techniques are used depending on the water availability in the region and the crop requirements. Efficiency of water use is very low, many irrigation schemes (ground and surface water) need restoration and use of fertilisers and pesticides is becoming a problem.

Tourism is a key sector that requires some immediate adjustments to maximise gains within a relatively quick window of opportunity available from the recent development of Myanmar as a prime tourist destination. Many measures could be taken to improve tourism and integrated management of water resources should be one of them. Water foot printing of the development of the tourism industry should be considered; not only in relation to water, but also in relation to the surrounding ecosystems.

Presently, Myanmar's export structure is heavily focused on a few primary commodities – natural resources, notably oil & gas and wood, along with agricultural and marine products. GOM will therefore pursue an active policy of encouraging the diversification of export products while promoting value added processes for primary commodities, including focusing on improving support services in areas of trade financing, market access and trade facilitation. The manufacturing services are to be developed to increase the added value of production in Myanmar.

Transport possibilities in Myanmar are still very limited. Rivers are very important for freight transport. In 2002, about 44.39% of the total freight-ton was transported via the inland water transport system. However, low water levels in the summer prohibit navigation by larger vessels. The Ayeyarwady and Chindwin rivers are the main waterways and play an important role in the county's transport network. Six new domestic ports along the Ayeyarwady and Chindwin rivers are planned to expand transport.

Myanmar's per capita electricity consumption is the lowest among the ASEAN-10 countries. In 2002 34% percent of the total amount of electricity was hydropower. The potential for hydropower is estimated to be 40,000 MW and many plans exist to build additional reservoirs solely for hydropower. The Hydropower development plan estimates a yearly increase of capacity of 13% and aims at a hydropower production of 26,000 MW in 2030/31.

According to reports of the international financing institutions and recognised international consultancy firms the economy of Myanmar will develop in a rapid pace during the years to come. Expected growth rate vary between reports and between the different growth's scenarios presented. But it is expected that the growth of the GDP will be between 4.5% and 8.5%.

Discussions with Myanmar officials (Ministry of National Planning and Economic Development) indicate that for the NCDP, economic growth will be between 4.7 and 8.2%. These estimations are based on different development scenarios for the country. For these scenarios different levels of technological development, investments and management changes have been assessed. These management changes are related to political management, economic management and administrative management. Although these scenarios still have to be finalised, it is expected that scenarios as presented in table 1 will be major input for development planning in Myanmar. The NCDP covers 4 five-year periods for the period 2011-2031.

Growth scenario	Technological development	Investment	Management reforms (political, economic, administrative)	Growth (GDP)
Moderate	+	+	+	4.7%
Medium	+	++	++	6.7%
High	++	++	++	8.2%

4.4 Challenges and opportunities

Assessing the current state of Myanmar's water resources many aspects turn out be to a certain extent problematic. Given a situation of economic growth, rising and shifting pressure on – often scarce – water resources, Myanmar faces major challenges for its water resources development. Note that these challenges differ strongly per region. For example, only 5% of the total amount of available water is used, but virtually all water (figures of 98% are being mentioned) is used already in the Central Dry Zone. Also, Myanmar's valuable water resources offer opportunities for further economic development that on one hand serves the population and is on the other hand environmentally sustainable.

Good management of the water resources, backed by good (water) governance should set the right conditions to meet with the challenges and opportunities of Myanmar's water resources.

The report diversifies between the mountain area, the dry zone, the coastal zone, the Ayeyarwady delta, rivers, reservoirs and lakes, and towns. The following challenges and opportunities are defined according to regional differences.

Drinking water and sanitation is the biggest challenge in all regions

- Safe drinking water, according to WHO standards, and sanitations is a nationwide priority. In the future, more drinking water supply might be based on pipe water systems, at the moment rain water catchment and deep tube wells are the major sources for drinking water. The transition for solid waste collection from individual to collective responsibility is an important challenge, as is sewage water treatment. Water pricing; putting a price on clean drinking water and sanitation, is hardly present but can be put in place relatively easy.

Agriculture and irrigation

- In all agricultural areas, the main challenge is to provide the people with more profitable and therefor more sustainable forms of livelihood. Often problems are well known, but people have no alternative. Furthermore, improvement of agriculture can lead to land and water conservation. Water User Associations are an existing phenomena, but can be improved upon by turning them into true consumer/water users organisations. Another opportunity might be to install a drought early warning system.
- In the mountain area, the major challenges are the implementation of integrated watershed management, the change from slash and burn agriculture towards more sustainable forms of agriculture, and thereby stop deforestation.
- In the dry zone, existing irrigation systems need to be upgraded. Dams, both present and future, need to be (re)designed for multi purposes (power, irrigation, drinking water, water transport). Irrigation systems can be hugely improved when there is less loss of water; salinisation proves to be a problem
- In the coastal area, agriculture extension comes into conflict with mangrove forests.
- More specific in the Ayeyarwady delta only 14% of original mangrove forests survives. The main challenge here is to modernise the agriculture polders. An opportunity might be to use salinity as the basis for economic growth via aquaculture/sustainable shrimp farming.
- In the reservoirs and lake areas the reduction of sedimentation and rehabilitation of sedimented lakes and reservoirs forms an important challenge. The multiple approach needs to be reinforced. There are significant opportunities, for example in Meiktila or Inle lake, to integrate township and lake development with IWRM, thus creating a stepping stone for tourism, agriculture, small scale industry services and logistics.

Hydropower

- Existing dams in waterways can have their lifetime prolonged, for example based on improved sediment management.
- The larger dam scheme could be revitalised when based on a broader, more integrated approach, taking other IWRM opportunities (river transport, irrigation), environmental impact, stakeholder participation and social inclusiveness into account.
- The installed capacity could be raised considerably to meet the country's rapidly increasing need for energy and utilise this enormous potential for clean, sustainable energy
- Hydropower offers real opportunities for an IWRM approach; mutual benefits can be achieved and may provide opportunities for multilateral funding.

- There is a clear need for the implementation of solid environmental and social impact assessments; increasing knowledge, capacity and sufficient data in these fields is a real challenge.

River- and inland water transport

- In the mountain area, erosion control and sediment reduction of river flow reduce sedimentation in reservoirs.
- In the dry zone, close integration and cooperation between MoAI (responsible for irrigation) and MoT (responsible for water transport) for river water supply is a challenge. At the same time, when the irrigation water system is improved, alongside with the improvement of navigability and water depths for transport, real opportunities will be created for both the improvement of food production and economic growth.
- In the rivers, the main challenge is the improvement of the navigation channel. The inland river ports need to be stabilised, as need the river banks. Possible improvement of hydrographic and navigational information will reduce risks.
- The rivers and waterways are the main transport routes for cargo in Myanmar, so reliable navigation will provide a boost to the economy.
- In the towns, harbour and waterfront development combined with spatial planning, drinking water and waste water management will provide great opportunities, both for creating a sustainable living environment as for economic progress. At the same time, it will be a challenge to make or keep enough room for the river(s) for safe discharge of water during heavy rains or floods.

Flood and cyclone hazards

- The development of (an integrated) early flood warning system is a major challenge. For the mountain area and the dry zone, this system needs to be developed, for the coastal zone, the delta and the rivers, the system(s) need(s) to be harmonised and installed.
- In the mountain area and the dry zone, reservoir operations can prevent flash floods. Integrated watershed management is an excellent way to offer flood protection, but this proves to be a challenge at the moment.
- In the coastal zone, rivers and the delta, the existing chain from 'data collection via warning to evacuation' can be improved. Strengthening of public resilience and improvement of civic response are important challenges here.
- More specific in the coastal zone and the delta, the challenge 'post Nargis' is to continue and reinforce efforts to improve the shelter scheme, in combination with public resilience (multipurpose shelters to improve use of shelters both in times of normalcy and crisis) and livelihood improvement.
- In the reservoir and lake area, dam operation needs to be improved to ensure that dams can also be used as flood protection. This offers opportunities for multi-purpose dam operation.
- In the towns, drainage systems are to be improved.

Forestry and mangroves

- In the mountain area and dry zone, deforestation provides the main challenge, reforestation the main opportunity. Integrated watershed management is the best way forward.

- In the coastal zone and delta, the deterioration of the mangroves (especially in the Ayeryawady delta) is problematic, since mangroves are the only natural protection against floods of the scale of Nargis (approximately 140.000 casualties). Mangroves are mainly cut down to provide firewood and to clear the land for agriculture. To improve the awareness of the vulnerability of mangroves is therefore a major challenge. This cannot be done if improvement of the livelihood of the residents of area is not offered at the same time, as is the development of alternative sources of energy. The conservation of the habitat of mangroves and other forest need to be embedded in larger schemes for agricultural water management and aqua culture. Combinations between sustainable aqua culture and mangrove restoration can be made.

Industry and mining

- The main challenge for industry and mining in relation to water management is to protect water quality. Water quality should be controlled based on set standards, and standards should be enforced.
- Furthermore it will be a challenge to save water and prevent waste
- An opportunity might be to develop water foot printing as a (data) base for IWRM, and possibly also as a basis for water pricing.

Table 4-8 below summarises the most important water resources issues in terms of challenges (**C**) and opportunities (**O**) in relation to the specific water resources regions of Myanmar. A similar table may be drawn up for the management and governance issues.

Table 4-8 Water resources challenges and opportunities per region to be elaborated

	mountain area	dry zone	coastal zone	Ayeyarwady delta	rivers	reservoirs and lakes	towns
drinking water and sanitation	**C:** safe drinking water and sanitation is a nationwide priority **C:** transition to piped water supply **C:** solid waste collection from individual to community responsibility **C:** sewage water treatment **C:** introduction of water consumption saving mechanisms including water pricing						
agriculture and irrigation	**C:** implement integrated watershed management **C:** change away from slash and burn **O:** improve and make sustainable the livelihood of mountain people	**C:** rehabilitation and upgrading of irrigation systems **C:** more multi-purpose dams (power, irrigation drinking water) **C:** irrigation water saving mechanisms **C:** drainage improvement (salinisation)	**C / O** Move from over-exploitation to sustainable fishing and aquacultures **C:** modernisation of agriculture polders **O:** using salinity for economic growth in aquaculture			**C:** reduction of sedimentation and rehabilitation of sedimented lakes and reservoirs **C:** reinforcement multipurpose approach **C:** reinforcement multipurpose approach **O:** Integrated township/lake development with IWRM as driving force with benefits for: tourism, agriculture, small scale industry, services and logistics	
	C: land and water conservation by improved agriculture **C:** strengthening of water user associations **C:** drought early warning						
hydropower	**C:** prolong lifetime of dams, improved sediment management **C:** revitalise larger dam scheme by more integrated approach **C:** raise installed capacity considerably to meet country's needs and utilise enormous potential for clean energy **C:** thorough implementation of EISA **O:** IWRM approach for hydropower larger and small scale, for more support					idem, see mountain and dry zone	
rivers and inland water transport	**C:** erosion control → sediment reduction of river flow, reduces sedimentation in reservoir	**C:** close integration and cooperation MoAI/MoT for river water supply (irrigation) **O:** improved irrigation water supply for improved food production			**C:** improve navigation channel **C:** stabilise inland river ports **C:** stabilise river banks **O:** improved hydrographic and navigational information to reduce downtime risks **O:** economic boost through reliable navigation		**C:** keep room for river for safe discharge of floods **O:** harbour and navigation development for economic progress
flood and cyclone hazards	**C:** reservoir operations to prevent flash floods **C:** watershed management for flood protection **C:** Development of early flood warning systems		**C:** improve existing chain from data collection via warning to evacuation and other emergency measures **C:** installation flood early warning system **C:** continuation and reinforced effort in shelter scheme (combination with livelihood improvement)			**C:** improve dam operations in service of flood protection **O:** multi-purpose dam operation	**C:** improvement drainage systems
forestry and mangroves	**C:** planned reforestation **C:** integrated watershed management		**C:** Conservation and reforestation of mangrove system for flood protection **C:** Improve awareness of mangrove vulnerability **C:** provide alternatives for mis-use **C:** conservation of habitat in larger schemes for agriculture water management and aquaculture **C:** integrate aquaculture and mangrove restoration				
industry and mining and other strong economic development	**C:** water quality control and enforcement **C:** water utilisation savings **C:** use SEIA to support decision making, especially for developments like ports, special economic zones, resorts, oil- and gas exploration, mining, (eco) touristic developments **O:** development of eco-tourism **O:** development of deep sea ports and inland navigation for economic development of hinterland **O:** water foot printing as a (data)base for integrated water resources management						

4.5 Current financing mechanisms

4.5.1 Financing sources

After decades of isolation, Myanmar is currently undergoing a rapid political transformation towards a democracy based society accompanied with major economic and social reforms. Capitalising on these developments, most development partners have re-engaged with Myanmar and embarked on the formulation and implementation of programs in support of the reform measures.

Also private business (developers, financiers) have found their way to Myanmar, with a view to capturing part of the many opportunities. As the country is developing from a very low base and after decades of neglect, almost all sectors require massive investment. Specifically after the enactment of a new foreign investment law in November 2012 foreign direct investment surged as own project initiatives were actively encouraged by the Government. In fact, interest is so high that the Myanmar government has problems coping with the flood in un-solicited proposals. For example, in the power generation sector currently about 60 MoUs have been signed but did not commence yet, of which 40 relate to hydropower development projects (ADB interview).

Especially high added value / high revenue potential sectors such as oil & gas, power generation (hydro and thermal), industrial zone development / special economic zones and related port and maritime infrastructure attracted massive foreign investor interest. As a result, the economy is growing at a brisk speed with a GDP growth rate in recent years of 5-6%/annum.

Also the water resources sector has attracted wide interest. Financing in this sector mainly comes from public sources, as most measures aim at fulfilling public needs and have limited direct revenue generating potential. In principle, funding or financing for these projects can come from the following sources:

- Government budget, through taxes or government bonds
- Grants of development partners
- Loans made available by development partners at concessional terms or commercial banks with sovereign guarantees
- Available cash within government / utility companies from internally generated funds through user fees
- Private finance (equity, loans, bonds, funds)

As the Myanmar government budget and specifically its capital expenditure budget is constrained, other sources of finance are targeted. So far development partners – both bilateral and IFIs - have shown wide interest in the water resources sector. It is therefore expected that this will constitute a major source of finance.

A promising approach to mobilise funding for targeted, earmarked funding of water resources project could be the establishment of a fund mechanism. Such a mechanism can be organised at the national level, but also within a water basin, or region:

- A National investment fund for the improvement of water resources management. The source of such a national fund could come from environmental related taxes or fines

(water extraction fees, discharge permits), and/or an allocation from concession fees or royalties from the natural resources extraction industry (oil & gas, mining etc). Crucial is an effective governance system and project prioritisation mechanism through ring fenced fund management. The (recurring) tax base from the fund can also be leveraged to attract additional loans from IFI's or other sources, such that the fund is revolving in nature.

- An Eco–compensation fund is another alternative in which the direct (negative) environmental impact of big infrastructure project is compensated through pre-agreed specific charges into a dedicated fund. Such an earmarked fund is operating and managed at a regional or river basin level. It can be tied to one or multiple projects. The governance of such a fund is crucial. Especially important is to have a sound basis which environmental compensation measures are to be financed through the fund. This requires up front EIA studies. In addition, the eco-compensation mechanism system should be included in the contract or tender documentation or agreed during negotiations, prior to infrastructure commencement.

Box 4-3 Polish National Fund for Environmental Protection and Water Management

The National Fund for Environmental Protection and Water Management is a Polish state institution operating on the basis of the Act Environmental Protection Law. Its most important task is the effective and efficient use of (grant) funds from the European Union. The main purpose of the financial instruments implemented by National Fund is the development and modernisation of the infrastructure of environmental protection in Poland.

The sources of receipts for the fund are charges for business use of the environment and penalties for violations of the environmental law. Thanks to the fact that the main form of financing activities is loans, the National Fund represents a "renewable source of funding" for environmental protection. Loans and grants, as well as other forms of financing, used by the National Fund are intended to cover the financing, in the first place, of large investments of national and supra-regional importance in terms of eliminating pollution of water, air and land. Recently investments using renewable energy sources have been a special priority.

In the last 20 years, the National Fund has played an important role in improving the state of the environment in Poland. The financial magnitude of the National Fund's activities is impressive: in the years 1989-2008 the National Fund concluded more than 14 thousand contracts, providing almost PLN 21.4 billion (USD 6.5 billion) for financing environmental projects. The cost of projects funded from the resources of the National Fund exceeds PLN 76.5 billion (USD 23 billion).

The table below summarises a non-exhaustive list of existing financing sources which might be tapped to fund water resources development projects in Myanmar.

This inventory will be used to identify potential financing sources for the long list and eventually shortlist of IWRM measures and projects, identified within the course of this study. In addition, the potential of engagement of private finance (equity & debt) through PPP arrangements or other forms of private sector participation will be identified as well. For this reason an assessment is made of the current PPP enabling environment and latest developments as this is critical for successful engagement of private finance sources for infrastructure development.

Institute / financing source	Sector / project focus	Type of finance
Investment funds		
Infraco Asia (Private Infrastructure Development Group)	• Private sector finance of pro-poor infrastructure • Irrigation	• Equity • (Senior) debt • Guarantees
Commercial banks		
Rabobank	• Agriculture	• Micro finance • SME finance
Insurance		
Atradius	• For NL business / all sectors	• Export finance guarantee (Myanmar is expected to be eligible in the short run)
IFI organisations and multilateral institutes		
Asian Development Bank	• irrigation improvement dry zone • PPP's in (hydro) power generation • PPP institutional support	• Technical assistance grants • Concessional loans • Trust fund: NL funded Water financing program (USD 15M; Myanmar is eligible country)
World Bank	• River training works • Institutional development NWRC & hydro-informatics centre • Hydromet monitoring system	• Concessional loans • Trust fund: Water trust fund (NL funded)
IFC	• Urban water supply improvement (NRW reduction and bulk water supply Yangon)	• Technical assistance grants
UNDP	• Inlay lake outreach	• Technical assistance grants
EU	• Food security • Water & sanitation	• Technical assistance grants
EIB	• Unknown / MoU soon to be signed	• Concessional loans
Bilateral development partners		
Japan through JICA	Many relevant sector interests: • Irrigation • Ground water resources • (hydro) power generation • Urban water supply & sanitation (Yangon) • Flood prevention & early warning systems • Meteorological monitoring stations	• TA grants • Concessional loans
Norway	Environmental programme through MOECAF comprised of 4 components: • Monitoring Inlay lake • IWRM Sittaung and Bago River • IWRM tools development • Establishment national water quality lab oratory at MOECAF • Hydropower operations TA	• Technical assistance grants
Denmark	• Fisheries sector (still programming)	• Technical assistance grants
Korea	• Prevention salt water intrusion in delta area	• Technical assistance grants • Concessional loans (EXIM bank)
Sweden & Finland	• Interested in water sector but still deciding on focus areas	• Technical assistance grants
Switzerland	• Land policy (through MOECAF)	• Technical assistance grants
China	• Hydropower generation	• Concessional loans (EXIM bank)

Institute / financing source	Sector / project focus	Type of finance
UK through DFID	• Food security and alleviation (rural) poverty	• Technical assistance grants • Livelihoods and Food Security Trust Fund.
Netherlands	• Integrated water resources management • Capacity building & knowledge development	• Technical assistance grants • PPP (sustainable water fund) • private sector finance (Dutch Good Growth Fund, FMO)

4.5.2 PPP enabling environment

A quick review was made of the existing institutional and regulatory environment in support of a public-private partnership project implementation modality. Currently, almost all projects and investments are initiated by private proponents as the capacity of the Government to develop projects and run a competitive procurement procedure is limited.

As can be expected, the overall assessment is that an enabling environment for PPP's is still very much in its infancy, but several positive steps have been taken in the recent past:

- A new Foreign Investment Law ("FIL") was enacted in November 2012 which facilitates private sector development in a wide range of sectors, although certain restrictions apply[4]. The following forms of cooperation are allowed:
  - a 100 percent foreign owned company;
  - a joint venture company formed by a foreigner and a Myanmar citizen, or government department or organisation;
  - a public/private partnership, including a BOT contract or other analogue system

  A range of favourable tax incentives is provided for foreign investments that have received a Foreign Investment Permit from the Myanmar Investment Commission ("MIC"), the regulatory authority empowered under the FIL.

- A President's degree on Public procurement is in place, which prescribes competitive tendering procedures for the purchase of government goods & supplies. It is not entirely clear whether this degree is also applicable for government procurement of projects structured as a PPP and/or services and works contracts.

- Some experience is gained by the Government with the competitive bidding of (i) mobile telecoms license, awarded to Telenor and (ii) competitive airport PPP deals for the new international airport in Yangon / Hanthawaddy won by South Korea's Incheon International Airport Corporation and the improvement and operations of the Mandalay airport awarded to a consortium comprised of Japan's JALUX Inc., and Mitsubishi Corporation, along with SPA Project Management Ltd.

- The Asian Development Bank is currently assisting MOEP to develop a standardised Power Purchase Agreement which can be used for power generating facilities through

[4] Restricted activities are those which are potentially detrimental to public health or the environment, could be prejudicial to the culture of the country, as well as certain services and/or manufacturing activities that are related to agriculture, livestock and fisheries activities. For example, generation of electricity under 10 megawatt is included in the restricted activities list. Yet, even in these sectors foreign investment will be allowed with prior permission of the State.

independent power producers ("IPPs"). In addition, a technical assistance project is approved and will commence in 2014, which will provide support to the government in improving a PPP enabling environment. This TA will also assist MOEP in the drafting of standardised PPP procurement documentation for IPPs.

- IFC, the private sector arm of the World Bank, has commenced operations in Myanmar and is assisting MOEP in the PPP procurement of a 250MW gas-fired power plant in Mandalay, the Myingyan IPP Project, using the standard PPA developed through the ADB assistance referred to above. IFC is also assessing PPP projects in the urban water supply sector in Yangon.

Latest international insights and best practice identifies seven components of a comprehensive enabling PPP framework . These seven components are listed in the table below. The current state of affairs in Myanmar is analysed against each of these seven components.

Overall conclusion of this quick assessment is that GoM is receptive to the idea of PPPs, either on the initiative of private proponents through the Foreign Investment Law, or via a competitive public procedure with the GoM in the driving seat. Although the PPP environment is far from complete and many risks and (legal) uncertainties exist, both modalities offer opportunities to develop projects in the IWRM sector – specifically project with a clear revenue generating potential, sufficient to make a viable business case.

PPP enabling framework components	Myanmar current state of affairs
1) A clear national vision, commitment and leadership regarding PPPs, and clear and regular communication between the government and the market	- No PPP policy exists - However Myanmar Government has shown commitment by engaging with the ADB to commence with the formulation of a PPP institutional / enabling framework
2) Overall policy guidance and appropriate legislative support for PPPs that is developed over time as the PPP market develops and evolves	- See above - Foreign Investment Law specifically identifies a PPP modality through a BOT structure - A Presidential Degree on Public Procurement is in place but it is not clear whether this will be applicable to a PPP procurement - No specific PPP law exists, nor a concession law. Need for such a PPP law needs to be assessed against existing and planned legislative environment
3) Clear institutional responsibilities and establishment of specific public institutions to coordinate, support and enable PPPs	- No dedicated PPP units exists; - Past transactions have been initiated by individual line ministries and in most cases directly negotiated with private proponents; - ADB is supporting the GoM in identifying a suitable institutional arrangement for a central PPP unit which is to coordinate policy and manage/coordinate a PPP transaction deal flow in close cooperation with line ministries. Current idea is to have the Central PPP unit directly placed under the President's Office
4) Procedures for the identification, structuring, procurement, approval and management of PPP contracts that provide certainty to public officials and to the private sector;	- No specific PPP identification and development procedure is in place. Transactions are identified and developed on a case-by-case basis - No standardised PPP procurement or documentation in place. Standardised PPA for power generation facilities being developed

PPP enabling framework components	Myanmar current state of affairs
5) Introduction of specific direct and contingent financial mechanisms to support PPP development and where necessary the bankability of projects	- No current financial mechanism in place - Most transactions are revenue-generating and can fully cover the cost of the investment and O&M, hence direct financial liabilities are expected to be more limited as opposed to availability type PPP's. Needs further investigation whether government has embarked on 'take-or-pay' type of minimum revenue guarantees - No mechanism in place to close viability gaps of otherwise economically viable projects
6) A pipeline of well-selected PPP projects to serve a demonstration effect as well as to deliver important infrastructure;	- No overall pipeline of PPP transactable projects across all sectors is currently being developed - Experience is however gained with eth PPP procurement of airports - Following power outages, the power sector and specifically IPPs is a clear Government priority to bring on steam additional power generation capacity as soon as possible. - PPP procurement of IPPs through a competitive bidding process is currently being developed with the assistance of IFC and ADB. ADB intends to upscale and replicate experience gained to the National level
7) Development of capacity and expertise within the public, private and financial sectors to develop and manage PPP projects, as well as wider public communication	- All at very early stages of commencement - Capacity building can be expected from the ADB TA and IFC transaction advisory services, but this will take time to have tangible impact

5. Future development scenarios (long term till 2040)

5.1 Vision and possible scenarios

The NWRC has adopted a vision on Myanmar's water resources management.

The NWRC vision of Myanmar is '*to become a water efficient nation in 2020 with well-developed and sustainable water resources based on fully functional integrated water resources management system. The entire populace will benefit from gradually increasing income, better quality of life, greener environment, peace and stability due to efficient use of water and fair, transparent and inclusive allocation of water to many competing functions such as agriculture, forestry, mining, manufacturing, power generation, recreation, tourism as well as protection of water resources such as groundwater recharge and environmental flow in rivers.*'

This vision is leading for the development of integrated water resources management and has to be met for future socio economic development in the country.

To assure that this objective can be achieved it is important to be prepared for any possible future development. This means that the full range of potential developments should be identified and investigated. This will allow for elaborating different strategies to be prepared from an IWRM point of view to achieve the goals of the NWP.

For this strategic study it was chosen to develop three different scenarios covering a broad spectrum of possible future developments for the country using the presence as starting point. These scenarios are:

1. progressive shift towards a balance between agriculture and small to medium scale industry
2. rapid shift to industrial development
3. prolonged agricultural based development

Each of these scenarios will have its own effect and pressure on the available water resources in the country. Water demand will change accordingly, technology will influence the efficiency with which water is used and exploitation of ground water and surface water can shift. Different developments will pose different challenges in relation to water quality and requirements in relation to flood risk management may vary.

To develop these scenarios a workshop was held in Myanmar from 7-9 May 2014 in Nay Pyi Taw. This workshop was attended by a large variety of actors. Objectives were to:

- Familiarise participants with the role of future perspectives in water resources planning.
- Obtain a first set of future perspectives, or elements that can be used to construct perspectives later on.
- Further engage and strengthen a group of water and water-related professionals who are interested in water resources management and interested in playing a role in IWRM in Myanmar; also in the context of the Strategic Study.

The three scenarios will be described as potential developments for the country as a whole as well as with brief reference to specific regional aspects. To compare these scenarios it is important to have a clear view of the actual status of Myanmar and its economic sectors. As reference for the cause of this study the results of the McKinsey study is used. This study

differentiates between 7 economic drivers; agriculture, manufacturing, tourism, services, infrastructure, energy/mining and telecom. According to this study the GDP of Myanmar in 2010 was just over 50 billion US$. The contribution of the seven economic sectors to the GDP was a follows:

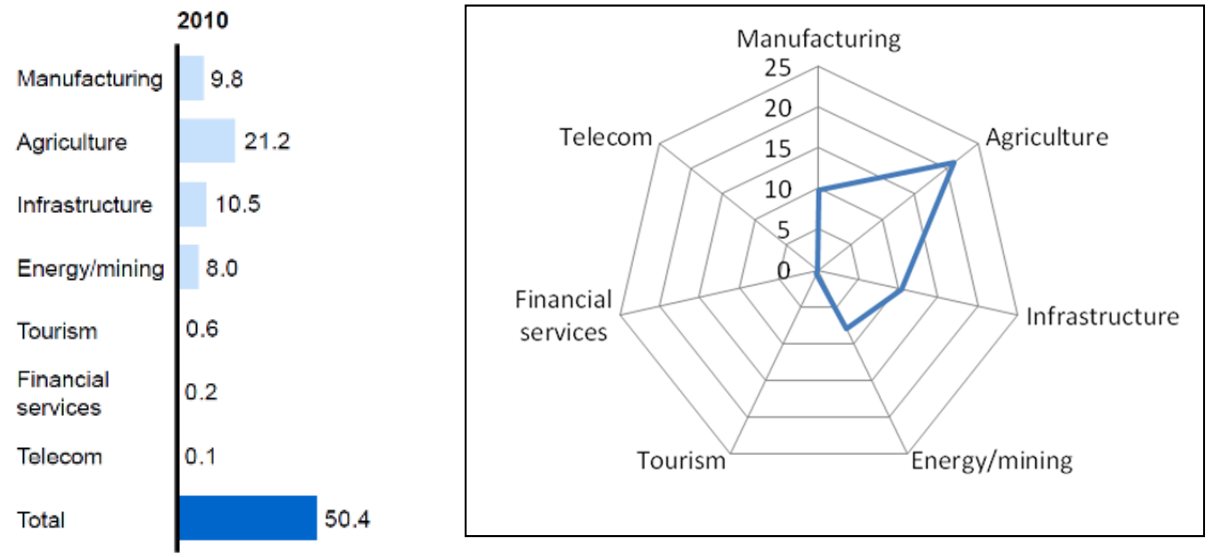


Figure 5-1 Contribution of economic sectors to GDP of 2010 (in billion US$) [source: ref. [16], page 35]

In the scenarios as described below, this heptagonal visualisation is used to compare them with the actual distribution of the GDP.

5.2 Progressive shift towards a balance between agriculture and small to medium scale industry

During the workshop the first (possibly preferred) scenario gave a development with initial focus on rural development through improving agriculture and gradual growth of small scale enterprises towards what could be characterised as a “green economy-green growth”.

Agriculture is diversified and intensified and becomes more efficient. Better crops, more efficient use of water, chemicals and fertilisers leading to higher yields per acre. Less intensive agriculture will be continued in the mountain areas but also highly efficient cultivation of crops that require more temperate climate is practiced. In the central dry zone irrigation schemes are rehabilitated and upgraded. Where possible, paddy production is cultivated, but in some cases, especially where the availability of water is insufficient, pragmatic choices have been made to cultivate other cash crops. Food processing is very important and leads to a steady economic growth in the first few years. In the Delta a sustainable combination of agriculture and fish/shrimp farming has been developed and is successful. With the improvement of the livelihood of the people in rural areas, the demand for luxury goods will increase. This will initialise a new economic development in the manufacturing sector.

The GDP will increase through a diversified development, agriculture at first, followed by manufacturing and facilitated by a steady growth in infrastructure. Manufacturing will be mainly centred around the bigger urban areas. This will attract people from the rural areas to

migrate to the city as wages are better in the manufacturing sector. Migration from the rural areas to the larger cities will induce an economic shift. The opportunities for light industries and sustainable development are far better than for heavy industry. Foreign and local investments are in industries with added value and based on own niche products. Initially fast industrialisation will take place in sectors with low added value making use of Myanmar's cheap labour cost.

After catching up with power demand through increased multipurpose hydropower generation together with coal and gas plants, larger scale electric power generation will provide for increased domestic demand as well will generate foreign revenues.

Improved job opportunities will attract the Myanmar labour force that emigrated to look for opportunities abroad. Together with ongoing industrialisation a manageable urbanisation process is taking place. Improved socio-economic conditions upgrade the liveability in rural areas. An increased use of off grid energy fed by solar and wind power, biomass and small hydropower installations assure a continuous supply of electricity. Infrastructure improvements assure easy access of people living in rural areas to education, drinking water, markets, financial support and employment during the agricultural off season.

Important development takes place in the sector of tourism. The focus is mainly on cultural and sustainable ecotourism which will provide jobs for the local population.

As indicated, the agricultural and industrial growth is facilitated by a strong development of the infrastructure as well as the telecom business. Other sectors, such as the service sector and tourism profit from that green development. The infrastructure development facilitates the agricultural and the consecutive industrial development. This includes the development of inland water transport, rail roads, roads, air transport as well as the inland and deep sea harbours.

In summary the scenario can be characterised as follows:

- Agriculture, development to agribusiness, moderate scale rural farming/ groups of farms
- Looking for industries with added value and based on own niche
- Foreign investments in green economy
- Diversification of agriculture, own mix per region (stable, cash crops)
- Controlled urbanisation, development in communities in rural areas
- Energy for own use, hydropower, solar, biomass + export
- Increase of ecotourism and cultural tourism
- Infrastructure development (including harbours)

The figure below gives the possible relative contribution to the GDP in comparison with the present situation.

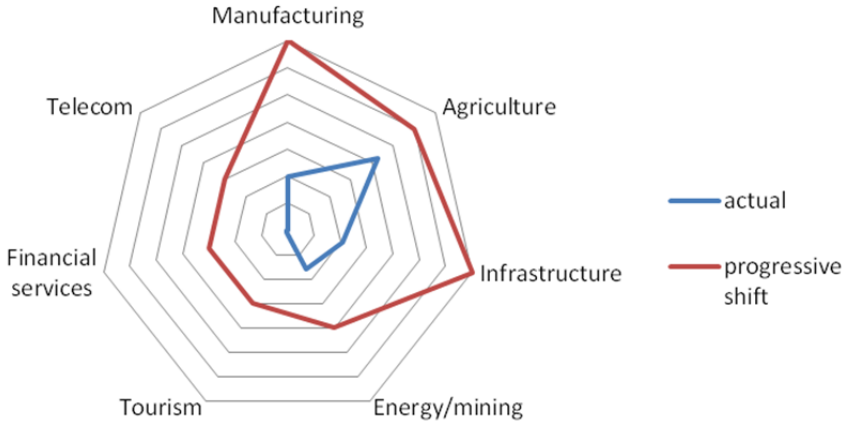


Figure 5-2 Development of a scenario compared to the actual contribution of the economic sectors to the nation's GDP *[source: ref. [16], page 35]*

5.3 Rapid shift to industrial development

This scenario is based on a fast development of Myanmar with heavy foreign investment in medium and large scale industry, power generation through both hydropower and gas and coal plants, logistics and offshore and inshore mining of oil and gas, precious metals and stones. The momentum will come from fast development of the special economic zones and will spread to other industrial areas. Many multi nationals have found their way to Myanmar as a new alternative for less favourable conditions in neighbouring Asian countries. The new large industries are, initially, successful because of cheap labour, but will gradually shift to production with more added values through employment of skilled labour.

Capacity building at all levels has created a skilled work force attracting even more private sector investments including high tech and in particular related to logistics. Myanmar is the hub of East Asia.

Also in agriculture a strong focus has been put on the agribusiness. A large part of the agricultural production is directed at production of export commodities. Also fish and shrimp farming are focusing on the export of raw, half and end products.

A fast urbanisation process has taken place as people move from the rural areas and migrated labour has returned to Myanmar. Infrastructures and facilities are rapidly improved with living conditions on par with the highly industrialised development.

The increased demand for energy has been answered by the construction of several hydropower dams. Gas is also being used for

power generation, but the larger part of Myanmar's natural gas is being exported, as is most of the energy generating revenues for Myanmar.

Tourism has intensified. Large tourist centres have been developed along the coast line and at cultural heritage sites. Desalination of sea water has relieved the pressure on safe drinking water in the coastal zones.

Extensive development has taken place in relation to infrastructure facilitating the fast industrialisation. Roads, railways and pipelines to China, Thailand and India have been constructed and a series of deep sea harbours function as logistical hubs to export products abroad. The development of these harbours also led to Myanmar's number one position concerning transport of goods from South East Asia to Europe, Africa and the America's.

This scenario is characterised as follows:

- New large industries, starting with cheap labour costs, own industries?
- Large scale agro-complexes, crop diversification, fish, export
- Foreign investments (many, big)
- Urbanisation, growing fast
- Migration of people to urban areas
- Energy for own use like hydropower, gas + export for foreign currency revenues
- Increase of tourism
- New infrastructure, harbour development
- SE Asia logistic hub

The heptagon as compared to the present situation looks as below.

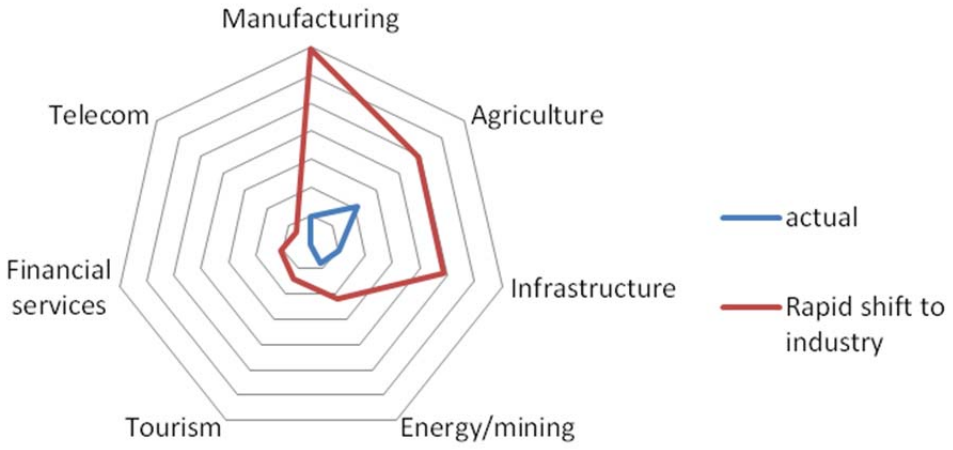


Figure 5-3 Development of a rapid industrialisation scenario compared to the actual contribution of the economic sectors to the nation's GDP *[source: ref. [16], page 35].*

5.4 Prolonged agriculture based development

Agriculture remains the most important sector for the next decades in this scenario. In the mountains shifting cultivation still is common practice although, with the new Land Law, the area used for shifting cultivation has diminished significantly. Using external knowledge and new technology a more sustainable crop and fruit production is in place. This can still be

categorised as small scale rural farming. In some regions in the dry zone agricultural practices has shifted from extensive, mainly rain-fed agriculture to more intensive agriculture where irrigation from surface as well as ground water resources is being used more efficiently.

Mechanisation of the agriculture develops slowly and agribusiness depends on foreign investors and donors. Dams have been constructed to increase the available amount of water and extraction of groundwater is still a very important source for irrigation. The use of fertilisers and chemicals has gradually been optimised.

In the delta region large scale paddy farms have continued to be developed. Improved crop varieties have improved yields. Mechanisation is still low hampering further production increases and improved livelihood of farmers.

Improved infrastructure (roads, telecom) has facilitated the accessibility to markets and has reduced transaction costs, improving the lives of farmers throughout the country.

Next to the gradual intensification of the agriculture in Myanmar some (food) processing industry has started to create added value. Instead of exporting raw materials, Myanmar will increase its income by producing half and end products. Expanded drying and storage capacities allow for a more profitable marketing of the agricultural products.

Urbanisation has maintained a continuous pace. Because of the importance of the agricultural areas for the economic development of the country, farmers and their families will continue to intensify their farming system. Migration to urban areas does not offer the advantages as can be seen in the surrounding countries. Because of few large scale industrial complexes and small scale industrialisation related to agricultural and rural development, employment opportunities in the urban area have not improved. Development of the industrial sector is negligible and depends on emigration labour force.

Other economic sectors like mining, energy, tourism and services have been developing over the years, but as a result of slow rural development, Myanmar has not developed in the same pace as its neighbouring countries. Energy, especially from hydropower, remains important as an export product and also mining has not gained significant added value over the years. Tourism, although growing, is not developed to its full potential. Especially for other sectors than agriculture investments in infrastructure have remained low.

For this scenario the summary is:

- Agriculture, following current situation. Some developments, very slow
- Low mechanisation
- Agribusiness depending of foreign investor/ donor
- Industrialisation, some cheap labour industries
- Migration to the urban areas, emigration labour force
- Energy for own use and export of hydropower
- Mining for export, no added value
- Tourism, increase
- Low infrastructure investments

This scenario can be typified by using the following radar chart and again given in comparison to the present situation.

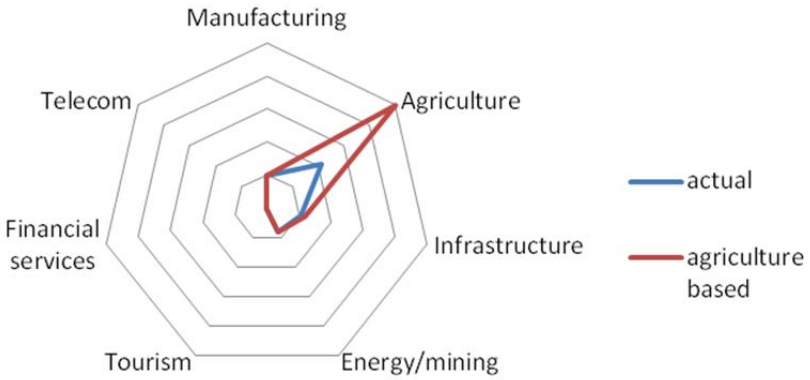


Figure 5-4 Development of scenario with prolonged agriculture based development compared to the actual contribution of the economic sectors to the nation's GDP [source: ref. [16], page 35].

5.5 Impacts of climate change

In the preceding paragraphs three possible future developments of Myanmar have been described taken from a socio-economic point of view. Generally socio-political and economic developments are one of the main exogenous driving forces affecting human activity, land and water utilisation and thus pressures on water resources.

In addition the possible impacts from climate change need to be considered.

Long-term impacts on the Myanmar water resources due to climate change generally follow the regional patterns:

- erratic occurrence of rainfall with respect to intensity and seasonal and spatial change;
- later start of wet monsoon or prolonged periods of droughts;
- consequently higher flood levels and lower low water levels in rivers;
- sea level rise with increase in salt water intrusion;
- rising sea water temperatures may cause more or deeper depressions;
- changing trajectories of cyclones from the Bay of Bengal.

With respect to cyclones it can be debated that cyclone patterns have a tendency to shift eastwards resulting in more cyclones which originally headed for Bangladesh, but recently tend to veer off more often towards Myanmar posing flood risks in the delta and central Myanmar.

In future master planning the actual impacts of climate change will need to be further studied and will be an important building block for the Myanmar National IWRM Master Plan. This also concerns possible changes in (seasonal) water availability and demand for food and energy security.

Box 5-1 Is Myanmar exceptionally impacted by climate change

Dr U Tun Lwin (DMH) comments on the second UN Climate Change Impacts & Mitigation Report that already in the short-term climate change effects need to be considered in strategy development:

"..... water security, extreme weather and climate impacts are all threatening to Myanmar, which is the second most impacted country in the world as far as impacts from climate change and natural disasters are concerned. Currently the levels of UV and the Heat Index are rising, especially in the summer and pre-monsoon seasons. Myanmar's monsoon characteristics have drastically changed since 2006 such as:

1. Later onset of monsoon season by as much as 15 days
2. Earlier withdrawal of monsoon season by as much as 25 days
3. A shortening of the rainy season by as much as 40 days
4. A disappearance of depressions in the Bay of Bengal by as much as 40%.

In addition to these impacts, Myanmar is expected to have a temperature rise of 5°C by the end of this century according to the UK's Hadley Centre, leading to increased scarcity of water resources."

Longer droughts and water shortage

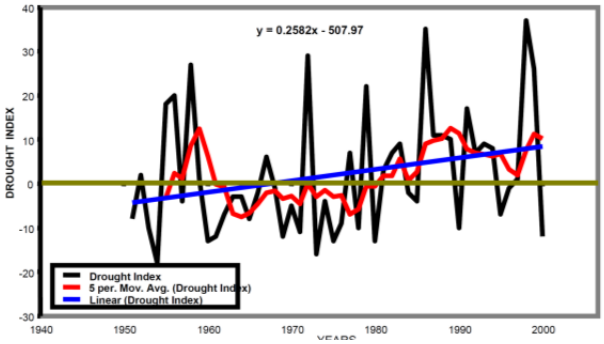


Figure 5-5 Droughts in Myanmar

Myanmar is a country with very uneven distribution of rainfall, both in geographical location as in the seasons. The irrigation schemes in the Central Dry Zone ensure fresh water supply for rice and other crop. Even in the wet monsoon rainfall is not sufficient for reliable agriculture. But also in the delta, the polder dykes have a function of retaining fresh water to "prolong the wet monsoon into the dry monsoon". Even in the current situation fresh water shortage is rather common practice than exception. Shorter wet monsoons will seriously impact the already strained irrigation practice.

Sea level rise

The Ayeyarwady Delta is flat and low, land levels are very close to mean sea level, virtually without protecting dykes or dunes. This makes the country very vulnerable to rising water levels. In the delta many townships, villages are built at very low level are subject to increasing problems.

Salt water intrusion already shows inland movement effecting both domestic and irrigation water supply. Especially in the estuaries, where high sea levels may coincide with – higher – river floods, sea level rise may have serious impact.

Figure 5-6 Be Tut village in the Ayeyarwady delta near Labutta lies at sea level.

Cyclones hitting Myanmar

Cyclones in the Bay of Bengal have hit Bangladesh often and hard in the past. In May 2008, seemingly out of the blue, Nargis hit the Ayeyarwady Delta and Yangon area hard [section 4.2.5]. A number of other cyclones has made landfall in Myanmar since. The serious climate change debate is whether the pattern of cyclones has changed. It is remembered that also in

1974 a serious cyclone has made landfall in Myanmar. An old study of Halcrow and Partners has already identified an earlier change in patterns. The actual cause of this pattern change is not really clear, it is merely a research finding in terms of actually observed cyclone tracks, rather than an explanation. It needs to be assumed that Nargis, was *'not just one event'*, a serious cyclone may occur again in Myanmar.

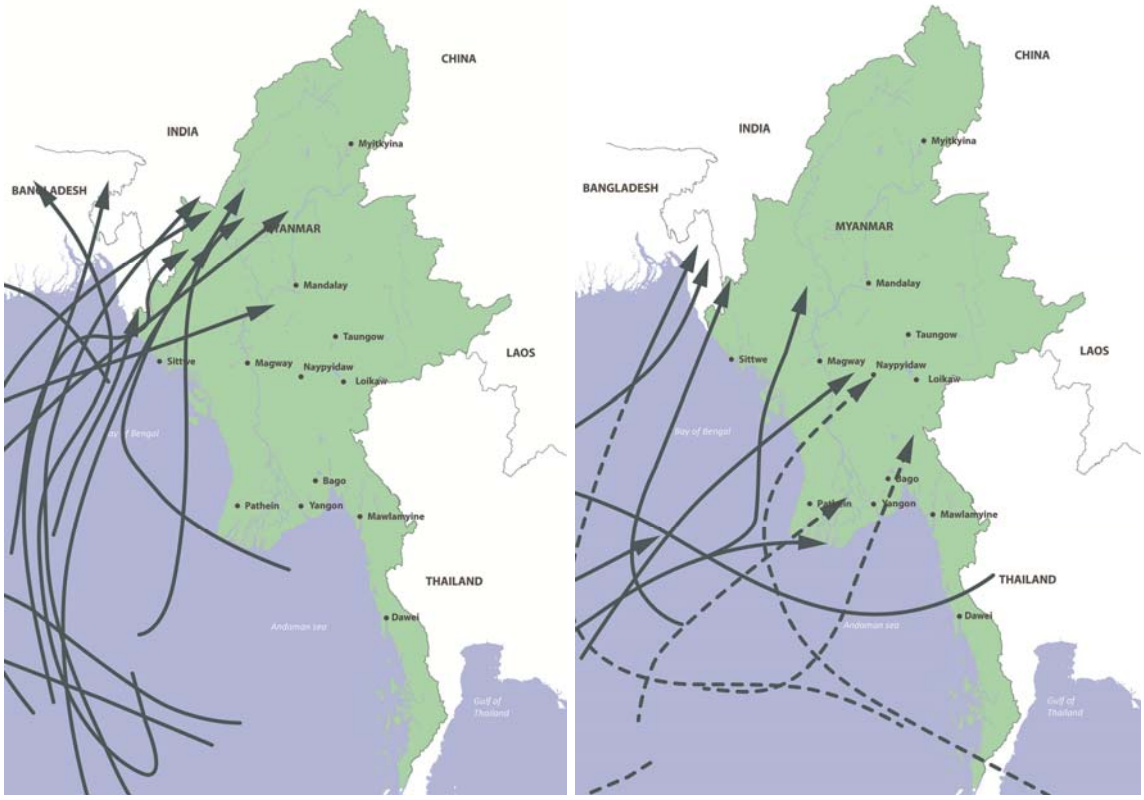


Figure 5-7 Changing pattern of cyclones observed. Two periods compared 1965-1972 and 1972-1978, *source Halcrow and Partners*

Conclusion on climate change

Climate change is a long-term effect. It is not only a long-term fact that looks into the future. The vulnerability of Myanmar's water resources is evident. This vulnerability is first of all strongly related to the problematic geographical situation of different regions (drought prone, flood prone, cyclone prone etc.). The current state and development of water resources management determines how well Myanmar will be able to cope with this vulnerability.

Climate change adds to the vulnerability and the demands on adequate water resources management.

Especially where it concerns longer periods of droughts intensification of water retention and water saving methods will be required, also given the fact that a growing population and growing wealth requires a higher utilisation rate of water for energy, consumption and food.

Where climate change affects the cyclone patterns and floods (intensified rainfall and sea level rise), measures will need intensified attention and increased dimensions.

5.6 Effect of scenarios on water use

5.6.1 Water allocation countries worldwide

Experience in other countries in the region provides useful insight of the changes in the water use of different economic sectors. Here a distinction has to be made between water users and water consumers. Users exploit water resources, but do not influence the water balance itself: hydropower, aquaculture and navigation. Water consumers on the other hand take water without returning it to the source. Large water consumers are agriculture, manufacturing industry and drinking water. Figure 5-8 to Figure 5-10 show different, relative mixes of water use. This can be used for the outlook of water use in Myanmar in relation to the development scenario that will take place. It should be mentioned that this is a qualitative analysis as the use and allocation of water depend on many different aspects that are difficult to foresee. At the moment only 5% of Myanmar's total water resources are being used and 89% is allocated to agriculture. The other 10% is largely used by households, leaving the demand of industrial water marginal at the moment (see Figure 4-9). Figure 5-8 to Figure 5-10 indicate that the countries that have passed through a strong industrial development tend to divide their water resources more evenly. The availability of water will also be affected by climate change. These effects should be superposed on this assessment.

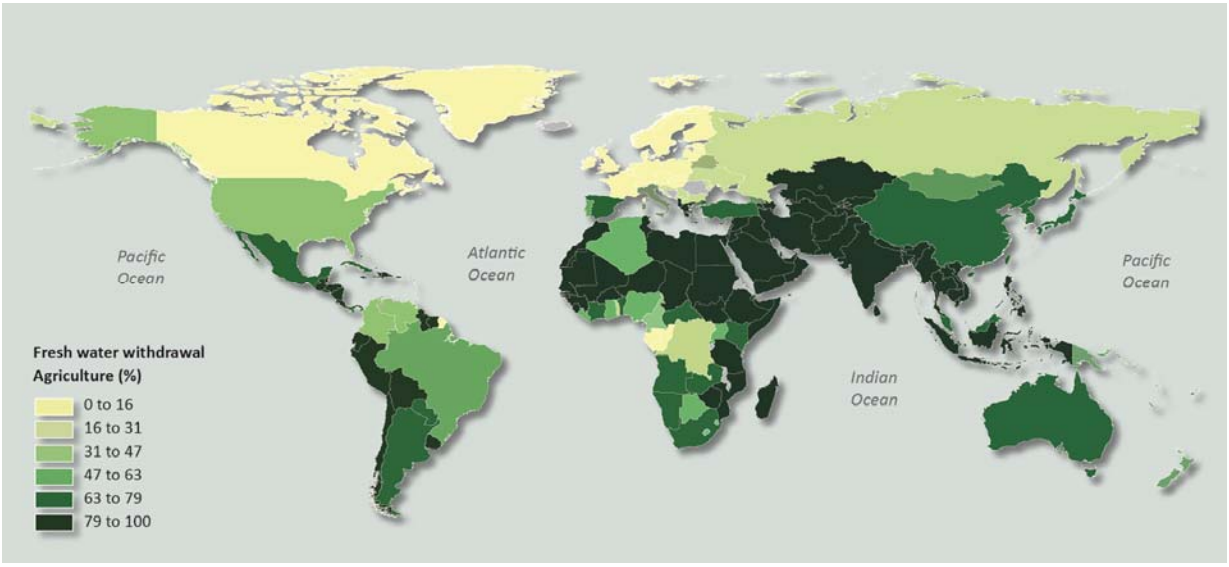


Figure 5-8 Fresh water withdrawal for agriculture in countries with different development levels *[source World Resources Institute 2001]*

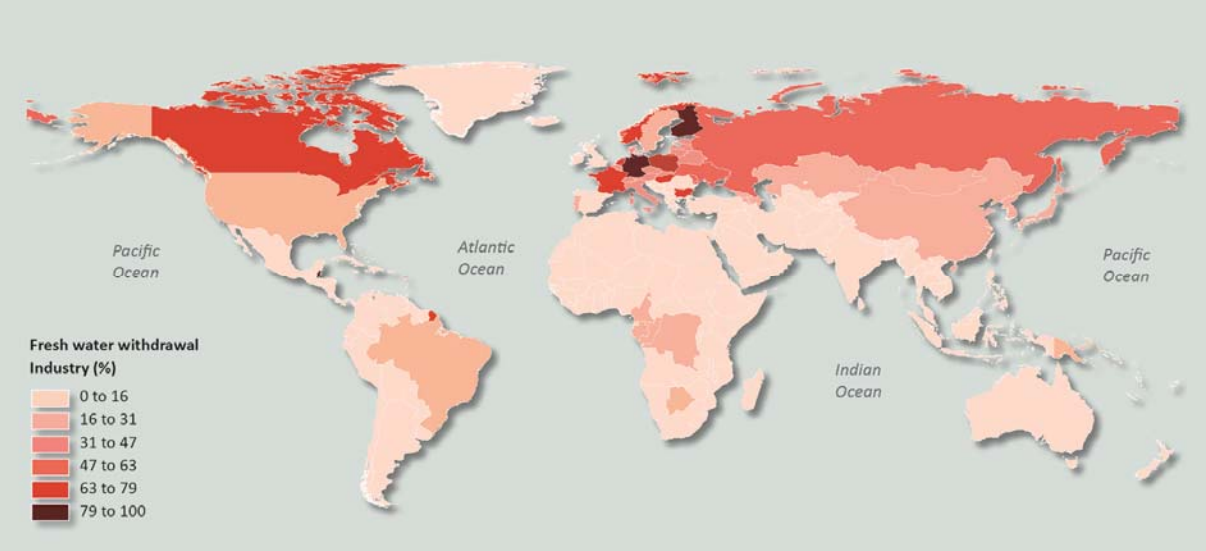


Figure 5-9 Industrial fresh water withdrawal in countries with different development levels *[source World Resources Institute 2001]*

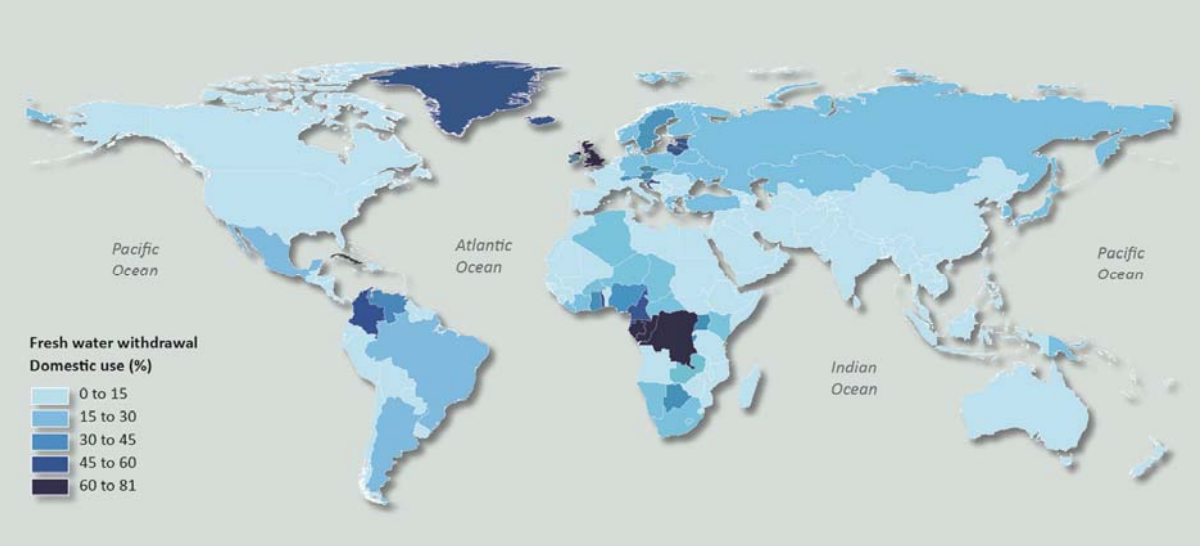


Figure 5-10 Domestic fresh water withdrawal in countries with different development levels *[source World Resources Institute 2001]*

5.6.2 Water allocation shift differs per scenario and region

Each of the scenarios will have, in time, an impact on the water resources situation of Myanmar posing new challenges as well as opportunities. Negative impacts will need strategies for mitigation and opportunities require supporting strategies.

Progressive shift towards a balance between agriculture and small to medium scale industry will show a consistent growth of agricultural production and improved conditions in the rural areas, jointly with more moderate industrial growth and urban

development. At present approximately 90% of the water use is taken by agriculture. In the future this may shift to 1/3 for agriculture, 1/3 for the industry and 1/3 for other purposes.

The progressive shift from agriculture to industry will pose increasing pressures on the water system in the different regions of Myanmar. Although efficiency of water use might increase in agriculture, the increased area covered by this land use might cause water stress, especially during the dry period that might lengthen because of climate change. Water stress will also deepen in the urban areas where the demand will increase on top of an already insufficiently operating supply system. Use of groundwater sources might speed up the process of land subsidence causing serious problems for the existing infrastructure. Deterioration of the water quality in view of increased use of fertilisers and pollution by industry is an unmistakeable threat.

This scenario results in an increasing demand for water in the agricultural areas as well as the regions around and in urban areas where industry in expected to be located. Hence, the strongest growth in water demand will take place in the Central Dry Zone and the Delta region where most of the activities are expected to develop. Although there is only – an estimated – 5% of Myanmar's available water resources being consumed, it is not expected that the consumption of water by agriculture will – or can - increase steeply, especially not in the Central Dry Zone where availability of water depends strongly on location and season and the percentage of the total water availability being used and utilised is already high. However, with the rehabilitation of irrigation schemes water use will become more effective and transport of water from longer distances can be achieved. The use of ground water will also increase strongly affecting the groundwater levels in the aquifers. Industry is expected to develop near existing urban areas as these are their demand areas. Most of these urban areas are located near large water resources, Nay Pyi Taw being one of the exceptions. Therefore the share of water used by industry is expected to increase more rapidly. As new water treatment and supply systems are upgraded and extended, improving the liveability of rural and urban areas domestic use is also expected to grow gradually. Water use in the mountain areas is not expected to change drastically under this scenario. The total amount of water used in this scenario is highest; agricultural water use will increase slightly while a strong increase is to be expected of the water being used by industry. These industries will be located near rivers and lakes, with an availability of water all year round. Climate change is expected to have a strong effect in agriculture and, hence, its water use.

The second scenario builds on the presumption that parts of Myanmar (especially in the 'Special Economic Zones') will experience a **rapid shift to industrial development**. This development will result is a much higher use of water for industry and domestic supply. The result of this development will also lead to a decrease of the water use of agriculture. Many people from rural areas will migrate to the larger cities and less land will be used for agricultural production. This development will also lead to a steep increase in the demand of electricity. This will be partly supplied through the construction of hydropower. The total water balance will change due to evaporation in the reservoirs and less water may become available for especially irrigation and navigation as these are depending on a stable discharge, which does not always concurs with the demand for electricity. Water quality will also become an important issue as industry will strongly affect water quality unless there is strong regulation and rule of law. It is also expected that industrialisation will have the strongest effect on transport. Raw materials (timber, minerals, agricultural products) have to be transported from upstream areas to the downstream regions where most industrial development will take

place. This will increase the demand for constant discharges all year round. And, consequently will affect the management of the river and its channels.

The fast urbanisation process will pose pressure on water availability within the cities. There will be a tendency to over exploit groundwater sources where easily available. Apart from eventual depletion of this water sources it may also result in land subsidence in the delta region.

The third scenario, a **prolonged agriculture based development**, will lead to a series of water quantity as well as water quality challenges for the future. Use of water for cultivation of crops will be more efficient in the future but intensive agriculture over larger areas will lead to an increased water demand. This will be met partially by capturing surface water, but also by using ground water. A prolonged agriculture base development might slow down the expected growth rate for electricity. This could have an effect on the operational protocols of the existing and new reservoirs, adapting these protocols more to a efficient use of their capacity for providing the rehabilitated irrigation schemes with more water. This scenario could also affect the land use in the mountainous areas causing. Intensified deforestation for agricultural purposes could lead to changing discharge patterns of the rivers, to more erosion and, hence, increased sedimentation in the lower stretches of the rivers.

The use of domestic water will also increase although not so strong, taken into consideration that development will mainly take place in the rural areas that are difficult to be reached / serviced by large treatment plants. This could possibly be done by smaller units with restricted capacities.

The prolonged agriculture based development water. At the moment it is not clear what the ground water depletion rate is, but many people have already conveyed their worries.

Intensification of agriculture could also lead to ongoing contamination of the water resources as a result of the overuse of chemicals and fertilisers.

Ongoing agriculture in the mountainous region will lead to further deterioration of the water sheds with the negative effects in the downstream areas.

Focus on (extensive) aquaculture in the delta could lead to an increasing pressure on the water quality.

6. Water governance

Integrated water resource management is not exclusively about measures in the water system, it deals with people as much as with 'hard' technical measures. When dealing with a failing water infrastructure, one can look at technical measures, but one can also look at the institutions and personnel involved. Are there clear rules and regulations? Do departments and institutions collaborate in a constructive way? Are the people working in water management well trained? These kinds of questions are the domain of 'good' water governance. This chapter will address the analytical framework of water governance, the 'as is' situation, and possible strategies and 'no-regret' measures for the future. No-regret measures at 'pilot level' will be found in the chapters on the pilots.

6.1 Analytical framework for water governance

There are a lot of definitions for water governance, but they have mostly the following elements[5] in common:

- powerful administrative organisation;
- legally embedded system of water management;
- planning system based on facts and figures;
- adequate financing;
- participatory approach.

The framework for this report is shown below.

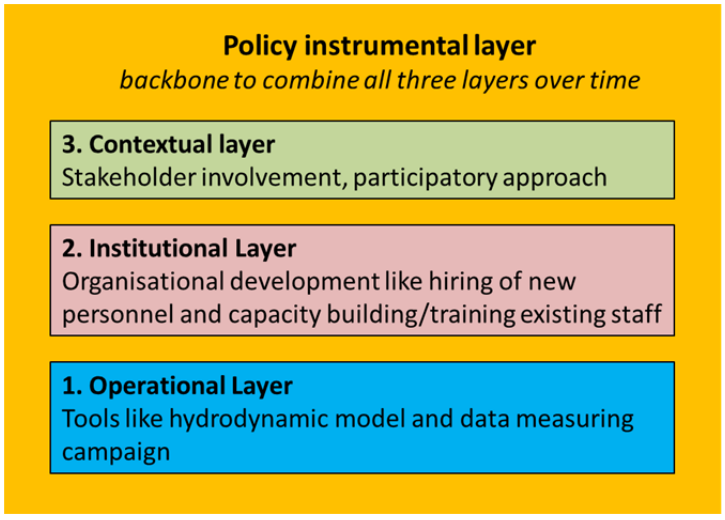


Figure 6-1 Framework for analysis of essential element in water governance

The Study Team has formulated hypotheses on all these levels, and validated these during desk research, interviews and workshops.

[5] 'Building blocks for good water governance', Water Governance Centre.

Operational layer

Research questions:

- What kind of information, data and prediction models are needed in order to assess water systems
- How can impacts of developments like climate change, social or economic growth and reforms be predicted
- How can ecological 'good' conditions be preserved
- How can sustainable growth be enabled.

Based on the hypothesis (first finding report) data collection and modelling key problems are to be addressed.

1. Institutional layer

On institutional level, the following research questions have been asked:

a. The '**administrative gap'**:
   - Can you describe the workings of the different government levels (i.e. union, regional and state governments, districts, townships, village wards), and the interaction between the departments?
   - Based on the hypothesis that in Myanmar there are a lot of ministries who cover parts of Integrated Water Research Management, but not necessarily work together, that most decision making goes 'top-down', and that the administrative boundaries not necessarily cover geographical boundaries of water systems.

b. The '**objective gap'**:
   - Can you describe the policy objectives of your government unit, or the government units you come into contact with?
   - Based on the hypothesis that there might be competition between different ministries and different rationales behind the formulation of targets.

c. The **'capacity gap'**:
   - Do you have sufficient staff to implement your (water) policy requirements, and do these people have the right knowledge, expertise and skills?
   - Based on the hypothesis that this might not be the case.

2. Contextual layer

Research questions based on the hypothesis that a participative approach is new in Myanmar, and might be little known.

- If, and how, does a possible 'bottom up' approach work?
- Is there a form of participatory approach towards water policy development and implementation?
- Does the government know who its stakeholders are, and how to involve them?
- To what level are stakeholders allowed to participate: are they merely informed, can they react on policy goals, or are they partly responsible for the formulation and implementation?

All this should be embedded in **'rule of law'** and **adequate financing.**

3. Rule of law

Under the heading of 'rule of law' the team has investigated whether or not there are specific laws, rules and regulations regarding water use and water management, and, if so, whether or not these laws, rules and regulations are actually enforced and monitored. Practices like licensing, permitting and fining, were also taken into account, as were some ideas on what basis and criteria for example licenses are issued and controlled.

4. Adequate financing

Under the heading of 'adequate financing', questions were asked like:

- Who is responsible for taxation and revenues?
- Where do these revenues go?
- Who decides on basis of what criteria how budgets are spend?
- Are budgets adequate for the issues that need to be solved?
- Is there a relation between the cost of water use and the price of services rendered?

In order to appreciate the importance of water measures, public or private water users and governments need to be aware of the costs of water utilisation and water management.

Social equity (one of the goals of 'good water governance, according to the National Water Policy) is best reached when 'polluters pay'. Or in analogy: water users who need the greater amounts of water should pay more, water users that infringe heavily on the quality of the water system should also pay more.

6.2 Current water governance

Following the analytical framework, all layers as they occur in present day Myanmar, will be presented. Note: the analysis is limited in scope, due to the fact that only a limited amount of 'field work' was performed. Where additional research might be valuable, this will be stated.

Box 6-1 Need for Basin Plan / Master Plans and sustainable development

Irrigation works / hydropower projects

Both the Irrigation Department and the Water Resources Utilisation Department provide irrigation water to farmers (where the Water Resources Utilisation Department provides it only through pumping water from rivers or groundwater and mainly active in the dry zone). When asked about the planning of these works they explain most areas are located elsewhere and that only a few areas overlap / join. The question who plans or coordinates expansion projects or e.g. the existence of Master Plans was difficult to answer. They are aware of the need, but have no approach or practice. A similar story can be told for the hydropower projects where little is currently done on basin plans of the different and potential hydropower projects.

Water abstractions permits

The Directorate of Water Resources and Improvement of River Systems is responsible for granting water abstraction permits. However no permits have ever been asked and there is no monitoring of abstractions along the river. It is not known who is responsible for groundwater abstractions.

EIA and pollution control

This is the responsibility of the relatively new department of Environmental Conservation Department. Currently they are busy with making the laws, regulations, policies and/or standards. Actual checking and/or approving of EIA reports or monitoring of water quality is not yet taking place.

6.2.1 Operational layer

The need for information and knowledge, facts and figures was widely recognised in the field work and interviews. At the same time, availability of data is notoriously bad, and every government body tries to gather their own data, to develop their own standards.

Box 6-2 Example scattered responsibility water quality standards

The Ministry of Health is responsible for drinking water quality standards, the Ministry of Environmental Conservation & Forestry is responsible for standards of industrial waste water and its impact on the environment, and the actual monitoring of water quality is done by municipal entities like the Yangon Municipality of City Development. But none of these parties have the standards, the equipment, the models or the laboratories to actually monitor water quality. So licensing is weak, or none existent, there are more illegal than legal tube wells in the Yangon area, and integrated, transparent decision making is not possible at the moment.

People are on the other hand very much aware of the kind of data they need, also when dealing with integrated water resource management. There is already a clear understanding of the amount and the type of data that are required.

The need for Environmental Impact Assessments (EIAs) to support decision making is widely recognised by governments, NGO's and the public. In nearly every stakeholder meeting or workshop stakeholders called out for transparent EIAs to analyse or predict the impacts of for example large plans, like hydropower dams, developments of industrial areas, ports and exploration of oil and gas in the sea before decision making.

6.2.2 Institutional Layer

Administrative gap

There seems to be a significant administrative gap. Different departments are responsible for sometimes overlapping, sometimes mutually exclusive water issues and water policies, boundaries of departmental, state- or regional, district- and township level do not always correspond with water system boundaries, most decision making goes 'top down'.

Box 6-3 Administrative gaps

While the Directorate of Water Resources and Improvement of Rivers (Ministry of Transport) is responsible for keeping sufficient water depth in the rivers for navigation and transport, the Irrigation Department (Ministry of Agriculture and Irrigation) is responsible for the embankments along the rivers for flood protection. The required coordination is done at the local level.

Water supply in rural areas is mainly the responsibility of the Department of Rural Development (Ministry of Livestock, Fisheries and Rural Development. However both the Irrigation Department and the Water Resources Utilisation Department (both Ministry of Agriculture and Irrigation) provide water for irrigation. Some of their systems also provide domestic water.

The Forest Department (Ministry of Environmental Conservation and Forestry) is responsible for watershed management. This is however only in the areas that fall under their jurisdiction, meaning the areas that are declared as Forest reserve (approximately 46% of the country is covered by forest and 30% is declared Forest reserve).

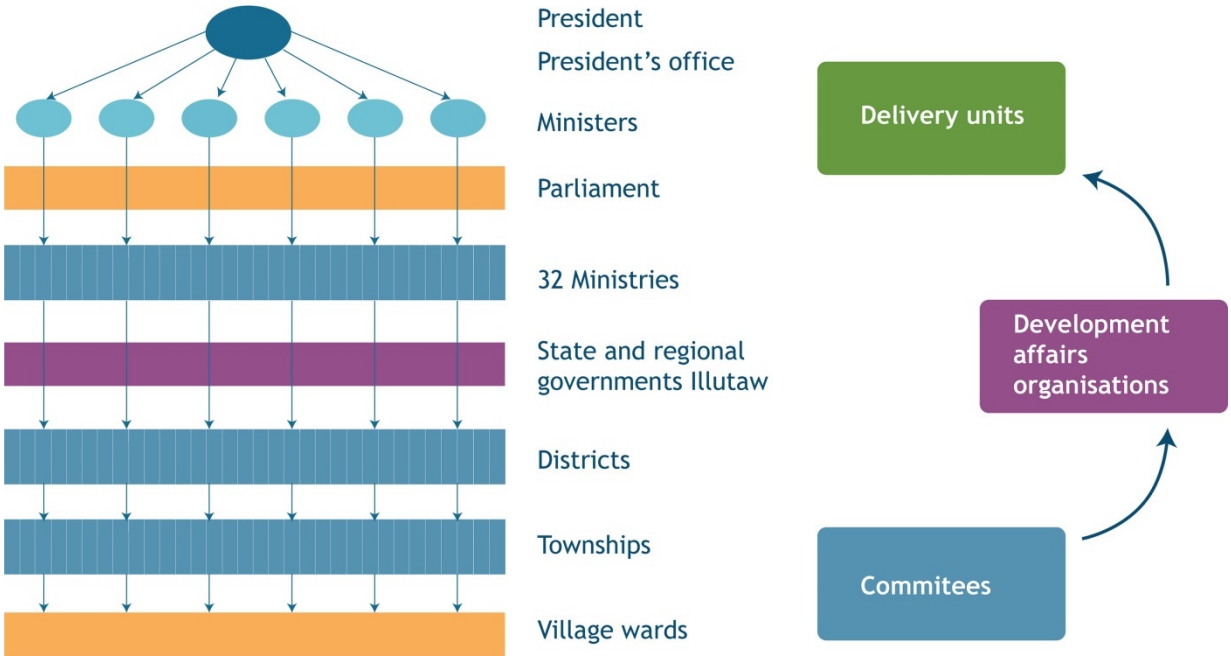


Figure 6-2 Government decision-making power and influence patterns

Most decisions are made at union level, and no major policy decision can be made without the support of the president and the president's office ministers. The president's office ministers are members of the personal 'cabinet' of the president, and carry special responsibilities.

Myanmar has 37 ministries, fifteen of them are more or less involved in management of water resources; sometimes they have overlapping tasks and responsibilities.

Ministries have regional offices at the state and regional level, in the districts, the townships, and often at the village ward level as well. Negotiations take place at the regional (sub-national) level.

Research[6] has been done to investigate the (relative) power of the State and Regional Governments (SRG), and the *Hluttaws* (regional parliaments). The members of the *Hluttaw* get elected. 'States' are territories with large minorities, 'regions' have a Burmese majority, they have the same level of relative independence. The highest official, the chief minister of the SRG is appointed by the president, he/she appoints the other ministers. The civil servants are appointed via the GAD, the General Administrative Department. SRG receive very little own funding, and cannot decide on the spending of their own budget (see below). The SRG will have 'development affairs organisations', formally known as 'municipal offices' that may assist them.

At village level it is possible to elect representatives for the *Hluttaw*. Elections for the national parliament are held at the township level.

[6] By the Asia Foundation, see report

When mutual decision making has to be reached, a committee will be formed (either on national, the state/regional or the township level).

Special consideration should be made for 'Special Delivery Units' at the Union Level, special national committees, or Task Groups. They fall directly under the supervision of a president's office minister, and are there 'to get results'. In fact, the distinction between 'Special Delivery Units' or National Committees is often unclear.

So an informal way of bottom up influencing might be in place. At a local level, different departments with local offices will meet every month to discuss the issues at hand. These 'guidance committees' will discuss matters with (elected) representatives of the village wards. It is difficult to assess the precise workings and effectiveness of the committees. On the one hand; they appear to be a clear form of a potential bottom up- participative approach, but on the other hand, it is uncertain how well local issues are represented.

Objective gap

In the interviews, the interviewees mention a conflict of interests between government layers and government agencies. For example, targets for economic development will clash with environmental concerns, need for drinking water might interfere with need for irrigation water etc. As the National Water Policy is still in its early stages, and there is no unified water act yet, there is no multi criteria framework available to breach this objective gap.

Capacity gap

Some departments (but not all) stated that their main concern is capacity building. They don't have enough manpower, and their officials lack the knowledge and training for the new demands of integrated water resource management. Lack of sufficient capacity, both in quantities of staff and in quality, seems to be a major issue [see chapter 7 Capacity Development].

Basin Authorities

In view of the above there seems to be ineffectiveness in properly coordinating water resources management at local and Union level. The institutional gaps at local level prevent water management which receives appreciation by the people. Directing at federal level may overlook specific regional and local requirements both from a technical as well as from a socio-economic perspective.

In line with the newly established Myanmar National Water Policy consideration may be given to the establishing of Basin Authorities for the major rivers. Many good examples exist in the world and many of them are associated within INBO (International Network of Basin Organisations; www.inbo-news.org).

For regional management of water supply and demand (e.g. drinking water versus irrigation water) regional water authorities, preferable with involvement of public and private partners, under the basin authorities might give an effective and transparent way of water resources management in Myanmar.

6.2.3 Stakeholder participation

The importance of stakeholder involvement is something that is widely understood in our interviews and field work. But, as one respondent said: 'this is easy to say, but hard to implement'. The implementation might be hindered by two main constraints:

1. Stakeholders themselves are afraid to participate. People still need to discover that it is ok to express an opinion or to elect a spokesperson. Furthermore people on the village level are not used to expect service delivery from the government, so they fail to see the use of participation. This will take time, and good experiences.
2. Civil servants and officials need to learn how to enable a participatory approach. When asked, 'participation' is often confused with 'explaining the issue and telling people what to do'.

6.2.4 Rule of law

Recently there have been some changes in legislation related to water, but in general the legal framework is dated and no longer appropriate for addressing the challenges in the water sector. The majority of the current water legislation has its starting point at the beginning of the twentieth century under British rule. It should be noted that the legislation for the irrigation water supply is still in place at present. In the last decade of the twentieth century there was a general legal reform to facilitate the economic liberalisation policy of the government and the changes that took place concerned only the urban water supply legislation. The legislation for the other types of water resources did not change, though, the Environmental Conservation Act 2012, which is the result of a ten-year discussion, is a very important act for the implementation of IWRM principles. The ministry representatives recognise the need to develop a new and integrated legal framework. At present, the legal framework in Myanmar is still following a sectoral and operational approach and is consequently not well coordinated and fragmented.[7]

A need to reform the water legislation framework in Myanmar has been clearly identified as a measure to be taken within the larger water sector reform. Indeed, the National Water Policy (NWP) approved by the National Water Resources Committee (NWRC) in March 2014 recognises the need for a system of laws and institutions (see for instance §1.2 and Chapter 3 of the NWP).

The Asian Development Bank has been supporting, through the ADB-UNESCO-IHE Partnership Fund, since January 2013 a project entitled "Supporting National Water Legislation in South Asia and Southeast Asia", which includes Myanmar. So far there has been a fact-finding mission in October 2013 and a workshop in Delft in June 2014, attended by four representatives Myanmar from the National Water Expert Group (EG) and various ministries.[8] Follow-up activities were discussed during the workshop in view of obtaining further funding to continue the project. It is anticipated some of these will be included in capacity building activities.

[7] For more details on the existing framework see the Country Mission Report for Myanmar by Zaki Shubber and Bart Teeuwen of October 2013.

[8] Ministry of Transport, Ministry of Agriculture and Irrigation and Ministry of Environmental Conservation and Forestry.

The World Bank (WB) has also indicated its interest to assist with the development of a new legal framework. It has been agreed that the activities of the WB and those under the ADB project in this particular area will be aligned.

The EG, which is advising the NWRC on the water sector reform, is leading the advisory work on the governance element through its thematic working group (TWG) "Water for People". This includes the development of a legal framework for water resources management. The TWG Water law is concerned with the drafting of the Myanmar Water Act.

At present, the approach that has been adopted by the EG has been to develop a “water framework directive” that is intended to serve as a basis for the drafting of the water act. This terminology has been borrowed from European legislation; however, it is a completely different type of instrument and does not have the same status at all as a European directive.[9] The EG has indicated that this document, MWFD, is being reviewed by various relevant stakeholders in order to be as inclusive as possible of issues and areas to be covered by the umbrella water legislation. Once this has been finalised, the content of the directive will be incorporated into a draft act that would then follow the usual steps and legislative procedure to be enacted by parliament. This involves the Office of the Attorney General (OAG) reviewing the draft to ensure it is aligned with the legal system and compatible with existing legislation. Comments are provided to the ministry responsible for the draft. The draft is then submitted to the cabinet before reaching parliament to be discussed in that forum and become enacted.

Drinking water standards are also in the process of being prepared with a view to finalisation by the end of 2014.

6.2.5 Financial framework

The financial system also works mainly top down. Revenues and taxes are collected locally, but the money goes 'up' and is mainly reallocated and redistributed at a national level. Sufficient funding is a problem everywhere. And note: Myanmar has about the lowest rate of taxation in the world; about 6% of the GNP. Criteria for budget allocation are sometimes hard to find. So, for example, while the Department of Rural Development has the target to provide 10.000 villages of access to clean drinking water each year, they only receive funding for 3000.

There is, furthermore, no clear sense of paying for water services rendered. People are used to paying something for their drinking- or irrigation water, but mostly this fee is insufficient to cover costs for maintenance, let alone improvement. On the other hand even very poor people seem to be willing to pay a 'fair' price for water services, as long as they are certain they get 'immediate return on investment', in other words, high quality delivery of the water they are paying for. Industrial users or polluters of water are not used to pay at all, and this causes great concerns. People (especially in the environmental part of the government and civil society) ask for measures whereby 'big users/polluters' are forced to use parts of their profits for mitigating or compensating measures towards the water system and environment.

[9] It has been suggested to the EG to use a different term to avoid confusion as to its status and value.

6.3 Basic good water governance

The strategy to achieve good water governance is built upon the governance framework, as described in the previous paragraph. This implies:

1. Starting with the **operational layer**, providing necessary data and impact assessments
2. On the **institutional level**, closing the '**administrative gap'**, in other words: finding ways of improving collaboration between government layers and agencies. And closing the **'objective gap':** enabling government units to reach an understanding about shared goals and objectives. Thirdly, closing the **'capacity gap':** finding ways of providing institutions with advise on hiring and training of staff, and closing the knowledge gap that prohibits stakeholders how to use water resources wisely.
3. On the **contextual layer**, finding ways of improving stakeholder participation, by focussing both on civil servants who have to initiate the stakeholder participation, and stakeholders themselves.
4. All this should be embedded in **'rule of law'** and **adequate financing.**

In Figure 6-3 one can see how all the 'pieces' will move, stage-wise over time, towards the final goal where Good Water Governance is concerned: Good governance through transparent informed decision making, crucial to the objectives of equity, social justice and sustainability. Meaningful intensive participation, transparency and accountability should guide decision-making and regulation of water resources. The parallel moving of the pieces is quintessential for success, and will benefit all stakeholders, not just one or two entities.

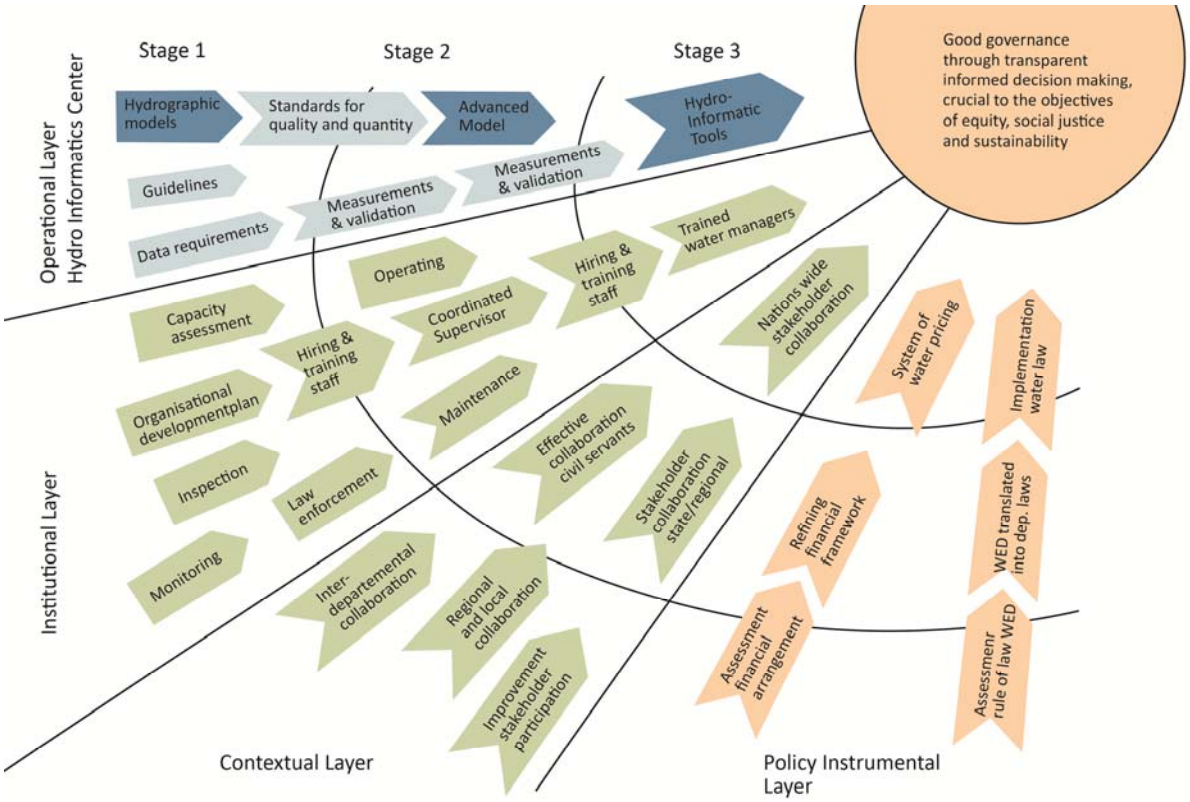


Figure 6-3 Ideal focus on good water governance. In order to realise truly integrated water resources management, all three "layers" must be given appropriate and well-balanced attention, supported by a strong and robust vision.

6.3.1 Operational Strategy (Hydro Informatics Center)

Building up the facts and figures is crucial for any decision making, licensing and upholding the law. Assessing the current condition is the basis for preventing further deterioration, for example deforestation, mangrove removal, mitigating impact of current industries and siltation of irrigation channels and reservoirs. Without data it is impossible to verify if water quality standards and pollution standards are upheld. Data are required to formulate and uphold licenses.

Assessment of the current condition of the water bodies can be done by monitoring and by modelling. Monitoring is costly and requires a lot of capable staff. Therefor, it would save money and staff to develop integrated and multi-functional monitoring networks and laboratories. Ministries should work together in developing these networks. Results should be in the public domain and online, so all ministries, other institutions and the public can see and use them. This prevents doing the same monitoring work twice and provides transparency into the current conditions of the water bodies. The issue of financing the monitoring and modelling in a way so all ministries can benefit must be solved, since currently one ministry has to buy data from another ministry.

Models of the Myanmar rivers and coast are essential to understand the current situation and to predict the possible impact of climate change, improvement measures and projects (like port development, river training, developments in the flood plain, discharges of industries, etc.). With very few models and little data available, a good strategy would be to build models from coarse to fine. For example, for the coastline a coarse 2D grid would be a good basis for further fine-tuning specific interesting areas, such as the developments in Dawei, once at least basic data are available to give sufficiently realistic results.

Digital leapfrogging

Myanmar is starting on its economic development journey in the digital age – when mobile and internet technology is increasingly affordable. Digital technology is accelerating development across emerging economies – and Myanmar has barely begun to tap its power. Capturing this opportunity will not be easy – in particular, Myanmar will need to move decisively on an aggressive telecommunications infrastructure plan. Using technology in government doesn't just save on costs and staffing but also boosts efficiency by increasing the speed of decision making and using electronic data to make those decisions better informed. Mobile phone technology for data sharing and processing can support in overcoming the large distances in Myanmar. The application of advanced monitoring and analyses technologies is an opportunity that could result in fewer laboratories and capacity (staff). For example, using satellites to monitor water quality enables a greater area to be monitored.

Hydromet Observation & Info Systems

Currently a Hydro-informatics Centre has been established and will be expanded. This entails:

- Institutional Strengthening, Capacity Building & Implementation Support
- Modernisation of Observation Infrastructure and Forecasting
  - Modernisation of observation systems, communications, ICT and forecasting
  - Design and pilot operation of water quality monitoring system
  - Reconstruction and refurbishment of offices and facilities of Department of Meteorology and Hydrology (DMH) of the Ministry of Transport
- Enhancement of DMH Service Delivery
  - Public Weather and National Climate Service
  - Disaster risk management operations/early warning systems
  - Service delivery to communities including introduction of mobile applications

An additional strategy can be to increase the role of this centre. The proposed Hydrometrics Centre can also fulfil a central and coordinating role in the development of a monitoring network, in developing models, making data available in a clear and transparent way and centralising associated investments and purchases. This Centre can coordinate the development of a national monitoring plan that can include:

- monitoring goals
- network
- parameters
- frequency
- quality criteria
- methods for analysis
- availability and communication of results
- required equipment and facilities

- required training and staff

Very important in this respect is that Myanmar is better off with one, well established centre, rather than with several competing centres. Priority should be given to one centre with national responsibility for supplying reliable data.

6.3.2 Institutional Strategy

The two main building blocks for the strategy to improve the institutional situation are:

- solving the objectives gap by a more active collaboration between ministries;
- capacity building of government staff that is involved in aspects of IWRM [see chapter 6].

Both are no-regret strategies that can be started immediately. Because it is not feasible to improve everything at once, following a 'hamburger' approach is a good alternative. In a 'hamburger' approach institutional strengthening is achieved top down and grass root level up and at some point in time this strengthening reaches the middle of the hamburger, the state and regional governments.

Active collaboration between ministries

A much more active collaboration between ministries would achieve a more integrated approach to water resources management and would result in a more sustainable and multi-functional plans and decisions. Many misunderstandings can be prevented when departments share issues and collaborate on making laws, policies, plans and projects. Misunderstandings, like planning a large urban development in the floodplain (like the study team heard in Mandalay) or single purpose hydro-dams, or the Fisheries Department giving licenses to fish in a canal where the Irrigation Department prohibits fishing. These misunderstandings can be found at all levels and can be tackled by an active collaboration. At the same time, the capacity of government staff is limited in Myanmar, so initially it is important to build upon what is already there and improve the collaboration step by step. A very good first step might be to stimulate 'learning by doing' in the pilots as described in chapter 10.3. Here civil servants can get to know each other and experience the benefits of joint policy development and implementation. Thus a network of professionals could be created that will endure beyond the scope of the pilot.

'Ownership' of issues and solutions is crucial. Somebody should feel personally responsible for solving problems and helping people, otherwise solutions will get stuck in bureaucracy. The various committees that are present in Myanmar on all levels are a good starting point, although improvement is possible by:

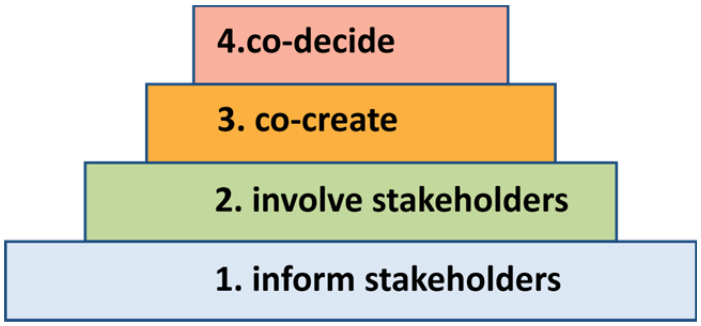
- organising these committees around very specific issues;
- verifying if the most important representatives are present to address those issues;
- agree on methodology and 'rules' of collaboration (including how to deal with conflicts);
- making sure the committee is transparent and communicates/publishes meeting reports, decisions and results.

A good intranet facility for government is also a fairly simple measure that would improve collaboration. Here progress and news about plans, policies and projects can be published. Also a people directory with search facility to find the appropriate colleague would help.

A change in behaviour is necessary amongst ministries to actively involve colleagues from other ministries. The study team always experienced enthusiasm, positive results and more mutual understanding of each other's issues during the workshops that were organised. Almost at every workshop people said, that these should be organised more often. Holding workshop with representatives from all relevant ministries/department when making policies, plans or developing projects are a simple measure with good results for IWRM.

6.3.3 Contextual Strategy

As stated before, two major gaps have to be bridged: civil servants need to be enabled to involve stakeholders, and stakeholders themselves will have to experience the fact that participation will improve their situation and their livelihood. A classical approach to stakeholder management follows the pyramid described below:



1 Inform stakeholders.

This figure implies that every form of stakeholder management builds on the foundation of shared information. Often in the form of 'shared fact finding'; everybody needs to have access to the data and the 'facts and figures' underpinning the issues at hand. Shared fact finding implies that all parties concerned are willing and able to define what kind of information is needed, who should provide the information, who should validate and monitor the information etc. Please note: to share information with stakeholders is not the same as to inform stakeholders. Although civil servants have every right to 'send' information they consider to be correct, sharing information implies a reciprocity. Stakeholders are 'allowed to talk back'; in other words, they are actively invited to share their own take on things.

2 Involve stakeholders

The next step implies a shared problem definition phase. Civil servants present their definition of the problem at hand, stakeholders might agree or add their own issues. The result of this phase is a combined definition of the problem(s) that need to be solved. This enables civil servants to gain local knowledge, and find future support for possible solutions.

3 Co-create

The third step implies the combined definition of possible solutions to the problems as they were defined in the second step. Since stakeholders are actively involved in both the definition of the problem and can provide their own support and expertise to solutions, the possibility that they will be willing and able to be partly responsible for the implementation of the solution, both in terms of financial support and maintenance will increase substantially. For example: if a solution for the lack of clean drinking water is found collectively in the form of rainwater catchment ponds with pumps, based on joint fact finding *(look at the results of water quality testing of the current wells; see how polluted the water is!)* the change that people will use the ponds wisely and maintain the pumps, is increased significantly. And since the system will become their own, chances are the stakeholders will also be willing to pay for the system.

4 Co-decide

The 'highest' step is shared decision making. This implies that the government does not steer towards certain solutions, but, for example, provides stakeholders with adequate funding and capacity building to solve their own problems in any way they decide upon. Here IWRM can be an excellent 'pilot area' for responsible social entrepreneurship and strengthening of democratic processes.

6.3.4 Policy Instrumental Strategy and rule of law

Development of a single water act

The following important points have emerged from discussions with members of the EG:

1. The overall objective is to have one water act that will act as a broad overarching legal framework for the entire country. This is in contrast with the current situation where water-related provisions are scattered in different acts. It would also involve both developing a new water act and amending existing provisions from the different acts involved.

2. The timeframe proposed to finalise a water act is April 2016.

Moreover, it should be noted that in addition to the principles expressed in the NWP, Myanmar has obtained the support of the Global Water Partnership (GWP) to integrate water security and climate resilience in its policy and legislation. These are elements that the Expert Group (EG) would also like to see incorporated into the water legislation.

The ultimate goal is to have a unified water act. This will require a number of steps to be clearly outlined in the action plan that the EG will recommend to the NWRC. At present the EG is still in the process of evaluating relevant key concepts and issues of water law in order to be able to formulate and carry out such a plan. Recommendations for immediate measures in relation to water legislation, which are listed below, should therefore focus on supporting the EG to formulate this plan and provide technical legal assistance in the different ways indicated.

Recommendations for immediate no-regret measures

1. Review and assessment of existing water legislation and other legislation with water-related provisions.

   There are a number of acts in force that already include provisions that deal with water. These need to be identified and their content carefully examined to obtain the overall picture of the existing framework. This will clarify the current institutional set-up, as established by law, and identify what areas have been covered. The result of the inquiry should also be reviewed in the light of the policy principles that are to be incorporated into legislation according to the NWP and any other relevant policy documents. This will help identify which acts may need to be amended and which aspects need to be incorporated into a new act.

   Legal experts will need to be engaged in translating the water policy documents into a legally correct and consistent water law.

2. Building the capacity of the Office of the Attorney General, of the EG and of relevant ministries in water legislation.

   The role of the Office of the Attorney in the drafting process is important as it reviews drafts of laws prepared by the ministries and ensures consistency with existing legislation. Without experience of water legislation, this is a task that is not easy to carry out. A workshop covering key principles in national water legislation as well as general water governance concepts would be beneficial for the officers that will be involved in the review of draft water law (and any other water-related legislation). The content should also include the NWP in Myanmar and the existing framework as identified and analysed in the above-mentioned assessment.
   In addition to the OAG, representatives of the different ministries that are concerned with water-related legislation and members of the EG should join the workshop. In this way the workshop would also present an opportunity to bring together stakeholders that will be impacted by the development of a new water legislation framework with a view to supporting coordination between them.

   A final element of the workshop would be specific to the OAG: it would involve technical aspects of water legislation that would be particularly relevant to lawyers.

3. Supporting the EG to develop a legal framework development action plan.

   The EG is currently acquiring information and knowledge about water legislation with two of its members participating in the above-mentioned workshop in Delft. It is thus at the beginning of articulating an action plan. It would benefit immensely from the support of legal experts, knowledgeable on the key elements of water legislation and its development process, to design an efficient and inclusive process to achieve the goal of a unified water legal framework, including not just the act but also regulations and standards needed to operationalise the principles agreed upon in the policy.

Approve and enforce standards to protect water resources

As an immediate course of action standards need to be approved and enforced, the most important being:

- drinking water standards;
- surface water and groundwater quality standards;
- crop standards;
- pollution standards (for discharging of waste water).

These standards form the basis for protecting the water resources from and for all kinds of socio-economic developments. During the transition period appropriate international standards can be used to start with. In a parallel process standards can be developed to fit the characteristics, quality and specific uses (including ecology) of the Myanmar water resources, including marine waters.

Legislation must be developed to be able to license activities with an impact on the water resources and set conditions in licenses, such as compensation, mitigation, water treatment. In addition a legal basis must be developed to monitor and enforce standards and licenses.

The government should move many registration and licensing processes online. Given Myanmar's severe capacity constraints in government, an e-government digital strategy should be considered.

Box 6-4 Dutch Water Authorities

Dutch Water Authorities want to share their expertise on regional water management with the world. By joining forces the Dutch regional water authorities strive to be of better service to the people and organisations that need it the most, bolster international business, and create mutual benefit from international cooperation. The Organisation for Economic Cooperation and Development (OECD) recently qualified Dutch water management as a 'global reference' and praised the effectiveness of Dutch water management. Dutch Water Authorities is the international umbrella organisation of 23 regional water authorities in the Netherlands and their Association (Dutch: 'Unie van Waterschappen'). The Dutch Water Authorities can help with:

- Information on regional water management
- Specific requests for international cooperation
- Requests after a recent calamity or to prevent water-related disasters

Dutch Water Authorities may be able to support Myanmar in developing standards, drawing up licenses and inspecting and enforcing the conditions of these licences, especially at regional and state level and river basis level.

Approve and enforce Environmental Impact Assessments

Another urgent measure is to have the legal obligation for Environmental Impact Assessments (EIA) approved by the president. An EIA describes the environmental impacts of a decision before a decision is made. It supports the decision making process of the government.

During a transition period international criteria can be formalised for immediate use in project appraisals. In a parallel process experts can develop Myanmar specific EIA criteria. The legal obligation of performing EIAs are crucial in transparent decision making and in developing a green economy. It can be a powerful legal instrument to balance 'people, planet, profit'.

It can be very useful to instate an independent EIA "Expert Committee" and is currently (partly) fulfilled by the recently established EIA Review Team consisting of 39 members of different ministries. Their status and powers should be embedded in legal instruments. The tasks of such an EIA "Expert Committee" can be:

- Development of criteria and procedures;

- Provide guidance to initiators of plans before and during carrying our an EIA;
- Reviewing EIAs and provide independent advice on the quality of EIAs;

EIA and mitigation or compensation measures, Eco-compensation fund.

An EIA is necessary to weigh the importance of environmental impacts in decision making on proposed projects with substantial environmental impact. In the design of a project negative impacts on environment should be mitigated as good as possible. Decision makers may request for additional mitigating measures (measures relieving or easing the worst environmental impacts). If in the end negative environmental impacts remain unavoidable, compensation of e.g. lost nature reserve, deteriorating water quality, compensation may be required at the expense of the project. It is often worthwhile to collect the negative impacts and the required funds for compensation for a group of projects in order to be able to make a substantial contribution to a compensation project. The establishment of a financial "eco-compensation fund" could be a very good instrument. The fund is to be filled compulsory by several projects or other financial sources.

Box 6-5 Dutch EIA-Commission International

The Netherlands Commission for Environmental Assessment (NCEA) is an independent expert body that provides advisory services and capacity development on environmental assessment. In the Netherlands the Commission has a legal status to act as an independent advisor since 1987, issuing non-binding advice to government agencies responsible for environmental assessments. The committee does not write EIA reports, because that is the responsibility of the initiator of the project. In international cooperation, the NCEA operates under an agreement with the Ministry of Foreign Affairs since 1993, with a special focus on countries eligible for Dutch International Cooperation. In addition, the NCEA also works in several other countries, under agreement with donors such as the Dutch Ministry of Infrastructure and the Environment, Dutch Embassies, the World Bank, European Union, etc. In international cooperation, the work of NCEA consists of the following activities:

- advice on Terms of Reference for and reviews of environmental assessments of plans, programmes and projects (EIA/SEA);
- capacity development of systems and institutions to improve the environmental assessment practice;
- knowledge and learning resources on environmental assessment;
- Dutch Sustainability Unit.

The Myanmar government may request support from NCEA, combining support with a large/complex EIA, such as the oil/gas winning on sea, with knowledge sharing and capacity building.

Need for integrated national policies and plans

From many sources the study team has heard the need for well written and integrated national policies to provide a clear and solid basis for State and Regional and local policy and plan making and decision making (decentralisation of water decision making based on a national framework). Examples of national IWRM policies are:

- National IWRM Plan;
- River Basin Management Plans;
- Policy Framework for Urban Development (to integrate (ground)water with spatial planning);
- Integrated Coastal Zone Management Plan;
- Flood Management Plan (combining flood resilience spatial planning, flood protection and flood response);
- Lake and Reservoir Management Plans.

Currently there is insufficient capacity (knowledge and amount of staff with policy writing expertise) to develop well written policies. It is recommended to develop some of the key

policies with the support of international expertise. This has two benefits: 1) improved policies; 2) building of policy writing expertise in Myanmar.

Adequate financing structures – some aspects for consideration

Change will not only come because of the better prospect. Saving in water consumption, integration of projects, seeking for multi-purpose needs incentives. Very important is the establishment of financial structures that enforce *and* enable individuals and individual organisation to work in the right direction, complying with their surroundings, their environment, their context as a whole.

- Water pricing
  - Pricing of drinking water;
  - Cost recovery of water management costs (for example via taxation);
  - Polluter pays principle
  - Interest ⇨ payment ⇨ right of say
  - What should be financed from general government budgets and what should/can be financed from other sources
- Environmental Compensations Funds
- Even poor people are willing to pay for water, provided they see direct returns/results.
- Start with small local solutions for financing the investment management and maintenance of local drinking water and irrigation solutions. For example small funds, local entrepreneurs, local workers. Agreements on paper and clearly agree on responsibilities for implementation and control of agreements.

7. Capacity Development

This chapter describes the existing competencies in Myanmar and core IWRM competencies necessary to develop and implement IWRM. Based on these two building blocks for a capacity development strategy are presented, including training needs and possible modalities to address these. The emphasis is on the key ministerial departments involved in water management in Myanmar as they are the main stakeholders involved in policy development, planning and operational management. The capacity and involvement of universities, institutes, training centres and civil society is also briefly presented.

Capacity has been defined as 'the ability of people, organisations and society as a whole to manage their affairs successfully' (OECD, 2006). The following three interrelated levels for capacity development can be identified:

- enabling environment, which is the broader institutional framework in which individuals and organisations function;
- organisational level, which comprises the internal policies, arrangements, procedures and frameworks that allow an organisation to operate and deliver on its mandate;
- individual level, which refers to the skills, attitudes, experiences and factual knowledge of individual people.

7.1 Capacities needed for IWRM

The field of IWRM has evolved strongly in the past decades. This field shifted from an engineering approach (water resources development), to water resources management (recognition that water can be 'overexploited' and accounting for ecological and social constraints), to Integrated Water Resources Management (IWRM) in which water management is embedded in an overall policy for socio-economic development, physical planning and environmental protection. Not every professional involved in IWRM will need the same competencies. Building on the distinction of competency categories (Cheetham and Chivers, 2005) and owing to the interdisciplinary nature of the challenges facing professionals, Uhlenbrook and de Jong (2012) have applied the knowledge/cognitive competency in the water sector. Specifically, they discern:

i) disciplinary knowledge in *one* scientific field (e.g. hydraulic engineering, irrigation, aquatic ecology or governance) (the vertical leg of the T-shape in Figure 7-1), and
ii) integrative requirements for the new water manager which are key to integration and working in multi-disciplinary teams (the horizontal bar of the T-shape in Figure 7-1). Through the horizontal leg IWRM professionals are able to build bridges to other disciplines. The horizontal bar stands, on the one hand, for knowledge and competencies outside the own discipline, on the other hand, for functional and personal competencies including e.g. project management, negotiation skills, leadership.

IWRM professionals will benefit from a T-shaped profile where a mix of competencies are required that will vary with their individual level (position) and organisational level. The width of the horizontal leg will depend both on the individual level and the organisational level, e.g.

a member of the NWRC will need to have a wider scope than an agricultural engineer involved in IWRM at the Ministry of Agriculture and Irrigation who will need a more solid vertical leg.

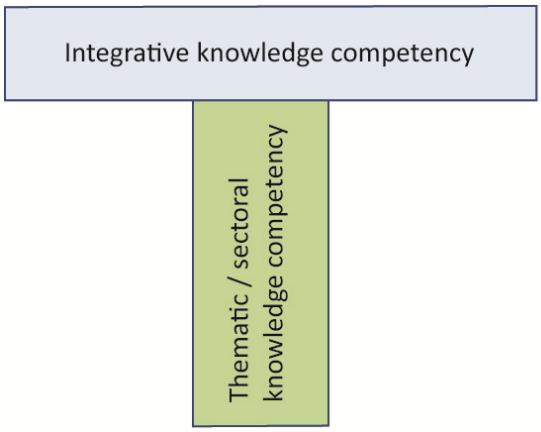


Figure 7-1 Competency profile for water managers *(adapted from Uhlenbrook and de Jong, UNESCO-IHE 2012)*

7.2 Educational system Myanmar

All capacity development starts with primary and secondary education which in Myanmar falls under the responsibility of the Ministry of Education:

- primary education (5-9 years), free of charge
- secondary education (standards 6-8, 10-13 years), free of charge
- upper secondary education, up to 10th grade (standards 9-10, 14-15 years), low course fee is required

Statistics of UNESCO (UNESCO statistics website, 2005) reveal that 100 % of the girls and 98 % of the boys enrol at the primary level and 91 % complete it. As however only primary school is compulsory, secondary level enrolment is 43 % for both genders. Upon completion of the upper secondary education school children need to take a so called matriculation exam (the University Entrance Exam). Approximately 1/3 of the children pass this exam which then gives them access to the universities. English is a subject taught in school (again since 1981) and water related lessons such as hygiene and sanitation, earth and space or earth surface process have been included.

Higher education institutions are organised along the field of study (like a faculty) and administered by different ministries. In 2014 Myanmar counted 163 higher education institutions under 13 different ministries, the majority under the Ministry of Education and Ministry of Science and Technology. These higher education institutions offer a variety of programmes - undergraduate, postgraduate diploma, master's degree and doctorate programmes, various courses and can confer degrees, diplomas and/or certificates. Besides higher education, Myanmar needs mid-level technical and vocational skills. Technical and vocational training is the responsibility of the Department of Technical and Vocational Education of the Ministry of Science and Technology. Training of technicians is e.g. undertaken in government technical institutes or state agricultural institutes and training of

skilled workers or basic craftsmen in technical high schools. Both institutes and schools also offer part-time courses for those already employed.

Some departments have set up their own training centre (e.g. ITC of Irrigation Department (Ministry of Agriculture and Irrigation), Department of Meteorology and Hydrology (Ministry of Transport)) to train the younger staff members. The courses are mostly provided by senior staff.

For IWRM the most relevant universities are[10]:

- Forest University (Ministry of Environmental Conservation and Forestry
  - Programme on Forestry (including Watershed management)
- Mandalay Technical University, MTU (Ministry of Science and Technology)
  - Bachelor Civil Engineering
  - Master Civil Engineering
- Maritime University (Ministry of Transport)
  - Bachelor River and Coastal Engineering
  - Master Harbour Engineering
- Yangon Institute of Economics
  - Bachelor and Master Economics, Management Studies, Public Administration
- Yangon Technical University, YTU (Ministry of Science and Technology)
  - Bachelor Civil Engineering
  - Diploma Water Supply
  - Master Water Resources Engineering
  - Master Environmental Engineering
- Yangon University or Mandalay University
  - Bachelor and Master Law, Geography
- Yezin Agricultural University (Ministry of Agriculture and Irrigation)
  - Master Agriculture
  - Bachelor Agriculture

A Comprehensive Education Sector Review (CESR) is currently underway to help inform Myanmar educational policy reform. In 2011-12, only 4.8% of the Government budget was allocated to education (Ministry of Education only) constituting only 0.78% of GDP. The total amount allocated to education will of course be slightly higher when the expenditure in all other government ministries on higher education and TVET is taken into account.

7.3 Existing capacities and capacity gaps

Through meetings with representatives (mainly director generals and directors) of the key Ministerial water related departments in the week of 6 - 13 June, 2014 the expertise available, required and training needs were assessed. The assessment and strategy were further discussed and finalised with key stakeholders in August 2014. Use was made of semi-structured interviews with the use of a questionnaire. Additionally, alumni of UNESCO-IHE were also asked to fill out a similar questionnaire. Some of them are member of the expert group and they were asked some additional questions.

[10] University not visited, except for Yezin Agriculture University, information retrieved from respective websites http://www.most.gov.mm/ytu, http://www.most.gov.mm/mtu, http://www.mot.gov.mm/mmu/ visited on 08-07-2014

Expert group

Four alumni and members of the expert group returned the questionnaire. This cannot be considered a good representation of the expert groups capacity, but for now it is the best available. As could be expected all expertise is considered (very) important for the expert group. The least scoring expertise are design, modelling and operation and maintenance. More relevant is the assessment whether the expertise is currently sufficiently available in the Expert Group and this is only partly the case, except for the subject-specific knowledge (such as hydrology, navigation or agriculture).

Key Ministerial departments

With respect to the vertical leg of the T-shaped competency profile (thematic/sectoral expertise), all departments indicate that subject-specific 'hard' knowledge is very important. Some indicate that besides the engineering knowledge they also find 'soft' knowledge of e.g. economics, social sciences or law very or moderate important. The other thematic/sectoral expertise like design, computational skills, operation and maintenance or policy formulation skills are also found moderate to very important depending on the mandate of the department (see also Appendix 5, section A5.2). With respect to the horizontal leg of the T-shaped competency profile (integrative requirements) the departments indicate that they find this very important. In order of importance, the expertise should include, monitoring and implementation, IWRM instruments and tools (e.g. SEIA and Decision Support Systems), sectoral and spatial integration, basin planning processes and understanding of procedures and institutional arrangements. The Department of Rural Development sees little to no importance in most of the IWRM expertise.

The departments were also asked to indicate their role in the key water issues[11] of Myanmar and with which departments they cooperate in those issues. As could be expected several water issues require the involvement of different departments, indicated by a small role (see also box below on closely related mandates). All departments indicate they have (large) role to play in water resources planning and allocation, while wetland and mangrove protection and water supply and sanitation is the responsibility of just a few departments (see also Appendix 5, section A5.2).

Capacity gaps

The following observations and capacity gaps can be described:

- Most staff have a Bachelor degree in Civil Engineering from a local university (Yangon Technological University or Mandalay Technological University) with some engineers having also a graduate diploma. The Director Generals and Directors often have a Masters or sometimes a PhD degree and are often trained abroad.
- Given Myanmar has been closed for many years, the existing knowledge and expertise needs to be upgraded. Existing expertise is not sufficient, both in terms of up-to-date knowledge, available staff and hardware (equipment for maintenance, monitoring and/or computer models).
- Given the current centralised system, most of the planning and management of the works is done at the head offices and the more operations and maintenance work is done at the

[11] The key water issues were based on the Master Class Sharing IWRM experiences and IWRM training workshop, organised in March 2014 and the report 'Myanmar IWRM Strategic Study - Report on First Findings'.

regional and/or local offices. In terms of skills, experience and training needs this will lead to different type of trainings. At the head office more Masters levels will be needed, while at local level much of the staff should be receiving technical and vocational training.

- Mandates are closely tied and some cooperation exists between departments. Understanding however needs to be increased on many of the linkages and interdependencies in water systems and governance and consequently the awareness to share, communicate and/or cooperate is little. (see also Box 6-3 Administrative gaps).
- There is much awareness, but little action on water quality monitoring. The responsibility lies with different departments (DWIR for river waters, Department of Meteorology and Hydrology for rain water, Ministry of Health for quality of drinking water, Environmental Conservation department for pollution control). Both the expertise and the equipment is insufficient.
- As there is limited monitoring, enforcement can also not be done effectively.
- Limited awareness exists on the need to make basin plans for sustainable development (eg groundwater abstractions, water allocation, hydropower projects; see Box 6-1 Need for Basin Plan / Master Plans and sustainable development).
- Government budgets are insufficient, so departments experience a lack of sufficient staff, lack of proper equipment, cannot expand and/or carry out all their tasks (e.g. monitoring and enforcement).
- Limited awareness of local water users on the correct use of water systems and/or have conflicting priorities. For example, the quality of rain water ponds for drinking water could be greatly improved if people would stop bathing in the water, stop their livestock drinking directly from the ponds or maintain the pumps provided with the ponds. The same applies to basic maintenance of irrigation canals, illegal digging of tube wells, dumping raw sewage in the river. Sometimes this behaviour stems from a lack of knowledge or education, often people see no alternative. They dig wells themselves because they only receive a couple of hours household water by the 'official' system, they dump raw sewage because there are no sewage treatment facilities.

7.4 Building blocks IWRM capacity development

The IWRM capacity development strategy is built on the premise that capacity development needs in Myanmar are large and a short to medium term and a longer term perspective needs to be considered. Based on the inventory of available capacities and capacity gaps presented in the previous section several building blocks and recommendations are presented to support this process.

The below building blocks have been identified.

Strengthen existing capacity of key Ministerial departments

In the short to medium term (between now and 5-10 years) immediate and focussed action is required in order to facilitate the required changes in water management in Myanmar as stipulated in the Myanmar water policy. The strategy is built up around the following elements:

1. Make distinction between water related departments with a wide horizontal bar and those which a smaller horizontal bar
2. Although existing knowledge, skills and expertise on the vertical leg need upgrading, priority should be given to developing IWRM capacity of the horizontal bar

3. Capacity development needs to be done at all levels (local-regional-national) and all positions, although in different intensities and through different learning modalities.
4. Have a mix of learning modalities, with an emphasis on case studies / projects and working groups, as IWRM is not only learnt in theory, but much also in practice.
5. As collaboration between the different key ministries is also very important the trainings should be used to establish a network of water professionals by providing the trainings jointly for staff of different departments.
6. Human resources development (HRD) policy of the key ministries involved should facilitate staff in starting an IWRM track
7. Monitor and evaluate the effect of the capacity development interventions, to learn and improve

These elements will be further elaborated in section 7.5.

Enhance awareness of local water users

Enhance the awareness of local water users in the importance of freshwater, sanitation and hygiene practices and advocating for the sustainable management of freshwater resources.

Strengthen existing capacity of Universities, Institutes and/or Ministerial training centres[12]

For the longer term the universities, institutes and/or Ministerial training centres should have sufficient teaching staff and state-of-the art teaching materials to train the water professionals of Myanmar. To achieve this universities, institutes and/or training centres will need to offer the relevant training courses, Bachelor and Masters programmes, e.g. Civil Engineering, Agricultural Engineering, Water Supply and Sanitation, Hydropower Engineering, Environmental Science, Water Management. To achieve this curricula and teaching material will need to be developed, in particular in areas like Irrigation Engineering, Environmental Science, Water Management and Governance. University staff needs to be trained on MSc and PhD level and receive pedagogical training courses. Universities can also play a role in delivering professional courses for the civil servants of different departments. Additional benefit is that this will lead to collaboration between universities and water sector organisations.

Roll out capacity development through Training-of-trainers

As the capacity development demand is high use should be made of the groups of experts trained in the first years. They should become groups of experts who can also deliver targeted trainings in combination with universities, institutes and training centres.

[12] NUFFIC has started identifying possibilities for a new NICHE project in the priority area 'water' aiming to strengthen institutional capacity for institutions and organisations providing post-secondary education and training. Calls for tenders are expected to be published in August of September 2014. (source: www.nuffic.nl)

7.5 IWRM capacity development of key Ministerial departments

Knowledge and expertise needed

The first element of the strategy is to make a distinction between water related departments that have a role and mandate that requires strong IWRM knowledge and expertise, and those which are less dependent on IWRM knowledge and expertise. This distinction will help to focus on which IWRM capacity development is needed and for which groups. A distinction can be made between:

1. Water related departments that have a role and mandate that require strong IWRM knowledge and expertise:
    - Department of Hydropower Implementation
    - Directorate of Water Resources and Improvement of Water Systems
    - Environmental Conservation Department
    - Irrigation Department
    - Water Resources Utilisation Department

    The capacity development of these departments needs to focus on a solid vertical leg and a wide horizontal bar. The competency profiles of these departments show great similarity for the horizontal bar, with expertise on IWRM principles, Basin planning, Stakeholder participation and Monitoring and Enforcement.

2. Water related departments that have a role and mandate that require solid knowledge and expertise on one discipline and some knowledge about IWRM:
    - Department of Hydropower Planning
    - Department of Meteorology and Hydrology
    - Forest Department
    - Rural Development Department

    The capacity development of these departments needs to focus on a solid vertical leg and a small horizontal bar.

Figure 7-2 and Figure 7-3 show two examples of competency profiles, indicating the main knowledge fields that are required to fulfil the role and activities of a department. In Appendix 5 section A5.2 examples of competency profiles are presented for each key department. These competency profiles give an indication of the most important training topics, but are certainly not a complete list of training topics.

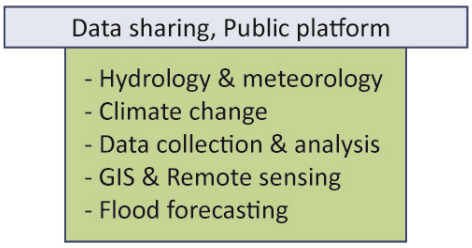


Figure 7-2 Department of Meteorology and Hydrology (strong vertical leg - small horizontal bar)

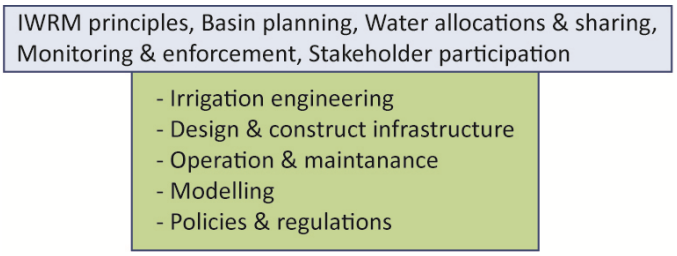


Figure 7-3 Irrigation department (strong vertical leg - need for wide horizontal bar)

A second element of the strategy is to give priority to the horizontal bar (integration, coordination and cooperation, master planning, etc.) of the competency profile. Existing knowledge, skills and expertise on the vertical leg (such as design, navigation, irrigation, etc.) needs upgrading, but knowledge and expertise exists in Myanmar while for the horizontal bar much less is known and/or practiced. While strengthening IWRM capacities on the 'horizontal' bar, gaps in knowledge in the vertical bars can be further refined. Table 7-1 shows an overview of training topics needed most by the different key Ministerial departments on the horizontal bar.

Table 7-1 Indication of 'horizontal' IWRM training topics

	Ministry of Agriculture & Irrigation		Ministry of Electric Power		Ministry of Environment, Conservation and Forestry		Ministry Livestock, Fisheries & Rural Devt	Ministry of Transport	
	Irrigation Department	Water Resources Utilisation Department	Department of Hydro-power Implementation	Department of Hydro-power Planning	Environmental Conservation Department	Forest Department	Department of Rural Development	Department of Meteorological & Hydrology	Water Resources and River Improvement Department
Basin planning	+	+	+	+		+	+		+
Data sharing and dissemination								+	
Governance	+	+		+	+	+	+		+
IWRM principles	+	+	+	+	+				+
IWRM tools (EIA, DSS)			+	+	+				+
Monitoring and enforcement	+	+			+				+
Water allocation and sharing	+	+	+						+
Watershed conservation			+		+	+			
Stakeholder participation	+	+			+		+		+

Target group

In the short to medium term it is essential for Myanmar to upgrade the existing knowledge and skills of the current staff of the key ministries. The third element of the strategy is that this needs to be done at all levels (local-regional-national) and all positions, although in different intensities and through different learning modalities. The following approach is suggested for strengthening the IWRM expertise:

1. Develop capacity at the Director General and Directors level on the horizontal bar, meaning e.g. IWRM principles, Basin planning, Policy formulation, Environmental Impact Assessment (EIA) and Stakeholder participation. Management skills such as project management and communication should also be addressed. It is important to include Directors from the Regional offices.
2. Strengthen the expertise of the NWRC and Expert Group on the horizontal bar, meaning e.g. IWRM principles, Basin planning, Policy formulation, Governance and socio-economic aspects, Water sharing issues, Consensus building and mediation.
3. Train groups of mid-level water professionals from different key departments in IWRM and involve the local universities and vocational training institutes. The training will cover e.g. IWRM principles, Basin planning, Policy formulation, Environmental Impact Assessment (EIA), Stakeholder participation and Monitoring and Enforcement, and should be including case studies and in-depth analysis by the water professionals of those case studies. The choice of the case studies will allow analysis from different perspectives and illustrate the interdependencies and need for cooperation between the key department and between the national, regional and local level. Training of the personal skills such as critical thinking, reporting and presenting should also be included. Through the joint trainings it is envisaged that informal networks of water professionals will be formed that will contact each other easily. It is recommended to have new groups starting these trainings every year, whereby the previous year trained professionals can train the new group (Training-of-trainers).
4. Enhance knowledge and skills at the local level in awareness, community participation, monitoring and enforcement. As operators and local maintenance people are the link involving them and the vocational training institutes is the main target group. Monitoring will require additional funding for the equipment.

Learning modalities

IWRM knowledge and expertise need to be addressed by means of a broad mix of learning modalities to allow water professionals to learn, understand and practice IWRM in Myanmar. Such learning modalities include e.g. module-based self-learning and class-room teaching, but also modalities such as learning-by-doing, on-the-job training, coaching and working groups [see Appendix 5]. Besides theoretical knowledge much of the IWRM learning will be achieved through case study applications and e.g. group discussions. The fourth element of the IWRM capacity development strategy is therefore to have a mix of learning modalities, with an emphasis on case studies / projects and working groups.

As for Myanmar it concerns large numbers of people and the available staff cannot easily be missed for long periods the best way to do the capacity development is through providing training in the country, e.g. tailor-made trainings and/or delivering short courses in the country. As collaboration between the different key ministries is also very important, the fifth element of the capacity development strategy is that these trainings should be used to establish a network of water professionals by providing the trainings jointly for staff of

different departments. Members of the Expert Group suggested to include an assessment of the learning at the end of the training courses.

Table 7-2 Possible learning modalities

	Who	Modality									
		Case studies / projects	Class-room 1-2 (short, days)	Class-room (longer)	Coaching	Exchange visits	Field visits	On-the-job	Self-learning	Working groups	Workshops, seminars
1.	NWRC					x		x	x		x
	Expert Group		x			x	x	x	x		x
2.	DG	x				x	x	x	x		x
	Directors & Dep. Directors (national + regional)	x	x			x	x	x	x	x	x
3.	Mid-level water profs (national + regional)	x		x	x		x	x	x	x	x
4.	Junior water profs (local + regional +national)	x		x	x		x	x	x	x	x

Implementation and learning

This section addresses capacity development implementation and learning.

A next element of the strategy is that human resources development (HRD) policy of the key ministries involved should facilitate staff in starting an IWRM track. This element actually relates to the level of the organisational context that should support capacity development at the individual level. HRD departments should also further refine selection criteria for participation in a capacity development track. Possible selection criteria that can be used for identifying the most suitable staff for a training include:

- Relevance of the training topic for their work
- Previous education
- Number of years at service, could be a minimum or maximum
- Age, could be a minimum or maximum
- Examination on subject knowledge and English level (very common in Myanmar, as trainings are only provided to the best qualified staff)[13]
- A conditional statement claiming that selection will be upon approval of a selection committee (which could include members of the donor organisation)
- Capacity development modality should be part of HRD track. Will it contribute to IWRM portfolio which allows younger staff to built up and practice knowledge and expertise
- Pre if candidate has been involved in previous training workshops before to create group of experts and allows for incremental learning.

[13] Currently staff members have to take an examination and only the best will be nominated for foreign scholarships. Selection is then done by the Public Service Commission. This means that at the moment individuals cannot apply for study abroad and study leave. A request has been made to change this policy so that individuals can apply (personal communication Tint Swe)

The last element of strategy relates to monitoring and evaluation to see what the effect is of the capacity development interventions, to learn and improve. E.g. interview DGs and staff and see how interventions can be improved.

8. Strategy development for IWRM

8.1 Impacts on Myanmar's water resources versus development scenarios

In the preceding chapter 5 three possible scenarios for the future development of Myanmar have been defined. Section 0 describes the interaction between speedy or less speedy development and pressure on water resources and management challenges.

8.2 Guiding principles for Myanmar IWRM strategy development

The Myanmar National Water Policy does provide the main guiding principles to bring the development of Myanmar's water resources towards achieving the stated future vision of a water efficient nation with well-developed and sustainable water resources within the country's development policy of green growth and green economy.

The strategy will have to 'meander' between the scenarios and what will actually take place in the coming years. The only certainty with any scenario is that it will never precisely happen as it has been described.

Comply with general Myanmar policy

The main question for the implementation of the National Water Policy, when dealing with different development scenarios, is what kind of strategy to formulate that will:

a) Meet the requirements of the National Water Policy and eventually the water law(s)
b) Meet the overall policy requirements of the Union Government of Myanmar, formulated by the President that is 'poverty reduction, stable political development and green economy/green growth' (Speech President 31 March 2011 and reiterated on 5th June 2014): '*Another task we will have to implement is environmental conservation. We will lay down a new policy in which we will work for economic development in parallel with environmental conservation'*.
c) Meet the 'triple bottom-line/baseline requirements', meaning every measure should be: economically viable, environmentally sustainable and socially acceptable/inclusive.
d) Follow the two tracks approach as mentioned by the Vice President in his speech at the IWRM seminar in June: First track = policies and strategies, second track = programmes and initiatives. In other words: the strategy will have to address both the meta-level and the practical level with a clear focus on implementation of concrete measures.
e) Deal with 'external' variables like climate change and national, regional and global socio-economic and political developments.

Two tracks for slower and faster speed

Development in Myanmar has been very slow during the last decades. With the socio-political reform since 2012 the country is catching up and in need of immediate improvement of basic facilities including those related to water resources management such as clean and reliable drinking water, improved agricultural practices, power generation, etc. For this reason, there is an urgency to follow 'the two tracks', meaning both strategy formulating and implementation of concrete measures for quick implementation. In this report it is aimed to not only to elaborate a strategy, but also to advise on implementation.

"Development depends as much as where you are as where you want to go"

The country boasts large water management infrastructure such as polders in the delta, irrigation schemes in the dry zone area, hydro power facilities in the mountainous areas, etc. Some of this infrastructure dates back hundreds of years and some has been put in place relatively recent. The works vary in their state of repair and operational efficiency. This is due to poor maintenance and sometimes incomplete designs. Nevertheless this infrastructure represents a large investment which when taking the proper measures has a good potential to create a positive return. Building on what is already there is an important consideration in the proposed overall strategy for Myanmar's water resources development and management.

Green Growth and Green Development

A strategy of green, sustainable growth implies integrated water resource management. This means:

b) Taking into account all different kind of water uses; drinking water, water for irrigation, watershed management, water safety and risk of flooding, hydro power, navigation of rivers, harbour development etc.
c) Taking into account the relationship between water resource management and other sectors, like agriculture, (de)forestation, fisheries, industrial developments, energy, urban and rural development.
d) Taking into account the balance between people, planet and profit, in other words, social equity, ecological sustainability and economic viability.

Considering the proclaimed policy for green growth and green development two internationally accepted good practices in IWRM will provide additional inspiration on the proposed strategy:

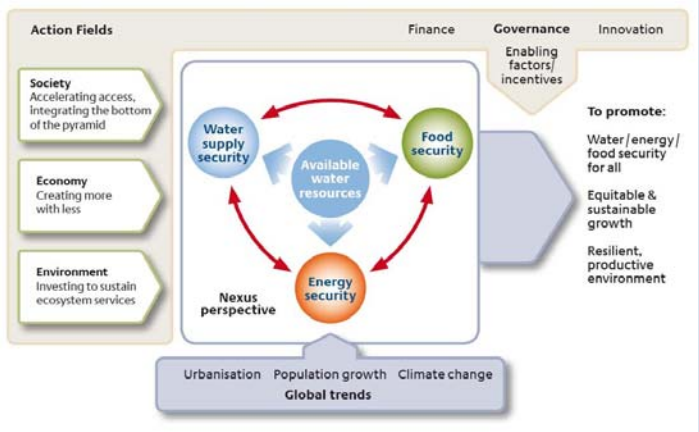
- The Water, Energy and Food Security Nexus as a guidance towards Green Growth and a Green Economy
- The EU Water Framework Directive – EU WFD aiming at maintaining good ecological status of all waters

Box 8-1 The Water-Energy-Food Nexus

A nexus approach can enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance across sectors.

A challenge to the task of safeguarding resources is *rapidly increasing demand* for them. Population growth and the urgent need to improve water, energy and food security for the poorest all place growing pressure on limited resources.

Climate change is also likely to aggravate pressure on resources and so add to the vulnerability of people and ecosystems, particularly in water scarce and marginal regions. A nexus approach is needed to help climate mitigation measures be more 'water smart', adaptation measures (e.g. irrigation) to be less energy intensive, and to avoid damaging consequences for food production and other vital ecosystem services.

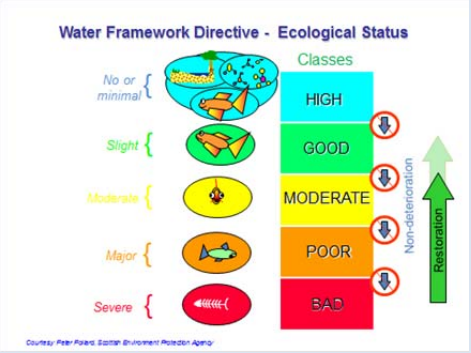


Productivity and the availability of water, energy and land vary enormously between regions and production systems which is also very apparent in Myanmar. There is a large potential to increase overall resource use efficiency and benefits in production and consumption. The nexus approach can boost this potential by addressing externalities across sectors. For example, nexus thinking would address the energy intensity of water demands in renewable energy production (e.g. biofuels and some hydropower schemes) or water demands of afforestation for carbon storage. Also, action to avoid land degradation saves water and energy, for example by increasing soil water storage and groundwater recharge, as well as reducing the use of energy-intensive fertiliser.

Water, which has only very recently received attention in the Green Economy debate, is an essential input for all biomass growth and hence for all ecosystem services and associated jobs and livelihoods. Improved water resources and intact ecosystems ('natural infrastructure') can mutually reinforce each other and generate additional benefits.

sources: Appendix 3 and http://www.water-energy-food.org/en/whats_the_nexus/background.html

Box 8-2 Principles of the EU Water Framework Directive



The EU Water Framework Directive is a European Union directive which commits countries to achieve good qualitative and quantitative status of all water bodies (including marine). It is a framework in the sense that it prescribes steps to reach the common goal rather than adopting the more traditional limit value approach. The Directive aims for 'good status' for all ground and surface waters (rivers, lakes, transitional waters, and coastal waters). Surface waters are assessed according to the following criteria: biological/ecological quality, hydro-morphological quality, such as river bank structure, river continuity or substrate of the river bed, physical-chemical quality such as temperature, oxygenation and nutrient conditions and chemical quality (pollutants). Groundwater must achieve “good quantitative status” and “good chemical status” (i.e. not polluted).

www.water.europa.eu and http://bookshop.europa.eu/en/the-eu-water-framework-directive-pbKH0414216/

Prevent from getting polluted rather than clean it afterwards

Myanmar has a major advantage over the European situation: the water bodies of Myanmar are still largely unspoiled and in good condition. Where European countries have to make

huge investments to meet the EU objective of ecological restoration and indeed restore polluted water bodies to healthy water bodies, Myanmar should aim to avoid pollution by taking appropriate measures now!

Using the EU WFD as a blue print for a Myanmar WFD may not be appropriate. There are however three important components in the EU WFD which are considered of relevance for Myanmar:

1. Assessment of the status of all water bodies within a river basin; monitoring the status, legislation and enforcement to improve the status and in any case avoid further deterioration. For Myanmar this would mean:
2. record the current ecological, physical and chemical condition of the water bodies, starting with rivers, coastal water and vulnerable lakes and maintain this condition (prevent further deterioration);
3. establish monitoring and enforcement system to maintain the good qualitative and quantitative status of all water bodies and improve these where necessary and possible but in any case avoid deterioration.

Transparency in governance

Also the principles of 'good water governance' have to be taken into account as elaborated on in chapter 0). According to these principles, good governance has to be based on transparency (general availability of facts, figures, data, models, criteria, impact assessments) in order to provide for accountable, transparent decision making, enough capable staff, collaboration between and within government layers, stakeholder participation, a valid financial system and the rule of law.

8.3 Building blocks for Myanmar IWRM strategy

In the preceding chapter the current situation and possible futures related to water resources management have been described, analysed and assessed. Challenges and opportunities have been formulated. In the course of the research, the interviews with stakeholders, the work-shops with government officials, experts and specialists images have been built and shared which elements need to be addressed when dealing with (integrated) water resources management. These elements can be categorised into groups and form the building blocks for strategies, diversified per region and for an action plan for integrated water resources management.

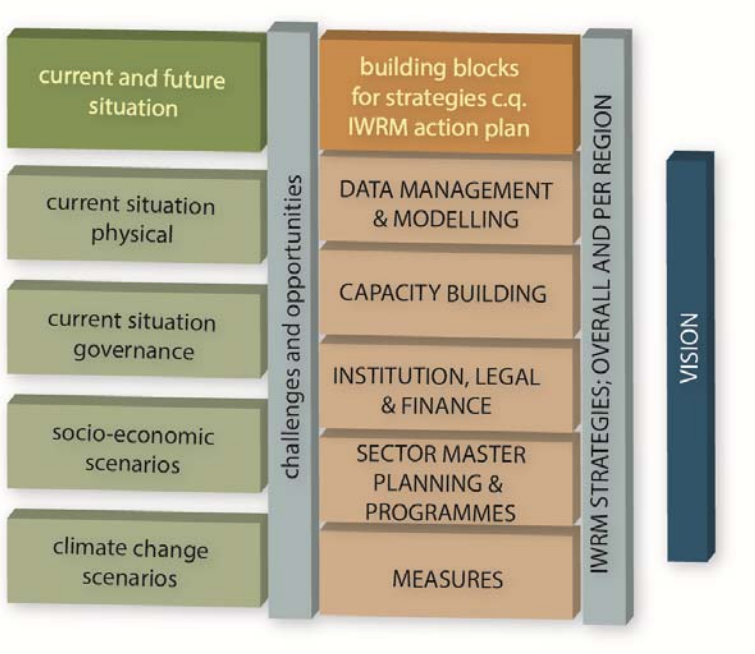
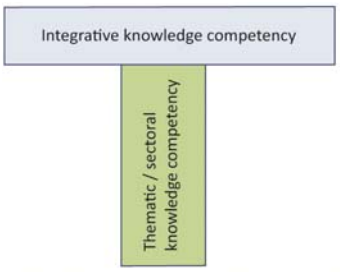


Figure 8-1 Building blocks for the IWRM action plan

8.3.1 Capacity building, sector specialists and integration experts

Knowledge and capable human resources form the foundation for water resources management as applies for administration and management of all other sectors of society. For the water sector, focus on specialist knowledge on river flow, irrigation, drinking water supply, groundwater, cyclones, sedimentation, sewage, drainage, but also in forestry, agriculture, aquaculture, industrial processes and so on.



Where sectors need good specialist to reach a good level of design of hydraulic structures, water management systems etc. additional expertise is required to integrate problem solving in order to make the value of each individual discipline more than just the sum of it. One needs a specialist to solve specific sector problems; one needs experts to place it in an integrated context. Following the idea behind the earlier described T-shape profile is a basis for the strategy in capacity building.

8.3.2 Data management and modelling

Many data are available in Myanmar, sometimes difficult to access, or unknown where to find. On the other hand, many data are also lacking, too few measurements can be made, shortage of gauging stations, difficulties in realising reliable measurements and thus building sufficiently long and widespread data series.

Interpretation of data and modelling of the physical system, analysing the system and predicting the system's behaviour in case of planned or unplanned changes is important to know for decision making. Decision makers often need to decide without appropriate information. Data management, data analysis and interpretation should be factual and

undisputable or at least agreed on by the country's best specialists. They should not be subject to political weighing and consideration.

In the parallel project on data collection and model development carried out by Deltares good progress is made in developing IWRM decision support models for Myanmar such as WFLOW, RIBASIM, SOBEK and DELFT2D.

8.3.3 Institution and legal, also international

Integrated Water Resources Management will need to be embedded within a country's administration. For Myanmar the framework is well instituted with the establishment of the National Water Resources Committee. All government departments will need to coordinate and be connected to universities, knowledge institutes and the private sector. Proper mapping of all stakeholders and creating of cooperation mechanisms will be an important aspect to arrive at a fully supported national IWRM Master Plan.

Institutionalisation or rationalising the current institutionalisation of water governance is an important point to make things actually work. Of course new laws, adapted to the new and future challenges are important, but usually *follow* the existing way of operation and existing policies. The actual "workability" of a policy and a law depends very much on the force, monitoring and enforcement power of the distinguished institutions and their capability of collaboration. In the strategies this building block needs elaboration; strongholds are being mentioned elsewhere in this R&A Report.

It seems a separate issue, but the role of the international financing and donor community is at least as important as the institutional setting of Myanmar itself. The distinguished international partners set all their own policies, restrictions and opportunities for financing projects in Myanmar. It is important how Myanmar can organise and steer its donors and financers. There is certainly also a shared responsibility of the donors to fill this building block in a co-ordinated way.

8.3.4 Sector master planning & programmes

Each sector has its specific challenges, problems to solve and opportunities for further development. Well-considered master plans to solve these problems project-wise need to be developed. Programmes with series of similar or related projects need to be established, including a financing plan for the longer term.

Cooperation, tuning of programmes and of each project must be sought to acquire the desired integrative approach.

8.3.5 Measures

Programmes on e.g. delta development or integrated watershed management need to consist of actual projects to be planned, implemented and eventually be managed in an integrated way. Projects need to be formulated within the context of the objectives of the respective programmes and strictly fulfil the three bottom lines of technically and economically viable, environmentally sustainable and socially acceptable.

From all the above described building blocks certain measures impose themselves already. In turn, the ideas for concrete measures help to make the strategies and the building blocks.

Rehabilitation and upgrading of existing infrastructure is an important guiding principle for many of the measures. Many of the measures can be describes as adaptive to a – relatively –

slowly changing context. However, sometimes it is important to make great step forward in order to be able to step into a next phase of – economic – development.

Example of an adaptive measure is to build shelters in the Ayeyarwady Delta as a cyclone refuge, a structural measure (great step and to be in line with the then prevailing high level of economic development) could be to close one estuary, keeping out storm or cyclone surge all over and creating a fresh water lake for agro-economic purposes. Another example is the development of small scale hydropower as an adaptive measure to meet with slowly growing existing needs versus the construction of a large hydropower dam enabling a great economic step forward.

In section 8.2 the guiding principles for the development of a Myanmar IWRM Strategy have been presented as first building blocks to be considered in the development of a Myanmar IWRM Master Plan. There are more principles related to IWR planning, implementation and management which are of relevance. Eventually, and building on this report and future research, more aspects are to be considered also when planning for specific sectors such as hydropower, irrigated agriculture, IWT, etc.

8.4 Synthesis for strategies

Myanmar's water resources management needs a stronger base

In the previous chapters the Study Team presents an inventory and an assessment of the status of Myanmar's water resources and how they are managed. The most salient challenges as well as opportunities for the future planning, development, implementation and management have been described from both a physical perspective and, not less important, from a perspective of good water governance. From these challenges and opportunities the Study Team has formulated building blocks for water resources management strategies.

From the physical perspective Myanmar faces major challenges: in the water-food-energy nexus the provision of safe drinking water and using the opportunity for sustainable energy production through a balanced approach towards development of hydropower systems cannot be overstressed and should go together with integrated watershed management. In view of droughts and salinisation fresh water resources for food production, irrigated agriculture remains a key issue. Disaster risk reduction needs serious and increased attention: flood protection (both urban and along rivers) as well as protection against more frequent occurrences of cyclones. Climate change adds to these challenges.

From a governance point of view, capacity building is the first, very important challenge to be addressed. This is at all levels and in all water-related sectors. Well-integrated water resources management benefits from well-prepared sector knowledge. This capacity building should aim at the present-day staff in all water sectors as well as at future staff by well-structured professional academic and vocational training. Data acquisition, data management and analysis must provide a sound engineering base for administrative and political decision making.

The development of an integrative Water Framework Directive and Water Law needs to provide a long-term consistent approach throughout the country. A policy of good coordination of national and international funding organisation may well contribute to this consistency.

Develop a stronger base, building blocks

The conclusion can be reached that it is too early to define specific scenarios for specific regions. The challenges for IWRM are, in a certain way, so basic (clean drinking water, sanitation, flood protection, more 'crop per drop' in irrigation) that the coming years most effort will be needed to provide no-regret measures. Regardless the scenario as it will unfold in the coming years, the Myanmar Government already has a clear long-term vision with respect to its water resources development: a water efficient nation in 2020 with well-developed and sustainable water resources in a Green Economy based on Green Growth. Without formulating generic or regional strategies yet, the many above-mentioned challenges form the building blocks, the foundation of integrated water resources management in Myanmar. They all form the basis to manage land and water in service of people's health and economic progress, whatever socio-economic scenario will develop.

Direction and guiding principles are available

This basis is needed to take up detailed master planning and its implementation. The main building blocks consisting of data management and modelling; capacity building; institutional, legal and financial development and; sector master planning first require systematic attention. For each of these issues Myanmar needs to formulate its sub-strategy. Main guiding principles have already been formulated and will be addressed and taken into account when master planning for integrated water resources management is taken up.

Immediate strategy

In fact in August 2014, both the NWRC Expert Group and the Dutch High Level Experts presented to the National Water Resources Committee the immediate strategy for Myanmar's IWRM as summarised in the Key Messages.

1. **Key Message 1 Optimise what you have**

   Myanmar already has important water infrastructure, such as dams, canals, sluices and pumping stations, dikes and river training works. However, there is a large potential for improving, upgrading and redesigning the functioning of this infrastructure. Thus it can become a substantial base for the development in Myanmar. It is recommended to take the current infrastructure as a starting point and give priority to small short term actions with quick wins toward provision of clean drinking water, food and energy production and navigability of the rivers.

2. **Key Message 2 Take a "broad view" in the analysis of the problems**

   Looking into other interests, including future developments, in a well-considered integrated way is essential for successful solving water problems and developing water resources. This approach will deliver solutions which are more robust and give a better cost - benefit balance and broader support by stakeholders. For example, when planning for or re-designing dams, in particular large ones, reservoirs, embankments, sluices and canals for irrigation or drainage, and river works, it may well pay off to consider, next to single sector hydropower or irrigation, watershed management to avoid (further) erosion, possibilities for flood management, sediment management to help navigation, reduction of salt intrusion and nature development. The rapid degradation of water quantity and quality will spoil the efforts to bring development if IWRM is not wholeheartedly handled. Focusing on silo (or) compartmental development in Agriculture, Industry, Hydropower, and Service sector will lead to real conflicts among line ministries and create tensions with other

stakeholders. To avoid that possible damage and envisioning for equitable water sharing it is essential to give priority to IWRM through dialogues within NWRC. Such a **'broader view'** is also likely to be more robust with respect to shifts in socio-economic development.

3. **Key Message 3 Focus on education, capacity building and training**

   Capacity building is a key success factor for integrated development of water resources in Myanmar. Increasing capacity building is required at all levels, from gate-keeper to high level civil servants. It should consist of a multi-year program for young and senior professionals, improvement of curricula at universities, establishment of vocational education, training at the local level etc. It should stimulate the cooperation between ministries in policy and decision making processes, including the cooperation with regions. Cooperation in this field between programs of different donors in Myanmar needs to be stimulated.

Special attention is needed for learning by doing. IWRM is only useful in real-world cases. Capacity building programs should be connected with projects. The projects described below offer opportunities for capacity building for students and professionals.

9. From vision to implementation

Preliminary translation of strategies to measures

9.1 Measures

Introduction to measures

Implementation of appropriate strategies has been discussed in chapter 8. In this chapter a longer list of example measures and projects illustrates how to go from "vision to implementation". The chapter contains the study team's views so far. Further discussion and commenting is required for a list with ambition but also realistic in view of possible implementation and in particular it's financing. The measures can be categorised as follows.

Short term (~ 2020)

- Build on what is already available (restore, rehabilitate, improve).
- Swift reviews and implement first-step improvements
- Start master planning to avoid regrets including Environmental and Social Impact Assessment

Mid and long term (2040 and beyond)

- Implement master plans

In June 2014 at the Minister's seminar in Nay Pyi Taw a provisional regional/sectorial list has been presented.

(1) Provision of clean drinking water
- highest priority for people's health

(2) Integrated Watershed Management
- aimed at livelihood improvement
- Irrigation command area development
- rehabilitation and improvement existing schemes

(3) Integrated Lake Water Resources Development
- e.g. Inle and Meiktila Lake

(4) Multi-purpose hydropower development
- "Electricity Master Plan" being completed using the triple bottom line criteria

(5) Integrated River Master Plans
- Ayeyarwady Master Plan,
- piloting river training works,
- navigational aids,
- Bagan multipurpose project

(6) Water Resources Impact Assessment for urban and industrial developments
- e.g. groundwater extraction assessment Mandalay & Yangon

(7) Delta and Coastal zone improvement
- e.g. review on achievements WB Paddy 1, 2 & 3 with proposals for innovative delta management (GWP Delta Alliance)

(8) Data and information management and monitoring
- setup of Hydro-Informatics Centre

(9) Planning for Disaster Risk Reduction
- short-term impacts climate change
- (sea, cyclones, rain, droughts)
- flood early warning system, flood
- management centre

(10) Capacity development for water resources management
- across all sectors and all levels (from gatekeeper to PhD/DG)

Long list of measures projects

In line with the general list of measures a more concrete list of no-regret measures and projects has been drawn up. No-regret means that these projects all fit within the different scenarios and the accompanying strategies for IWRM towards the vision to realise a water efficient nation.

A broad variety of measures is being considered.

- Measures for both urban and rural communities;
- Measures for the short term, medium term and long term;
- Spatial variation of the measures: mountains, central dry zone, lakes, delta, rivers, coast;
- Non-structural measures, such as:
    - organisation/governance
    - financing instruments
    - capacity building
    - law and policies
- Structural measures (ideally bringing good water governance into practice) with the full planning range: strategic planning, master planning and project planning.

The long list of measures is presented in Appendix 1. As already indicated the list is preliminary and will require a further review based on comments received on this report.

9.2 Sustainable provision of safe drinking water

Provision of safe and affordable drinking water is highest priority for people's health. Clean drinking water prevents waterborne diseases and health problems caused by toxins. A secondary effect of safe drinking water is that its availability reduces sick leave and time spent preparing water for drinking, hence resulting in more available time for school and work and therefore a potential increase in income.

Implementation of drinking water standards

Drinking water standards have been developed by the Ministry of Health and by the NWRC; a process that started in 1990. These standards need to be formalised as guidelines or in law and implemented accordingly. Interestingly, in countries where drinking water quality standards do exist, most are expressed as guidelines or targets rather than requirements, and very few water standards have any legal basis or, are subject to enforcement. Two exceptions are the European Drinking Water Directive and the Safe Drinking Water Act in the USA, which require legal compliance with specific standards.

Standards should also specify the sampling locations and methods, sampling frequency, analytical methods, and laboratory accreditation. A system for monitoring needs to be developed to support its implementation and necessary measures/mitigation/enforcement.

Much can be learned from previous monitoring programs, for example the 2002 report of a monitoring program with support of UNICEF. The study revealed a serious health threat by Arsenic, Fluoride and Faecal Coliform. Recommendations were given to:

1 Formulate an action-oriented National Arsenic Plan;
2 Continue surveys and tests in the remaining areas of the country;
3 Confirmatory tests in the areas where Arsenic is present;
4 Information, education and communication activities to reach the grass-root level;
5 Clinical diagnostic survey for Arsenocosis;
6 Development of technology and alternative measures for mitigation of the problem.

Provide safe and affordable drinking water sources

Providing all people in Myanmar with clean water is complex; local circumstances dictate the solution with the best fit. Besides the local socio-economic situation, two factors are important for the selection of the best fitting solution:

- population density: urban, rural, single;
- drinking water source: sufficient rain water, good quality groundwater, river water.

Currently most drinking water in Myanmar is taken from surface water, such as ponds, lakes, reservoirs and rivers. Since the groundwater may contain arsenic and other diffuse pollutants and, particularly in the delta, tends to be saline, careful use of groundwater is recommended. Instead, it is better to build upon the structures that are already present and improve on those. The following building blocks for measures are suggested.

- Medium to large scale water treatment for the cities and townships, developed by water companies. Water companies need to be controlled by guidelines and legislation. The future demand and availability of water should be predicted in line with the population development of these cities. The use of groundwater should be carefully monitored to measure the water quality and the effect on groundwater levels.
- Pond rehabilitation, other rainwater harvesting, safe groundwater wells and small scale water purification stations for rural communicates. For rural communities there is often a change needed from free water to having to pay for household water. It was found that people are willing to pay when good quality water supply can be guaranteed. Ownership needs to be organised for the operation and maintenance of the system. Two models are possible:
    - Village community responsibility model; non-profit.
    - Entrepreneur model: social enterprise and market-based, making enough profit for a decent living for the entrepreneur.

  Rural communities in most cases cannot bring up the full investment needed to construct a water treatment system, so a combination of Government funds, NGO's, corporate social responsibility funds and funding by World Bank, Asian Development Bank are required. NGO's and private initiatives need to be supported by national guidelines and policies.

Box 9-1 Franchise model for safe drinking water

An interesting franchise model was developed by *1001fontaines* and *ICS* and is currently enrolled in Cambodia where circumstances are very similar to the Delta. A franchise model increases cost efficiency. Trying such a franchise model in the Delta can be a successful project. An example is:

- 1 platform: managed by ICS, provides technical services to the 60 water stations in the area. Each operator pays a franchise fee of 20% of the income generated by the station to benefit from the services delivered by the platform (maintenance, on-going training, assistance…).
- 60 water stations: the 60 stations will be located in 60 different villages. Every station is managed by a local entrepreneur. The water is purified and sealed in 20liter plastic reusable bottles. End consumers buy a bottle once, the entrepreneur makes sure it gets cleaned and refilled. Based on experience, on average 60 stations are needed to make the platform break even.
- Kiosks / communities: the local entrepreneur and his/her team deliver the bottles to the end consumer through home delivery and/or through kiosks. These kiosks are existing local shops.

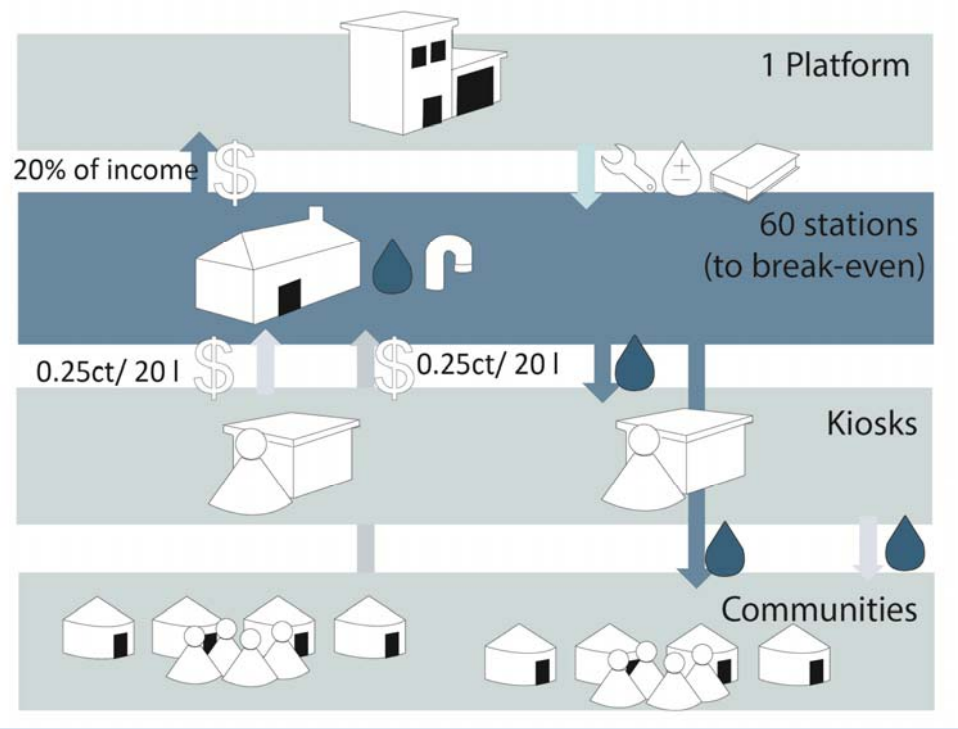


Figure 9-1 *ICS* and *1001FONTAINES* franchise model for NW Cambodia

The provision of clean drinking water always results in the production of (urban) waste water. To avoid that new environmental and health problems are created the provision of drinking water should always be combined with measures on waste water and preferably also on sanitation and hygiene.

Monitoring of the quality and price of drinking water

In order to enforce the water quality standards, it is necessary to set up a program to systematically monitor the quality and price of the drinking water that is sold to people, both

via pipelines and by bottles. Such a monitoring programme can be implemented by the government or an independent organisation. This can be seen as product quality control to protect the consumers, but also to learn how to improve the quality and how to reduce price in the medium term.

9.3 Measures in the mountain area

Commercial wood cutting, single purpose hydropower production, slash and burn agriculture and mining are presently ongoing practices in the mountainous areas. They are taking place with virtually no measures to mitigate the obvious negative effects. Land and water conservation is to be central in IWRM for the mountainous areas.

Watershed management falls under the responsibility of the Watershed Management Division of MoECaF. This division is undertaking planning and implementation of watershed management with the objective to systematically conserve watersheds in Myanmar. Political and financial support is required. Good watershed management is to be considered core to integrated water resources management for the country as a whole.

The following measures are applicable:

- Good governance in forest management.
- Planned reforestation will be required to stop erosion of the mountain slopes. With continued erosion taking place, reintroducing vegetation cover will eventually become impossible and thus create bare mountains with neither any ecological nor economic value. Forestry is the responsibility of the Ministry of Environmental Conservation and Forestry (MOECAF).
- Watershed management in which both the environment and improvements of the farmer's livelihoods in poor and highly degraded watersheds are addressed is to be considered. This can be done through promoting an integrated and replicable model of sustainable rural development of which minority groups in the mountain may be the first beneficiaries.

Box 9-2 Integrated Watershed Management

Integrated Watershed Management has as objectives to improve farmer's livelihoods and protect the environment in poor and often highly degraded watersheds in the mountainous regions of Myanmar by promoting an integrated and replicable model of sustainable rural development. Through a participatory design process activities will be packaged into an integrated set of interventions for individual sub-watersheds. These activities are categorised into three components. The first component, entitled soil and water conservation consists of predominantly physical investments for soil and water conservation primarily of public interest including minimum capital farmland, sediment retention structures, afforestation and vegetative cover, and village infrastructure such water supply facilities. The second component, entitled livelihood improvement, consists of predominantly physical investments designed to improve the income of farmers including: terracing of slope land, horticulture and fruit and nut trees, grasslands, livestock development, irrigation and drainage and renewable energy supply. The third component, entitled project management and support services, will ensure the participatory design process with inclusion of vulnerable groups, the quality implementation of activities under the first two components, the right institutional setting for sustainable operation and maintenance of project activities, the mitigation of environmental and social risks, and strong project management including monitoring and evaluation.

Eco-compensation schemes may need to be set up where (downstream) water quality needs to be preserved for e.g. tourism or water supply of major urban areas (similar to protected water recharge areas). This may be required for preserving tourist locations such as Inle Lake. Eco-compensation not only shares characteristics with payments for ecological services, but also encompasses fiscal transfer schemes between regions and states to improve the apportioning of funding for and clarify responsibilities and tasks on environmental management, especially on watershed ecological services.

Revision of Reservoir Operational Rules of hydropower and irrigation schemes towards multi-purpose use. This to balance between optimums for hydropower generation, irrigation and drinking water supply, maintaining environmental flows in the rivers for ecological conservation and restoration and requirements for sufficient draft for ships in river channels for inland water transport.

Environmental protection of mining sites and mitigation of pollution of river beds to bring the quality of river water within proper environmental flow conditions and avoid complex and expensive river water treatment for rural and urban drinking water supply. A prerequisite is proper environmental laws and an efficient enforcing mechanism.

Planning for sustainable (small) hydropower schemes in e.g. sub-catchments of the Chindwin River and Thanlwin River. It is noted that the Government of Myanmar is promoting small scale hydro power (in Myanmar referred to as “micro hydropower”). As a matter of fact Myanmar has tried to promote the latter earlier; however, it has not been taken forward due to limited knowledge and difficult access to new technologies.

A dam will, by its nature, create a sharp transition between the up- and downstream catchment area with e.g. creation of eco-system isolation over the transition. A sound EIA

including sustainable mitigating measures are required to amongst others manage this aspect. Eco-compensation valuation, as mentioned above, may assist in making the right choices.

9.4 Measures in the Ayeyarwady Delta

Water resources management measures in the delta relate all strongly to livelihood improvement. An important flanking measure is the improvement of transport to, from and through the delta, especially in the direction east-west, which requires numerous and expensive river crossings. Economic progress cannot go with navigation transport (mainly north-south) alone.

Flood protection measures for the lower floods (horseshoe dykes in the upper delta, polder schemes in the coastal delta) exist throughout. Building on the existing measures, rehabilitation and upgrading to a modern and more integrated approach will contribute to improvement. Great opportunity is to be sought in adaptation to salinisation and further development of aquaculture.

A concrete measure could to redesign the Paddy Land Development Projects following the guidelines as mentioned in this study (see also section 10.3.1).

Several modern flood early warning systems are already being worked on. After Nargis, the importance of these measures goes without saying, but the fact that there is more than one system is cause for concern. Swift implementation is needed for the 'Myanmar action plan on disaster risk reduction' (MAPDRR), which was drafted by a Task Force of 12 involved ministries, aiming at collaboration between the relevant authorities. Modern technology can speed up the communication to the township and village level. More multi-purpose shelters are needed to protect the current population. The focus for further risk reduction should be on strengthening the capacity for disaster preparedness and response and coordination at Township and State and Region levels. Long-term disaster preparedness by interlinking disaster risk with spatial development is essential for sustainable economic development. Building codes can play an important role. Currently, better data and high resolution maps are urgently needed.

9.5 Measures in the rivers

The rivers find their main purpose in water supply for hydropower, irrigation and to a lesser extent domestic and drinking water. Navigation for all kinds of transport is a challenge and opportunity.

In view of the objective to improve the navigability and to identify a long-term master plan development of the rivers, emphasis has been placed on structures which would guide the river into a single channel of alternating left and right bends with the minimum length of straight sections between the bends. Once the correct alignment is obtained, a low water channel of appropriate width could be designed to provide the appropriate least available depth.

River training and dredging works should in view of above mentioned be carried out gradually in time to avoid too abrupt changes in the river configuration which would upset the dynamic equilibrium. Sufficient time must be allowed for the river to adapt to a new morphological equilibrium. When changes are too abrupt, adverse conditions, either upstream or downstream of the river section being improved, may cause the river to abandon the desired

low water channel alignment entirely and breach through the flood plain in a secondary channel. Less drastic adverse effects that may occur include the formation of shallow areas in adjoining river stretches and an overall instability of the channel system.

Optimising economic use often leads to squeezing resulting in transition with widening and narrowing of the main channel. In The Netherlands' rivers but also in other countries with intense economic use of the rivers, their flood plains and embankments, the squeezing has led to hard to sustainably manage these transitions. Myanmar still has the optionto prevent this to a large extent. 'Room for the River' for instance can still be easily maintained through proper spatial planning at locations where the thread for squeezing exists. Laws, regulations and enforcement for land use and development at the land water transitions will need to be developed.

The implementation must be phased, primarily because of the reasons outlined above. Since the river system is bound to change during the period of implementation of river works, the systems changes must be monitored and documented carefully. This may guide modifications to the works and yearly river maintenance requirements. Because of these changes, it should be realised that master planning is of imminent importance and will be a continuous on-going activity.

Regarding pumped water supply from the river to irrigation schemes, sedimentation of the access channel to the pumping station or river bank erosion endangering the pumping station is often problematic. River training in combination with navigation measures could well be combined with locations for pumping or even micro hydropower.

9.6 Measures in the Central Dry Zone

From the IWRM perspective also in the Central Dry Zone land and water conservation is to be the main focus. Measures in this region are primarily to be focused on the water resources for agriculture and domestic use. Existing (irrigation schemes) find their water sources either in reservoirs or in the rivers: integration with river training, hydropower and reservoir operation (also for flash floods!) is the leading idea. Apart from that, urbanisation is an issue that needs a careful approach.

A first elaboration of a strategy for this reason could lead to the following measures.

Land and water conservation of vulnerable soils through improved agricultural practices to avoid soil erosion from water and wind.

Rehabilitation of irrigation and strengthening WUA's and WUG's by implementing Irrigation Command Area Management with extension to watershed management in the upstream catchment from irrigation reservoirs and ponds. ADB has initiated the formulation of such projects.

Drainage system improvement in dry zone irrigation schemes through construction of drainage schemes from field drainage to main drainage. The aim is to improve leaching conditions of irrigated areas to mitigate negative effects of salinisation.

Strengthening resilience to droughts. The risk of droughts is prominent in the CDZ. Most townships should have a Township Risk Reduction Plan, but according to various

sources, these are still very weak and not actually used. Further strengthening of individual resilience to drought, but also on the township level is required. Water allocation protocols in which water use is prioritised according to the most urgent needs, would help management of the water during extreme droughts.

Flanking integrated planning to industrial and urban zones development. Urban and industrial planning tends to focus on economic and demographic aspects only. Integrated planning with concern for the environment is given little attention though (obligatory?) superficial ESIAs are prepared. Examples at Dawei and Myotha development near Mandalay show that in particular water management aspects, quantitatively and qualitatively, initially only focus on immediate need and the best economic solutions for the areas themselves. This leaves a high risk for the surrounding area and sometimes region. This was however recognised at Dawei where a water supply scheme was stopped and redesigned to be more sustainable for the region as a whole. Proper integrated regional and urban planning, including planning for IWRM, and implementation should accompany each of such developments which in itself are generally positive for development when planned and implemented taking all other aspects into account as well. Water foot printing is a way to assist in creating awareness for water issues and to allow for integrated planning.

9.7 Measures in Coastal Zone and port areas

Protection and restoration of Mangroves

As mangroves are the first line of flood defence for Myanmar and are of great value for food (essential for fish development) and local wood production, the restoration of the mangrove forests are essential for the livelihood of many people all along the coast, especially in the Ayeyarwady Delta area. The first course of action is to strengthen the protection of the existing mangroves. The local communities need to be engaged, since they rely on the mangrove wood for their livelihood. Furthermore, mangroves need space to 'migrate', so paddy encroachment right up to the flood line poses difficulties. The Department of Forestry has good experience with community mangrove plantations for local wood production and sustainable shrimp farming combined with mangrove reclamation. Good measures, but at the same time still large areas of mangroves need to be restored all along the coast, especially in the Delta and Rakhine State.

Coastal Zone Spatial Planning

The coast of Myanmar is still pristine to moderately developed, but specific areas are expected to develop fast. Economic drivers for these developments are urban development of coastal towns, tourism, industry, transport and fishing. These developments often take place in the same areas and interact with each other. There is also an important interaction between the developments and the physical, ecological and social environment. Uncontrolled development will lead to cluttering of the coast resulting in lower social and economic value, for example because of negative impacts of development on each other, unsuitable infrastructure (energy/water), unsuitable transport chains, flood risk, sedimentation / navigation problems, pollution of sea and beaches.

Even though there is a lot of development activity expected all along the coast, there is no bigger plan to steer these development for the best socio-economic and environmental result. Specific areas with interlinked developments on the coast are in need of integrated coastal

spatial frameworks to support long-term development in a safe and sustainable way. By combining information on the requirements for developments (access to beaches, vicinity to ports, etc.) infrastructure, water availability, coastal characteristics and sand transport along the coast, flood risk and flood levels and ecological constraints, the most optimal result can be mapped in zones in Integrated Coastal Spatial Plans. These Spatial Plans should also contain the conditions that are required for envisaged developments and also the conditions to be met by the developers. The key aim of an integrated spatial coastal plan is to use the regional strengths and weaknesses and to structure them for the most optimal spatial development

The coast of Dawei is an interesting area to start a pilot on Coastal Zone Spatial Planning, because of its complex physical, economic, social and environmental situation:

- The potential development of a Special Economic Zone and deep sea port. There is still much debate on the most suitable location for this economic zone. In addition there is much resistance to the plan because of its environmental and social impact, and there are questions about its economic viability.
- Dawei town and the nearby Maungmagan Beach have good potential for tourism.
- The Islands near Dawei are protected by a marine sanctuary status.
- The development of a deep sea port and infrastructure to Thailand are of great interest to provide a fast connection to Bangkok. Sediment transport along the coast is likely to impact navigation to the port.

Different types of major developments might take place in the near future in and around Dawei. A well thought through and integrated spatial plan provides a decision support framework on which informed decision making is possible for decision makers and developers. A pilot in Coastal Zone Spatial Planning would also benefit capacity building in the fields of integrated coastal management and spatial planning. A full description of the pilot Dawei Integrated Coastal Spatial Plan is given in Appendix 10.

9.8 Measures for lakes and reservoirs

Myanmar is rich in natural and artificial lakes and reservoirs, like Inle Lake, Meiktila Lake, Indawgyi Lake, Kandawgyi Lake and Inya Lake, to name only a few. These lakes are very important for the livelihood of people and ecosystems. Lake and reservoirs function as water retention areas and are therefore an essential source of water for drinking and domestic/industrial use, food production (agriculture and fishing) and can play a role in preventing floods. They also have a significant cultural and natural value.

Use lake and reservoir IWRM to support a green economy

Lakes with sufficient water of good quality will support social development and economic growth of the area using the lake. Long-term water security is an essential component in the development of people, agriculture, businesses, schools, industries and tourism. It is therefore of the utmost importance to plan the management of lakes and reservoirs, taking in account all current and future interests and considering socio-economic future developments.

Lakes and reservoirs, therefore, have to be considered within their surrounding systems of irrigation canals, dams, watershed areas, combined use of drinking water and irrigation, importance for urban and rural planning, forestry, agriculture, fisheries and, not least of all, nature and the environment. A transparent and structured method of planning lake and reservoir IWRM is to develop Lake and Reservoir Management Plans in a participative process with all stakeholders and users. These plans should analyse the entire water system related to

the lake/reservoir and they must clearly describe how all the different interests of the water users were considered. It must describe a transparent decision process for (water) management of the control area in and around the lake or reservoir. Examples are measures to reduce certain types of pollution, reforestation, sustainable deforestation to prevent siltation, the operational protocols for gates and weirs to manage water levels and irrigation systems, agreement on water shares for the different users, priority rules for water shares during times of extreme drought, where fishing is allowed, and so on. Such plans and should also include insight in the budget and staff that is required for implementation.

Prevent further deterioration of lakes and reservoirs

Lakes and reservoirs are notoriously difficult and expensive to rehabilitate. Therefore, investing time and budget in prevention of further pollution and siltation now will prevent huge expenses later in time. The solution to this problem is complex, and can only be tackled top down and bottom up simultaneously. Top down, laws and policies are being developed at Union level. The next step is to start enforcing these to prevent untreated wastewater entering the lakes and reservoirs or their tributaries. In addition deforestation should stop along the tributaries to prevent erosion and further siltation of the lakes. Appropriate Integrated Watershed Management projects, including reforestation, should be implemented.

Bottom up, it is important to start a dialogue with water users who have a negative impact on the lake or reservoir. For example, make a transition plan with polluting industries to be cleaner within a certain time or talk to farmers about minimising the use of pesticides and fertilisers.

Implement lake and reservoir rehabilitation projects for the most urgent and/or polluted cases

Most lakes in Myanmar are still pristine. However, some important lakes are seriously polluted. These lakes should be identified, analysed, prioritised and rehabilitated to enable a sustainable use of these resources. Both technical measures and good water governance should be considered. A plan of action is suggested in the following table.

No-regret/ immediate	Short time	Medium time	Long time
Mapping of all the lakes above a certain size.	Prevent further deterioration of lakes and reservoirs	Implement lake and reservoir rehabilitation projects for the most urgent polluted and / silted cases.	Implement lake and reservoir rehabilitation projects for the other polluted or silted lakes.
Collection of data	Lake and Reservoir Management Plans for the most urgent lakes	Develop Lake and Reservoir Management Plans for the other lakes.	

As a no-regret measure the implementation of IWRM for Inle Lake or Meiktila Lake is suggested. Both lakes are in urgent need of IWRM practices to support further sustainable socio-economic development of those areas. Inle Lake suffers from eutrophication and pollution with pesticides. Meiktila Lake is heavily silted due to deforestation and the management of the lake is single-purpose. The problems for both lakes can only be solved sustainably by an integrated approach and by supporting technical measures with good water governance.

10. Selected quick-wins projects Myanmar–Netherlands

10.1 Selecting early measures and quick wins

Why quick-win projects

In the framework of this study under the Myanmar-Dutch cooperation, a number of projects has been identified for implementation in the short term, partly under the umbrella of the Memorandum of Understanding between the Union of Myanmar and the Netherlands and partly also within other frameworks. It concerns early no-regret measures and/or quick wins. The latter are potential "direct implementation measures".

The definition of a no-regret measure is: 'A measure that will be part of the preferred strategy, whatever scenario becomes reality and whatever strategy is selected'. Hence, the selection of the preferred strategy does not depend on this specific measure, nor does this measure impede the optimisation or adaptation of the preferred strategy over time.

To identify whether a no-regret measure is also a quick win, a series of criteria was used for qualitative scoring.

These criteria are:

- whether measures are urgent and can be carried out in the short term (technically and financially feasible, broad support)
- the added value of the measures in gaining experience with the adaptation of IWRM principles and good governance;
- up to what level the measures answer to the triple bottom line;
- and whether the measures are needed under each of the three scenario's, as this was the selection criterion for identification of a no-regret measure.

10.2 Integrated approach in predominantly technical projects

10.2.1 Pan Hlaing project and review of paddy land development

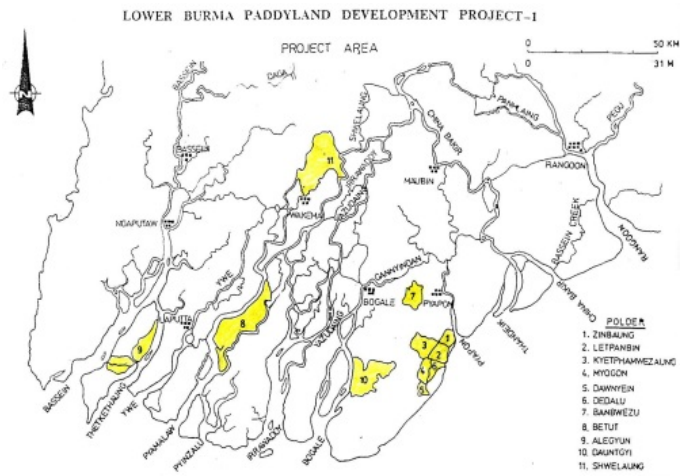


Figure 10-2 Paddy 1 polders
[source: World Bank 1986]

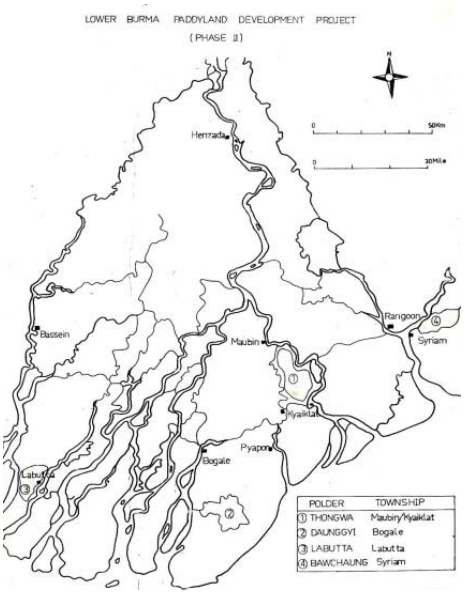


Figure 10-2 Paddy 2 polders
[source: World Bank 1984]

Current situation

In the period between 1976 and 1988 the Ministry of Agriculture and Irrigation (MoAI) realised the Paddy Land Development Projects 1 and 2 (in short Paddy 1 and 2). These were World Bank supported projects for creation of polders for mainly rice production. Follow-up projects Paddy 3-7 have been formulated. Parts of Paddy 3 have been realised. Much of the infrastructure of these projects has been destroyed by Nargis in 2008. MoAI, often with aid of Japan, is in a process of rehabilitation of the dyke system and the sluices. This includes dyke raising to a higher protection level. After these "Paddy 1 and 2" projects Myanmar continued to reclaim land for cultivation.

Myanmar's MoAI Irrigation Department continued land reclamation for paddy after the World Bank Paddy Projects. Nyaung Done Island was one of the major reclamations for rain fed paddy and tidal irrigation for summer paddy cultivation (1994-2000). the Pan Hlaing river is gradually losing its irrigation and drainage function due to sedimentation of the coarser river sand at the (western) Ayeyarwady end, sedimentation from the paddies in the central part and finer sedimentation at the eastern end (Yangon side), the latter being flushed by the tide, leaving some width and depth in the Pan Hlaing. MoAI is planning to restore the function of the Pan Hlaing River by dredging and construction of a sluice at the Yangon end (Pan Hlaing Estuary Sluice) to prevent the tide (with sediment and brackish water) coming into the Pan Hlaing.

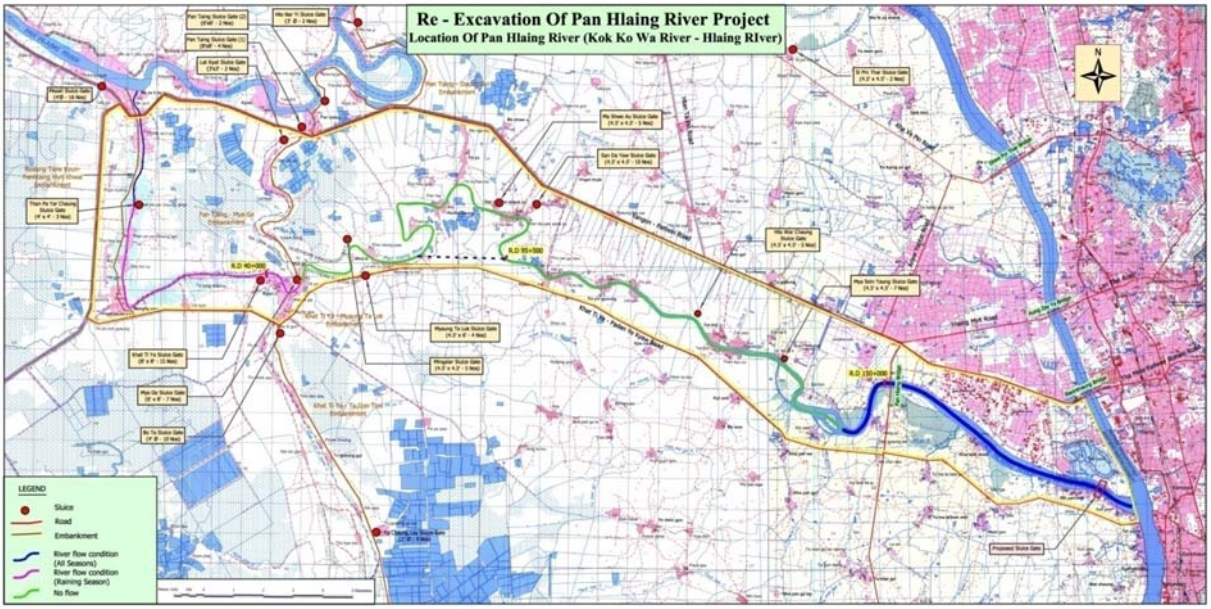


Figure 10-3 Pan Hlaing River from the Ayeyarwady branch Kok Ko Wa (fresh water, little tide, coarse sediment) to the Hlaing/Yangon River (brackish, substantial tide, fine sediment) for drainage and irrigation of Nyaung Done, Tetthit and Shwemayinnkwin Islands. The river is silted up losing its functionality [source MoAI-Irrigation Department, 2014]

Quick win and IWRM approach

MoAI – Irrigation Department has requested the Netherlands mission in Myanmar for support in restoration of the Pan Hlaing using an IWRM approach.

In line with the IWRM Strategic Study and the need for tangible and quick results this would materialise in a two-way approach:

A. (pre)feasibility study for the Pan Hlaing Estuary Sluice and river dredging components
B. review of paddy land development approach in the Nyaungdone Island and the wider lower delta

A. (Pre)feasibility for Pan Hlaing Estuary Sluice and river dredging

The (pre)feasibility would comprise at least the following items:

1. design of IWRM project process with focal ministry and involvement of most important stakeholders
2. multi-purpose definition of project objectives (IWRM)
   a. potential beneficiaries
   b. qualitative benefits of the project
   c. potential developments in the region (agriculture, industry, urbanisation)
   d. identification of potential financers including PPP opportunities
3. sluice location and general dimensions
4. need for navigation lock
5. required river dimensions and dredging works

6. required additional works (sluices, sluice restoration, embankments, mitigation measures)
7. assessment on effectiveness of the project
8. assessment of social and environmental impacts
9. general cost benefit analysis
10. training of stakeholders in integrated water resources management

With reference to item 7 and 8 particular attention is to be given to the effects of sediment management in the effected part of the delta and in the Pan Hlaing itself. Also drainage of from the industrial zone may require special attention to avoid building up pollution in the Pan Hlaing after closure.

B. Review of Paddy Land Development approach

The World Bank Paddy projects and the Nyaung Done Island reclamation have been designed with the views and knowledge of the 1970s, 1980s and 1990s. The conditions, the actual situation and the view on integrated water resources management has developed since. The Study Team and Irrigation Department of MoAI have discussed to initiate a review and potential revision of the Paddy Land Development based on the new Myanmar NWP and the recommendations in this document as well as information received from the ongoing Delta Alliance study. The review is to result in packages of technically and economically viable projects which can be presented to financing agency for (immediate) funding.

New conditions

1. further deterioration of protective mangrove system (e.g. mangrove deprived of habitat by polder systems, mangrove cutting for fuel);
2. further mechanisation of agriculture;
3. increasing salinisation;
4. increasing pressure on availability of safe drinking water;
5. further development towards fish farming;
6. further opening up, increasing accessibility of the delta;
7. changing administrative system;
8. changing financing potential;

The above-mentioned elements offer a great opportunity for formulating a truly integrated problem approach for the Pan Hlaing river. Originally purely designed for agriculture, mainly low-value paddy, the integration with new developments must be aimed at a higher added value for the restoration of this river: drainage for new urban and industrial areas, potential water supply and navigation for industrial developments, serving developments for crop diversification and aquaculture.

The Pan Hlaing project could thus be the start for a wider scope than the Nyaung Done Island and implement new views in a review of the former Paddy 1 and Paddy 2 approach.

New views

1. stronger focus on environmental conservation;
2. potential of "building with nature": environmental conservation can add to flood protection and to sustainability of economic activities (e.g. mangrove protects against flooding, but is also *the* birthplace for seafood);

3. progress of knowledge on sustainable agriculture and aquaculture;
4. new possibilities for administrative effectiveness and stakeholder involvement;
5. dynamic fresh-salt water border, economically profitable adaptive strategy (compare Mekong Delta Plan).

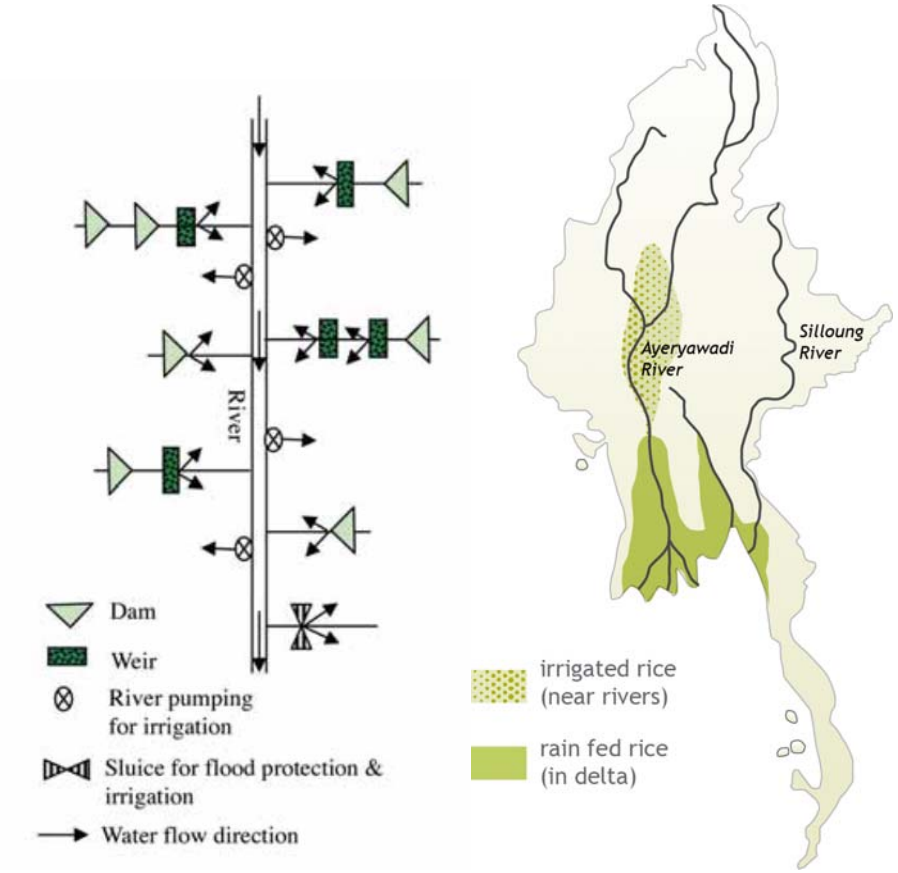


Figure 10-4 Irrigated rice upstream and rain fed rice downstream

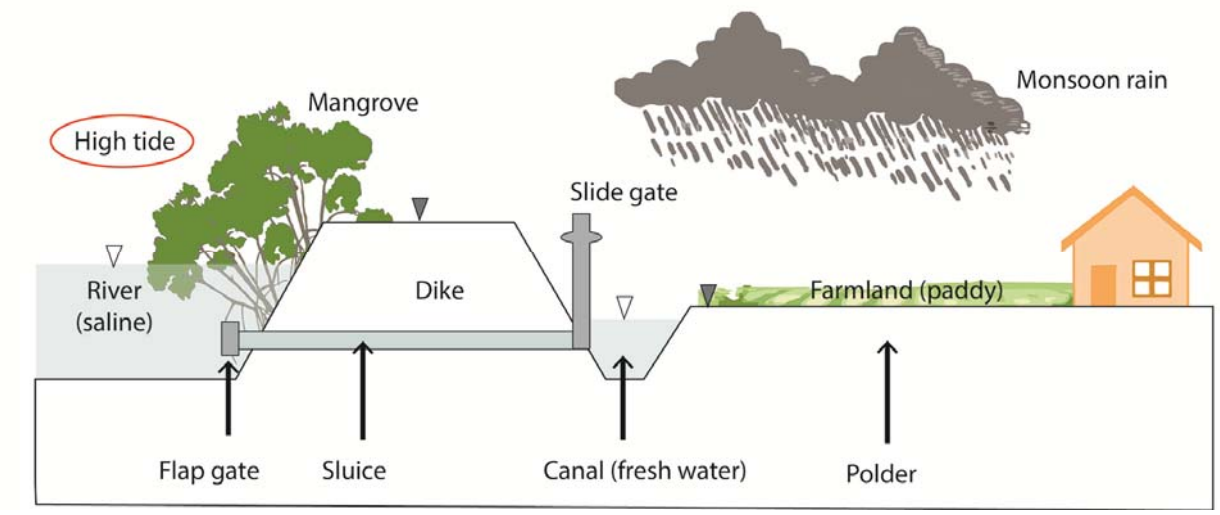


Figure 10-5 Polder systems in the Ayeyarwady Delta are water management polders, rather than flood protection polders. The dykes retain high (spring) tide levels, thus protecting the farm land from saline water. Generally fresh rainwater discharges by gravity into the river estuary. The paddy grows in a rain fed system. Towards the dry monsoon the discharge sluices clos (flap gates) or get closed (flat gates) to retain fresh water for the crop, thus prolonging the growing season *[source JICA]*.

10.2.2 Feasibility Study Mandalay – Bagan navigability improvement

The Ayeyarwady River as well as its downstream branches and its main contributory Chindwin have a valuable role in the development of Myanmar. The Ayeyarwady connects cities like Mandalay (1.2 million inhabitants) and Yangon (5.2 million inhabitants); by looking further up north, the massive southern China is part of its hinterland. The mainland of Myanmar has many resources to offer. Besides agricultural products, wood, gas, oil, coal and gold are important trade products. All of these products are particularly fit to be transported over water.

Intensification of the navigability in the upcoming years would benefit this trade route. However, large scale navigation is hampered by the monsoon climate. In the dry season the river is shallow, allowing little draught and blocking passing lanes. During the wet season, water levels may rise by twelve metres at several locations and discharges become ten times higher. This seasonal variation causes problems for navigability. High flow velocities occur locally and create dangerous situations. Human interventions in the rivers are practically absent; a highly exceptional and invaluable case

compared to other similar sized river systems in the world. This has left the river in a more or less natural state, which is a value in itself. Investments in river training will be economically aimed at the development of a reliable and competitive transport route, meanwhile harmonising with the characteristics and natural values of the Ayeyarwady.

The now proposed study aims for an update of the 1986-1988 Haskoning study on technical and economic feasibility. The technical update will include a review and update of the River Training Master Plan focusing on river training works such as groynes, closure of secondary branches, bank protection works, flow and sediment guiding structures, etc. The review and update will take into account present-day knowledge and experience regarding (large-scale) river training works, including aspects of social and environmental impacts.

The update and review will provide an overview of the newest technologies, developments, system characteristics and local capabilities. Based on these updates two pilot areas, in close cooperation with the Myanmar stakeholders will be selected and further studied to improve the river transport conditions. The result of this study, the project outcome, will be used by the World Bank in the so called AIRBM project. The project results include the definition of the pilot areas with river training works.

10.2.3 Bagan multi-purpose river beautification project

In the context of the Integrated Water Resource Management program for Myanmar, a multi-purpose river beautification pilot project in the Ayeyarwady River near the cities Nyaungu, Old Bagan, Myin Ka Bar and New Bagan is considered [see Figure 10-6]. The proposed river development measures will serve and should be optimised for the following functions: mini hydropower, irrigation, water supply, improved navigation, tourism and river beautification and flood and erosion control.

A number of interventions are being considered such as: river training works and dredging, Dutch "Room for the River" concepts, navigation improvement, provisions for irrigation and water supply and flood and erosion control works.

Interventions fit in a phased development of Ayeyarwady River as no-regret measures and should have no negative socio-economic and environmental impact.

Initial conceptual designs have been prepared and a possible layout of interventions is presented in Appendix 6. In this design, natural deepening of the main channel is stimulated by concentrating the discharge to the main channel. In the secondary channels, mini hydropower turbines in groynes are proposed,

to generate electricity during the wet season and to store water for the dry season. These groynes allow sufficient flow through the secondary channels to generate hydropower and prevent flooding, while stimulating discharge through the main channel during low discharge to enable navigation.

In order to prevent extensive sediment deposition in the secondary channels, which is a general problem of secondary channels and hydropower groynes, training works are proposed to guide the flow and sediment transport. The entrances of the secondary channels will be positioned at the outer bends of the main channel, which reduces the sediment inflow to the secondary channel significantly. The main channel is fixed by spurs and bank protection to reduce the natural shifting of both the main channel and the entrances of the secondary channels. At the same time, advantage is taken of the natural sinuous shape of the main channel to prevent new 'short cut' channels and enable natural maintenance of the main channel.

It is emphasised that further studies are required to arrive at a pre-feasibility report required for next steps in preparing the Term Sheet and Financial Closure which needs to satisfy all partners both technically and financially. The envisaged revenue generating mechanisms could consist of the following flows of income: electricity for city, tourism, water for irrigation schemes, optimised flood protection and improved accessibility for tourism and people and thus reduction of investment cost along the river locations, improved navigation and thus reduction of transport cost and due to sustainable intervention reduction of maintenance cost.

The pilot project should be based on a Public Private Partnership where public (Myanmar Governmental authorities, Dutch Government via e.g. DGGF financial instrument) and private (potential Myanmar SME developers and investors, Myanmar fleet operators and tourism industry and Dutch initiators) should work closely together.

At this point in time it is envisaged that the CAPEX of the pilot project would be some 15 – 20 million euro with an annual OPEX of some 0.5 million euro. The funding could come from private developers from Myanmar and possibly the Dutch Good Growth Facility (DGGF).

As said, it is emphasised that further studies are required to arrive at a pre-feasibility report required for next steps in preparing the Term Sheet and Financial Closure. It is also emphasised that the pilot project should fit into the IWRM approach and proper socio-economic and environmental assessments need to be conducted.

The proposed pilot project is a typical example of “Learning by doing” and is as such also contributing to capacity building and training of Myanmar experts in the various fields of expertise.

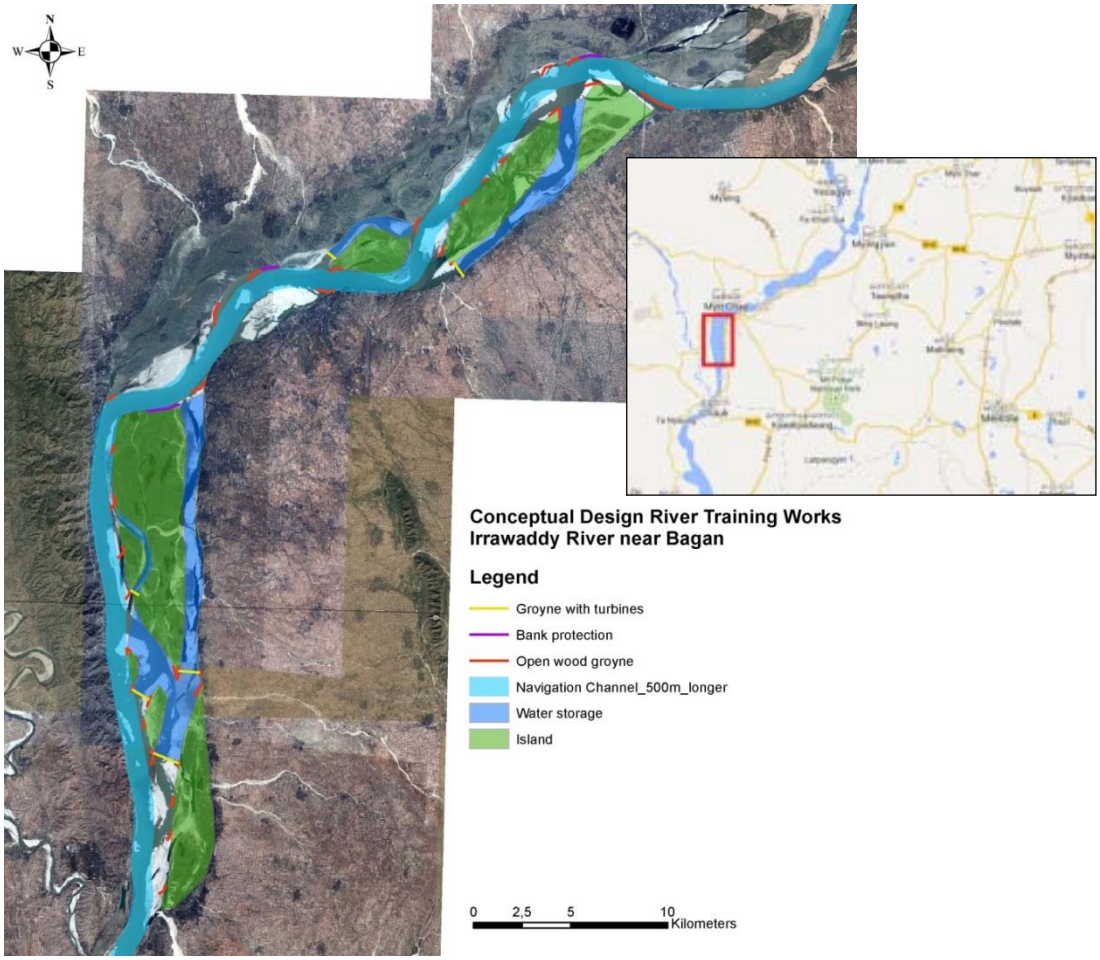


Figure 10-6 Situation Ayeyarwady near Bagan

The proposed pilot project is a typical example of "Learning by doing" and is as such also contributing to capacity building and training of Myanmar experts in the various fields of expertise.

10.3 Governance and capacity building projects with IWRM focus

10.3.1 Capacity development for water resources management

Train young water professionals in IWRM

As emphasised in the Myanmar-Dutch Expert Groups Meeting in Yangon on Saturday 23th of August, 2014 one essential step is to focus on education and capacity building, looking at the future especially of young people. Although many different projects would be necessary a quick-win (no-regret) project with an impact in the short to medium term is to jointly train young water professionals working for the different key departments on the horizontal bar of IWRM. Through the joint trainings it is envisaged that informal networks of young water

professionals will be formed that will contact each other easily contributing to a more active collaboration between the ministries.

The project will be in line with the described elements of the capacity development strategy [section 7.4 and 7.5].

- Involve the water related departments that have a role and mandate that requires strong IWRM knowledge and expertise
  It is recommended to initiate such a training programme with those departments that need a wide horizontal bar most and where collaboration needs to be reinforced most. The training group would therefore need to include at least staff members of the Department of Hydropower Implementation, Directorate of Water Resources and Improvement of Water Systems, Environmental Conservation Department, Irrigation Department and Water Resources Utilisation Department. As the training is for young professionals, candidates should have around 4 - 8 years of working experience at the department.
- Proper balance between training to improve coordination training with focus onthe horizontal bar (integration, coordination and cooperation, master planning, etc) and technical training within the vertical bar which should aim all levels from gatekeeper upwards also on added value of cooperation with related departments.
  Training topics will need to include IWRM principles, IWRM tools (EIA, DSS), Basin planning, Water allocation, Watershed conservation and stakeholder participation with curricula adapted to the level of trainees.
- Train at all levels (local-regional-national) and all positions, although in different intensities and through different learning modalities.
  The training project will be a combination of conceptual background information of the training topics illustrated and applied to case studies. To focus the training impact a concrete case will be selected which highlights the IWRM issues of Myanmar, e.g. Meiktila Lake or the Sittaung-Bago Canal Integrated Water System Analysis. The focus will be on staff members of the national and regional level, where the case study of choice will be leading in selection of the regional staff and key departments involved.

The training is envisaged to take 12 to 18 months with 3 to 4 moments for the joint training and exchange of information. The following elements are envisaged as part of the training programme:

- Plenary sessions (workshops) for all participants and for smaller groups to familiarise with the concepts and theories
- Group assignments on case study, to apply the concepts and theories
- Field visits and role plays
- Coaching sessions related to the group assignments, with involvement of senior staff members of key departments

10.3.2 Meiktila – A Royal Lake Revived

Lake Meiktila is situated in the Mandalay Region on the crossroads of the Bagan-Inle Lake route and the Yangon- Mandalay route. It was constructed over 900 years ago by the Burmese King Anawrahta for irrigation purposes. In the Meiktila District live about 600.000

people; a number of 260.000 in the Township Meiktila depend on this lake and irrigation system for their livelihood.

Current situation

Lake Meiktila was famed for its clear water. However, severe deforestation along the tributaries led to enormous amounts of silt deposited in the lake. The lake now comprises of a north lake and a south lake. While the southern lake is still deep and clear, the northern lake has turned into a shallow water body with marshland (see photo).

The volume of the lake has decreased due to siltation. The last decade has shown decreasing rainfall. The population in the Meiktila district is growing. This results in increasing water stress: where drinking water has priority, irrigation water shortages have arisen, drinking water quality is inadequate. In addition there is an inadequate sewage system.

Water availability and allocation is not planned in the future and potential new services are not recognised. This inhibits the social and economic development of the Township of Meiktila.

The city of Meiktila accommodates several military squadrons and various universities. The region is an important agricultural area with its main market in Meiktila and Mandalay. There is much trade and a textile factory. The area attracts some tourists, mainly from Japan. Rehabilitation of the existing lake and irrigation system may lead to expansion in agriculture. There is also a great deal of interest in agro/food processing industry, technology, solar and wind power and reviving the air transport.

Little data about the lake and the region are readily available. The Irrigation Department of MoAI operates the irrigation system. Due to the lack of data and capacity there is insufficient general and integrated overview and knowledge of the functioning of the total watershed and lake system. Stakeholder consultation with farmers is limited and concentrates on the timing of water supply; other user groups for the lake are usually not involved. Still, it is clear that the problems of the lake go beyond drinking and irrigation water supply; for an adequate integrated problem description and assessment, all stakeholders need to participate in a process to decision making on integrated solutions for the lake. Like anywhere in Myanmar, there is inadequate legislation, monitoring and enforcement to protect the lake against pollution. Policy and protocols on how the lake water should be managed and shared are not available. Without these guidelines there can be no good and transparent water management.

Proposed Strategy

The case of Lake Meiktila is a good opportunity to put the building blocks of this IWRM strategy into effect with respect to lake watersheds. Meiktila is of particular interest for rural and township level development with IWRM at lake watershed level as driving force.

Transparency, accountability, responsibility, between the government and the people was the main message that resulted from a multi-stakeholder workshop. Decision-making needs to be based on reliable data. Monitoring, data collection, modelling and data transparency is therefore the first course of action. For a proper analyses of the lake problems and to determine possible solutions (e.g. dredging) an environmental impact assessment (EIA) is proposed. An EIA can support a transparent decision making process and may be a good tool to involve all stakeholders in this process. An important side effect can be the introduction of EIA in the capacity development program.

There are several forms of capacity building required, like training of Irrigation Department staff, increase in staff numbers and budget. Training on stakeholder participation would be beneficial to get more results from their stakeholder consultation efforts. Information on water use and pollution prevention on schools and in public places would increase the water awareness.

The first step in taking structural measures is a technical, social, economic and environmental feasibility study for rehabilitation of the lake and irrigation system. This should also include proposals for financing modalities with consideration of a combined involvement of public and private sectors. The second step is developing a concrete plan for (phased) implementation.

10.3.3 Sittaung-Bago Canal Integrated Water System Analysis

The Bago region has a number of water management characteristics that require *and* enable to show how integrated water resources management may work:

1. The region has several water bodies influencing each other [see map Figure 10-7]
   a. Bago and Sittaung Rivers; several smaller rivers;
   b. Reservoirs;
   c. Moe Yun Gyi Wildlife Sanctuary and Wetlands (RAMSAR-site);
   d. Bago-Sittaung Canal;
   e. Irrigation polders;
2. Several authorities need to work together with interests that are not in agreement at all times: MoT/DWIR, MoAI/TCI Bago, MoHD, Bago Region, MoECAF and other.
3. The region has many water related challenges:
   a. floods in the wet monsoon;
   b. balance between agricultural need for water and wetlands' requirements for sustainable nature management;
   c. safe drinking water supply;
   d. hydropower optimisation in the reservoirs;
   e. agricultural sustainability;
   f. salinisation in times of drought.
4. Bago is home to the Irrigation Technology Centre; hence the presence of a great knowledge institute should be of advantage for a pioneer role in IWRM for Myanmar.
5. Bago is attractive for tourists, being in the vicinity of Yangon is an advantage; a positive economic development will contribute to the position of this region to play a pioneer's role;
6. JICA has already started an agriculture support project in the western Bago Region.

The project on an integrated water system analysis of the Sittaung-Bago Canal in its full context has a multi-purpose objective in itself:

1. independent data collection
    a. acquisition of all relevant physical water-related data
    b. mapping of organisation structure of water management
    c. inventory of water-related problems, both physical and organisational;
2. independent and advanced data and system analysis
    a. physical modelling of the water system
    b. RIBASIM and SOBEK may be good options for modelling;
    c. regional development scenarios (socio-economic, agriculture, hydropower) for the nearer and mid-term future;
    d. mapping of opportunities for Bago region e.g.: agriculture and aquaculture, tourism and recreation
3. propose improvements for singular water management operations in the context of the whole system
    a. operation of dams, sluices, water level control structures, pumps
    b. organisational structures for operationalisation on decision making in water management
4. institution and capacity building
    a. involvement of ITC-Bago to mobilise local expert knowledge;
    b. involvement of Delft University of Technology and UNESCO-IHE for knowledge exchange; one PhD (Shell-sponsored) has already started on IWRM, this number is intended to increase, also to establish relations within Myanmar between the several knowledge institutes and data centres: DMH, Hydro-Informatics Centre, ITC, other.
    c. possibly input from Wageningen University for input of typical agriculture-related water management, but also to establish better integration of water management and fisheries, nature conservation.

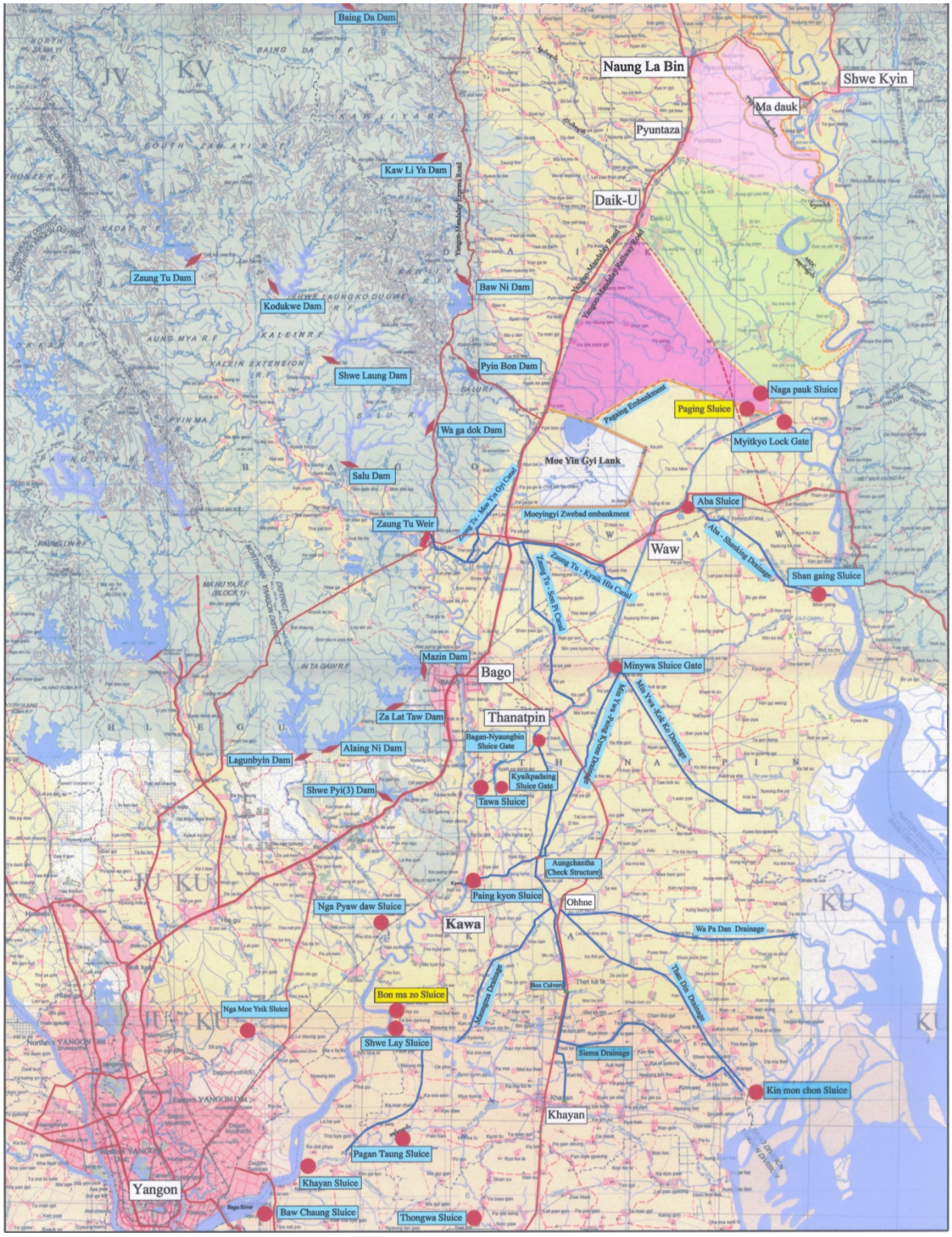
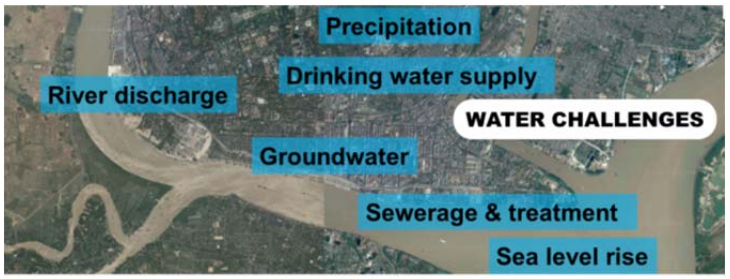


Figure 10-7 Bago Region northeast of Yangon between the Sittaung river and estuary (east) and the Bago river. Note the numerous dams west of Bago and the RAMSAR Sanctuary *[source: MoAI, Irrigation Department]*

10.3.4 Yangon River Front Development

Vision 2040

JICA has supported Yangon City Development Committee (YCDC) with the elaboration of a vision on Yangon 2040. The city is expected to grow from 5,2 million to 11,7 Million. This brings enormous challenges related to all urban functions. Prompt response is required. A broad range of water related problems occur. Water supply, sewerage, groundwater decline, storm water drainage and flooding are challenges that are faced. Climate change adaptation is required which offers opportunities to unlock its untouched potential in relation to residential, commercial and recreational functions in an integrated and sustainable way. Amenity values of the river have hardly been taken into account up to now and the concepts of living with water is yet to be introduced. A well-planned and integrated river front development is required to optimise to the full potential.



The actual port area of Yangon city covers most of the river front area of the CBD. It is expected that in the long run, these functions will be relocated to the Thilawa Special Economic Zone (SEZ) and the river front area of the CBD will gradually change from harbour to urban functions. This will provide ample opportunities to integrate this area in the urban functions. Myanmar Port Authority (MPA) is the responsible authority for the harbour and holds a key position in the transition process. Coordination is needed with many different stakeholders including the YCDC, the Yangon Heritage Trust, DWIR and project developers.

A coordinated, integrated urban development approach will improve the attractiveness and liveability of the CBD. A more appealing living environment attracts demand from residents and businesses alike for living and office space, and will catalyse associated services. It thus creates substantial added value through higher property prices and increased business activity. Different financial structures can lie at the basis of the investments required including public-private partnership arrangements.

A broad reconnaissance of a master plan is important to identify common grounds between the stakeholders. Innovative ideas are needed and stakes should become clear. A first reconnaissance supported by a 'third party' could result in the drawings of a shared vision.

This process will also support capacity building and knowledge exchange and provides ample opportunities for learning by doing.

11. Myanmar and its International Water Partners

Myanmar has been cooperating with many international partners on integrated water resources development, implementation and management. Since 2012 these contact have been revitalised and presently apart from cooperation with riparian states and long-term cooperation partners such as JICA and KOICA, old contacts with international financing agencies such as World Bank and Asian Development Bank as well as with many other countries worldwide have been revived. It is a challenge to align the cooperation opportunities with Myanmar policies to obtain optimum results. Doubling of efforts and interfering projects are to be avoided to prevent sub-optimal investments.

With respect to integrated water resources development, implementation and management the World Bank and the Netherlands' Embassy to Myanmar have taken the initiative, with the consent of the Government of Myanmar, to establish an informal Myanmar Water Partners Coordination Group. The group meets more or less on a quarterly basis and is co-chaired by the WB Mission Leader for the WB IWRM activities and the Netherlands Ambassador. Eventually this coordination may be taken over by the secretariat of the National Water Resources Committee.

As a result of the meetings and additional information a first list of ongoing involvement of financing agencies and countries (either direct or through their international development cooperation agencies) is prepared as a work in progress. It needs to be mentioned that the list is far from complete but is growing with more organisations and countries joining the informal information sharing on their activities in Integrated Water Resources Management.

The figures below give the status to date.

Figure 11-1 International donor activities in Myanmar, incomplete, growing and changing

Asian Development Bank
Irrigation Command Area
Flood and Drainage Management project in the Delta
Mandalay city urban service improvement (water supply)
Yangon Urban development (WASH)

World Bank
Ayeyarwady Integrated River Basin Management Project
- Water Resources Management institutions, Decision Support System & Capacity Building (CP-1),
- Hydromet observation and information system modernization (CP-2), and
- Navigation Enhancement on Ayeyarwady River (CP-3).

Korean International Cooperation Agency
Greening of dry zone
Delta Master Plan
Disaster Prevention, agriculture&rural development
Tuan Tay Canal Master Plan

Japanese International Cooperation Agency
Masterplan for urban development Yangon
Study expansion Thilawa Port
Masterplan improvement of water supply, sewerage and drainage system, Yangon
Rehabilitation of Baluchaung N02 Hydropower plant
Ayeyarwaddy Delta Integrated Mangrove Rehabilitation and management project
Small scale Aguaculture extension for Promoting of Livelihood and Rural communities
Rehabilitation of Yangon port and Main Inland Water Transport

Austria
Feasibility study for 'Inland Waterway Development'

Norway
Energy and Natural Resource management, environment/climate change
Inle Lake Conservation and Rehabilitation
Capacity building wetlands management, IWRM (incl. upgrading laboratories)
REDD+ Roadmap

Belgium
Hydropower study on Ayeyarwady River

UN Habitat
Lake Inle Conservation and Rehabilitation Project

EuropeAid

France /AFD
Water supply in Mandalay
Rehabilitation of pumped irrigation schemes in Magway region
Non Revenue Water Reduction in Yangon

NL AID
National IWRM Strategy Study
Data collection & Modelling
Capacity Building in Water Sector

Figure 11-2 Activities in the field of water resources management of international partners

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The above list of references is just a short reflection of all information being shared with the study team.
Much of this report is based on invaluable and direct contact between the team and Myanmar ministry officials and other authorities. In workshops, conferences, interviews, bilateral and multi-lateral meetings, information, knowledge and assessments have been exchanged, checked and verified. Presentations, data have been shared and exchanged. Sources have been mentioned at many places in the text.

Still, some of the data, figures are either not present, or cannot be reproduced by supporting documents. The study team trusts that sufficient references have been consulted to be in the capacity of making an appropriate assessment of the current situation with respect to the water resources of Myanmar. The team is responsible for the analysis and has found support from its Dutch expert team and the Myanmar counterparts in the various ministries and the Expert Group of the Myanmar National Water Resources Committee.

Appendix 1 Actions in NWP versus issues and planning periods

Item / Planning Period	Immediate	Short Term	Medium Term	Long Term
Operational Layer - Data and monitoring				
	1.3(vi): Water quality data, surface and groundwater, to be stored in NWRC data bank.	1.3(viii) NWRC address overlapping authorities on inequitable and unsustainable groundwater (over-) exploitation	7.1: System to evolve benchmarks for water uses for different purposes, i.e. water footprints and water auditing to be developed to promote incentivise efficient use of water. To be established at the national level.	14.1: Enter into international agreements with neighbouring countries on bilateral basis for exchange of hydrological data of international rivers on near real time basis.
	15.1: All hydrological data, other than those classified on national security consideration, should be made public domain.	11.4: Flood forecasting is very important for flood preparedness and should be expanded extensively all across the country and modernised using real time data acquisition system and linked to forecasting models with the aid of GIS remote sensing technologies.	6.3: Need to map aquifers to know total available quantity and quality of groundwater resources (replenishable / non-replenishable).	
	1.3(vii): Contamination and pollution water bodies and effluent discharge pinpointed and control by NWRC.	5.7: Present and future trends of hydrological and meteorological parameters under new climate change conditions can be investigated and appropriate adaptation strategies have to be implemented.	11.6: Frequency based flood inundation maps should be prepared to evolve coping strategies, including preparedness to supply safe water during and immediately after flood events.	
	13.5: Appropriate institutional arrangements for each river basin should be developed to collect and collate all data on regular basis with regard to rainfall, river flows, area irrigated by crops and by source, utilisations for various uses by both surface and ground water and to publish water accounts on the daily basis every year for each river basin with appropriate water budgets and water accounts based on the hydrologic balances. In addition, water budgeting and water accounting should be carried out for each aquifers.	7.7: Mechanism involving users for monitoring if water use pattern is causing problems: unacceptable depletion or building up groundwater levels, salinity, alkalinity, etc. This for planning appropriate interventions.	12.3: Urban domestic water systems need to collect and publish water accounts and water audit reports indicating leakages and pilferages	
	13.6: Appropriate institutional arrangements for each river basin should also be developed for monitoring water quality in both surface and ground waters.		12.4: Implementation of rainwater harvesting should include scientific monitoring of parameters like hydrogeology, groundwater contamination, growth of vectors, pollution and spring discharges.	
	15.1: National Water Informatics Centre (or National Hydro informatics Centre) should be established to collect, collate and process relevant hydrologic and water resources data regularly from various data sources such as DMH (Department of Meteorology and Hydrology), Irrigation Department, etc., conduct the preliminary processing, and maintain in open and transparent manner on a GIS platform.			
Institutional Layer - Operation and personnel				
	1.3(xviii): Need for trained people for scientific planning, utilising modern techniques for good water management and decision support systems.	1.3(xxi): Watershed and 'land and water' management to be promoted	8.2: A water regulatory authority (WRA) to be established; fix and regulate the water tariff system and charges according NWP.	8.4: Recycle and reuse of water after treatment to be incentivised through properly planned tariff system.
	9.5: Sources of water and water bodies not allowed to be polluted. Third party periodic inspection to be evolved and stringent punitive actions against polluters.	1.3(xix): Develop holistic and interdisciplinary approach (e.g. relation between urban development and environmental issues.		5.6: Upgrading existing reservoirs after rigorous studies to optimise water use for apprehending more irrigated land.
	4.5: Aggressive rainwater harvesting campaigns	16.4: A re-training and quality improvement programme for water planners and managers at all levels in Myanmar, both in private and public sectors, needs to be undertaken.	13.4: Integrated Water Resources Management (IWRM) taking river basin / sub-basin as a unit should be the main principle for planning, development and management of water resources. The departments / organisations at Union/ Regional or State Governments levels should be restructured and made multi-disciplinary accordingly.	
	6.5: Integrated watershed development activities to increase soil moisture, reduce sediment yield and increase overall land and water productivity. Existing traditional water collection techniques to harvest rain by farmers.	9.11: Notify relevant design flood magnitudes for drainage crossing structures to prevent from such kind of infrastructure damage.	1.3(xiv): Groundwater recharge zones to be addressed.	
	7.6: Use of very small local level irrigation through small bunds, field ponds, agricultural and engineering methods and practices for watershed management to be encouraged. Positive and negative effects to be kept in view.	2.1(ii): Water reservoirs should be located in every community for supplementary use.	11.7: To increase preparedness for sudden and unexpected flood related disasters, dam and/or embankment break studies, as also preparation and periodic updating of emergency action plans / disaster management plans should be evolved after involving affected communities. In hilly reaches, glacial lake outburst flood and landslide dam break floods studies with periodic monitoring along with instrumentation, etc., should be carried out.	

Item / Planning Period	Immediate	Short Term	Medium Term	Long Term
		7.5: Methods like aligning cropping pattern with natural resource endowments, micro irrigation (drip, sprinkler, etc.) automated irrigation operation, evaporation-transpiration reduction encouraged and incentivised.	11.5: Operating procedures for reservoirs should be evolved and implemented in such a manner to have flood cushion and to reduce trapping of sediment during flood season.	
		5.3: Better demand management through adoption of compatible agricultural strategies and cropping patterns and improved water application methods, such as land levelling and/or drip/sprinkler irrigation for enhanced efficiency.		
		9.5: Sources of water and water bodies not allowed to be polluted. Third party periodic inspection to be evolved and stringent punitive actions against polluters.	6.4: Where necessary artificial recharging projects should be undertaken to ensure that extraction is less than the recharge.	
		9.7: A suitable percentage of the costs of infrastructure development may be set aside along with collected water charges, for repair and maintenance. Contract for construction of projects should have inbuilt provision for longer periods of proper maintenance and handing over back the infrastructure in good condition.	11.3: In order to prevent loss of land eroded by the river, which causes permanent loss, revetments, spurs, embankments, etc., should be planned, executed, monitored and maintained on the basis of morphological studies.	
		9.8: Legally empowered dam safety services need to be ensured in the States and Regions as well as in Union level. Appropriate safety measures, including downstream flood management, for each Dam should be undertaken on top priority.	1.3(xix): Achieve low carbon urbanisation to not disturb and/or pollute fresh water resources, marine and land environment.	
Contextual Layer – Stakeholders and water users				
	11.6: Communities need to be involved in preparing an action plan for dealing with the flood/ drought/ cyclone situations.			
	5.4: Stakeholder participation in land-soil-water management.			
Rule of Law and Policies				
	1.3(vi): Drinking water standards enforced by NWRC through Government Agencies and remedial measures suggested.	1.3(ix): NWRC address national and international marine protection policy.	8.5: Water Users Associations (WUAs) given statutory powers to collect and retain a portion of water charges, manage volumetric quantum of water and maintain distribution system in their jurisdiction.	
	1.3(x): "Water Quality Standards" to be set by relevant Ministries. Both 'domestic and industrial' and 'economical use and their discharges'.	1.3(vi): Crop water standards enforced by NWRC through Government Agencies and remedial measures suggested.		
	1.2: Urgent need for clear communication and legal instruments for fair and peaceful sharing among regional and state governments with approval Union Government.	1.3(xxii): Specific policies should be introduced to protect loosing of valuable nation's land		
	9.12: Sea water and coastal water, with their related natural activities are part of national water resources and should be tackled by a specialist group of experts of NWRC including international dealing.	1.3(xix):Green building codes for all buildings.		
	11.7: To increase preparedness for sudden and unexpected flood related disasters, dam and/or embankment break studies, as also preparation and periodic updating of emergency action plans / disaster management plans should be evolved after involving affected communities. In hilly reaches, glacial lake outburst flood and landslide dam break floods studies with periodic monitoring along with instrumentation, etc., should be carried out.	10.8: Big infrastructure projects must establish "Ecosystem Compensation Fund", in addition to social compensations, to be used for ecosystem management, freshwater protected areas and flood control measures in the areas altered or impacted by the large scale projects.		
	7.2: Project appraisal and EIA for water use, particular industrial projects, including analysis of water footprints for the use.			

Appendix 2 Long List of measures

	Myanmar IWRM - Longlist projects				Triple bottom line				Scenarios		
					Economic viability						
	Project	Description	Urgency term short (< 1 yr) medium (1-3 yrs) long (> 3 yrs)	IWRM demonstration potential Low Medium High	Economic viability	Financial viability	environmental feasibility	socially acceptable	High industrial growth	Balanced green growth	Prolonged agriculture
	IWRM strategy study - QUICK WIN projects										
	Meiktila Lake IWRM	Artificial lake used for drinking water and irrigation with sedimentation and pollution issues and reduced water availability and water quality concerns. Rehabilitation / expansion of irrigation scheme (-20,000 acre)/ urban & rural development	Short term (< 1 yr)	High	✓	✗	✓	✓	✓	✓	✓
	Yangon Water Plan & River Front development	water plan to enable riverfront development + urban revitalization	Short (< 1 yr)	High	✓	✓	✓	✓	✓	✓	✓
	Mandalay groundwater assessment	Assessment of ground water availability & extraction to arrive at a sustainable water plan	Short (< 1 yr)	High	✓	✗	✓	✓	✓	✓	✓
	Pan Hlaing River dredging & review of Paddy Land Reclamation	Dredging sedimented river, restoration of irrigation and drainage in view of new potential developments in existing agricultural area near Yangon City. Review of old WB programme; evaluate lessons learned Paddy polder 1, 2 and improved delta development	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Sittaung-Bago Canal Integrated Water System Analysis	Integrating governance and capacity building for IWRM in the Bago region	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Feasibility Study Mandalay – Bagan navigability improvement	Feasibility Study Mandalay – Bagan navigability using physical river training measures and modern navigation technologies, pilot for WB study Ayeyarwadi Master Plan	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Bagan Multi Purpose Pilot River Beautification Project (river training works Ayeyarwady river)	River training works to improve navigatability,mini hydropower, irrigation, water supply and flood & erosion control.	Short (< 1 yr)	High	✓	✓	?	✓	✓	✓	✓
	Overall Measures										
	Provision of clean drinking water:										
	Rural drinking water		Short (< 1 yr)	Medium	✓	✗	✓	✓	✓	✓	✓
	Urban water supply	see Urban section	Short (< 1 yr)	Medium	✓	?	✓	✓	✓	✓	✓
	Integrated river improvement:										
	River transport development Ayeyarwady and Chindwin River (training works + dredging)	River training works + dredging	Medium (1-3 yrs)	Medium	✓	?	?	✓	✓	?	?
	Feasibility study for Inland Waterway Development	Austria	Short (< 1 yr)	Medium	✓	?	✓	✓	✓	✓	?
	Navigation Enhancement on Ayeyarwady River (CP-3)	WB programe CP-3 / Based on Haskoning report 1988	Medium (1-3 yrs)	Medium	✓	?	✓	✓	✓	?	?
	River training works	WB programe / Emergency measures / existing bottlenecks	Medium (1-3 yrs)	Medium	✓	?	?	✓	✓	?	?
	Hydropower study on Ayeyarwady	Belgium	Medium (1-3 yrs)	Low	?	✓	?	✗	✓	✗	✗
	Data and information management and monitoring:										
	Hydromet crash programme	water level + sediment transport + water quality	Short (< 1 yr)	Low	✓	✗	✓	✓	✓	✓	?
	Water quality monitoring system surface water	MOH has water quality lab(s) but is not used for surface water	Short (< 1 yr)	Low	✓	✗	✓	✓	✓	✓	✓
	Point source pollution monitoring + enforcement	Combination of water quality monitoring at pollution hot spots (i.a. mine tailings) + enforcement existing environmental regulations / permits	Short (< 1 yr)	Low	✓	?	✓	✓	✓	✓	✗
	Mine tailings - Point source pollution monitoring	Resolve existing pollution sources	Short (< 1 yr)	Low	✓	?	✓	✓	✓	✓	✗
	Development of National Watershed data set	MOCAF proposed to Norway (source watershed presentation)	Short (< 1 yr)	Low	✓	✗	✓	✓	?	✓	?
	Hydromet observation and information system modernization (CP-2)	WB program CP-2	Short (< 1 yr)	Low	✓	✗	✓	✓	?	✓	✓
	Capacity development for water resources management		Short (< 1 yr)	Low	✓	✗	✓	✓	✓	✓	✓
	Water resources Management Institutions, decision Support System & Capacity Building (CP-1)	WB program CP-1	Short (< 1 yr)	Medium	✓	✗	✓	✓	✓	✓	?
	Mountains										
	Integrated Watershed Management:										
	Integrated watershed management	copy WB approach in other countries / similar conditions	Short (< 1 yr)	High	✓	✗	✓	✓	?	✓	?
	Reforestation:										
	Establishing forest plantation to supply fuelwood and to control sedimentation	Mocaf proposed to Norway (source watershed presentation)	Short (< 1 yr)	High	✓	✗	✓	✓	✓	✓	✓
	Integrated Lake Water Resources Development:										
	IWRM Inle Lake (upstream watershed, biological fertilizer, cultural heritage protection / tourism potential, hydropower downstream, improve existing WUAs)	Floating gardens (pesticides) + increased sedimentation + lower water level -> impact on tourism development + agriculture. Also issue with sewage discharge / septic tanks->groundwater pollution->lake water quality deterioration	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Lake Inle Conservation and Rehabilitation project	Norway/Un Habitat	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Inya & Kandawygi lake IWRM	restore water quality in both lakes + pollution prevention measures	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Blue energy development:										
	Multipurpose dam (hydro+flood protection+irrigation) in tributary of Chindwin / Tanlwin River	Water resources development targeting irrigation, flood protection, drinking water and hydropower generation	Medium (1-3 yrs)	High	✓	✓	?	?	✓	✓	✓
	Rehabilitation existing hydropower plants & improved reservoir management	Discussed with IFC: overhaul / replace E&M equipment; mitigate sedimentation reservoir fill-up using innovative techniques; improve O&M and reservoir operations aiming at improved flood management	Short (< 1 yr)	Low	✓	✓	✓	?	✓	✓	?
	Revision of reservoir operation rules	for flood protection downstream of hydropower plants	Short (< 1 yr)	Low	✓	✓	✓	✓	✓	✓	✓
	Rehabilitation of Baluchaung NO 2 hydropowerplant	JICA	Short (< 1 yr)	Low	✓	✓	✓	?	✓	✓	✗

	Myanmar IWRM - Longlist projects				Triple bottom line				Scenarios		
					Economic viability						
	Project	Description	Urgency term short (< 1 yr) medium (1-3 yrs) long (> 3 yrs)	IWRM demonstration potential Low Medium High	Economic viability	Financial viability	environmental feasibility	socially acceptable	High industrial growth	Balanced green growth	Prolonged agriculture
	Central dry zone										
	Economic development:										
	Inland water port development (special) economic zones Mandalay		Medium (1-3 yrs)	Low	✓	✓	?	✓	✓	✓	✗
	Water & food security:										
	Rehabilitation irrigation systems	Expand with drainage + verify power availability (24/7) for electrical pumped schemes	Short (< 1 yr)	Low	✓	?	✓	✓	?	✓	✓
ADB	Central dry zone irrigation command Area development project	ADB; PPTA announced	Short (< 1 yr)	Medium	✓	?	✓	✓	✗	✓	✓
	Rehabiliattion of pumped irrigation schemes in Magway	France/AFD	Short (< 1 yr)	Medium	✓	?	✓	✓	?	✓	✓
KOICA	Greening of Dry zone	KOICA	Medium (1-3 yrs)	High	✓	?	✓	✓	✗	✓	✓
JICA	Small scale aquaculture extension for promoting of Livelihood and Rural communities	JICA	Medium (1-3 yrs)	High	✓	?	✓	✓	?	✓	✓
	Coastal Zone										
JICA	Study Expansion Thilawa Port	JICA	Medium (1-3 yrs)	Low	✓	✓	?	✓	✓	?	?
	Flanking measures for SEZ development / regional development		Medium (1-3 yrs)	High	✓	?	✓	✓	✓	?	✗
	Coastal aquaculture:										
	Magrove restoration project, communited based		Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	sustainable coastal zone management	Lighthouse - foundations, ArcCona Ecological Consultants,	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	developing a coastal network of Protected areas	Lighthouse - foundations, ArcCona Ecological Consultants,	Medium (1-3 yrs)	High	✓	?	✓	✓	✓	✓	✓
	Coastal forest rehabilitation and management	FAO	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	Coastal zone protection & sustainable tourism in coastal zone	Only 1 government owned luxury resort in the southern coastal zone	Short (< 1 yr)	High	✓	?	✓	✓	✓	✓	✓
	improvement hinterland connections	further development of transport corridors Dawee - Thailand and Sittwe - Mandalay - China	Short (< 1 yr)	High	✓	✓	?	✓	✓	?	✓
	Coastal Tourism development	ADB Myanmar Tourism Master Plan Coastal initiatives	Medium (1-3 yrs)	High	✓	?	✓	✓	?	✓	?
	Delta										
	Delta and Coastal Zone Improvement:										
KOICA	Delta Master Plan	KOICA (cancelled?)	Short (< 1 yr)	High	✓	✗	✓	✓	?	✓	✓
	Shrimp farming in delta	Resolve existing conflicts re. commercial shrimp farming inhibiting on local villagers	Short (< 1 yr)	High	✓	✓	?	?	?	?	✓
ADB	Flood and Drainage Management project in the Delta	ADB; PPTA announced	Short (< 1 yr)	High	✓	✗	✓	✓	✗	✓	✓
KOICA	Disaster Prevention, agriculture&rural development	KOICA	Short (< 1 yr)	Medium	✓	✗	✓	✓	?	✓	✓
JICA	Ayeyarwaddy Delta Integrated mangrove Rehabilitation and management project	JICA	Medium (1-3 yrs)	High	✓	?	✓	✓	?	✓	✓
JICA	Small scale aquaculture extension for promoting of Livelihood and Rural communities	JICA	Medium (1-3 yrs)	High	✓	?	✓	✓	?	✓	✓
	Water Infrastructure										
	Port development in Yangon river delta		Medium (1-3 yrs)	Low	✓	✓	?	✓	✓	?	✗
JICA	Rehabilitation of Yangon port and Main Inland Water Transport	JICA	Medium (1-3 yrs)	Low	✓	✓	?	✓	✓	?	✗
KOICA	Ytuun Tay Canal Masterplan	KOICA	Medium (1-3 yrs)	Low	✓	✓	?	✓	✓	?	✗
	Urban area										
	Provision of clean drinking water										
ADB	Mandalay City Urban service improvement (water supply)	ADB; ongoing	Short (< 1 yr)	Medium	✓	?	✓	✓	✓	✓	✓
ADB	Yangon Urban development (WASH)	ADB; ongoing	Short (< 1 yr)	Medium	✓	?	✓	✓	✓	✓	?
JICA	Masterplan for urban development Yangon	JICA	Short (< 1 yr)	Medium	✓	✓	?	✓	✓	?	?
JICA	Masterplan improvement of water supply, sewarage and drainage system, Yangon	JICA	Short (< 1 yr)	Medium	✓	?	✓	✓	✓	✓	✓
	NRW reduction Yangon	IFC targeted PPP transaction	Short (< 1 yr)	Medium	✓	✓	✓	✓	✓	✓	✓
	Water Resources Impact Assessment for urban and industrial developments										
ADB	Flanking measures for SEZ development / regional development	sustainable regional development	Medium (1-3 yrs)	High	✓	?	✓	✓	✓	✓	✗
ADB	Urban drainage measures	ADB (Peter Kerssens); formulation going on	Short (< 1 yr)	High	✓	✗	✓	✓	✓	✓	✓
	Water supply Mandalay	France/AFD	Short (< 1 yr)	Medium	✓	?	✓	✓	✓	✓	✓
	Non-revenue water reduction in Yangon	France/AFD	Short (< 1 yr)	Medium	✓	✓	✓	✓	✓	✓	✓

Appendix 3 Understanding the Nexus[14]

A nexus approach can enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance across sectors.

A challenge to the task of safeguarding resources is *rapidly increasing demand* for them. Population growth, an expanding middle class with changing lifestyles and diets, and the urgent need to improve water, energy and food security for the poorest all place growing pressure on limited resources.

Climate change is also likely to aggravate pressure on resources and so add to the vulnerability of people and ecosystems, particularly in water scarce and marginal regions. A nexus approach is needed to help climate mitigation measures (e.g. REDD+[2] or CCS[3]) be more 'water smart', adaptation measures (e.g. irrigation) to be less energy intensive, and to avoid damaging consequences for food production and other vital ecosystem services.

A3.1 The water – energy – food security – nexus

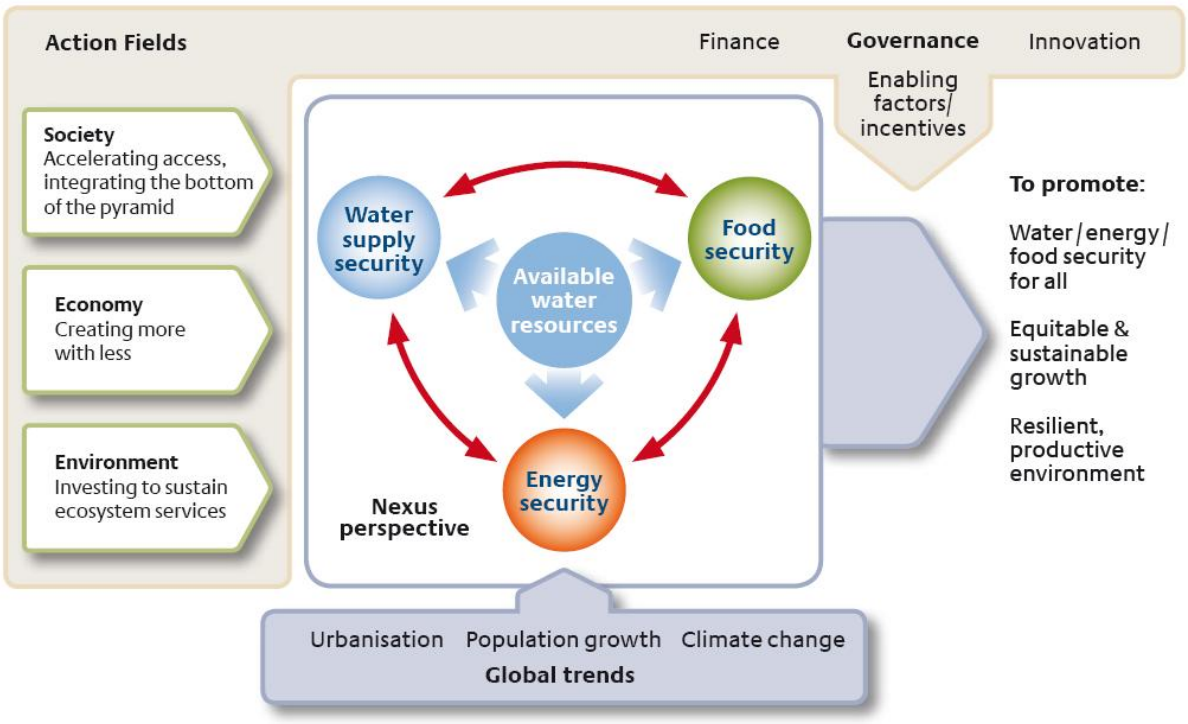


Figure A 1 The water-food-energy nexus *[source Bonn 2011 Nexus Conference, SEI]*

Productivity and the availability of water, energy and land vary enormously between regions and production systems. There is a large potential to increase overall resource use efficiency and benefits in production and consumption, e.g. by addressing intensive agriculture (which often has higher water productivity but lower energy productivity than other forms of agriculture) or water- and energy-intensive meat products. The nexus approach can boost this

[14] ref. Background paper for the Bonn 2011 Nexus Conference Water Food Energy Nexus, SEI November 2011

potential by addressing externalities across sectors. For example, nexus thinking would address the energy intensity of desalination (also termed 'bottled electricity'), or water demands in renewable energy production (e.g. biofuels and some hydropower schemes) or water demands of afforestation for carbon storage. Also, action to avoid or land degradation saves water and energy, for example by increasing soil water storage and groundwater recharge, as well as reducing the use of energy-intensive fertiliser.

Water, which has only very recently received attention in the Green Economy debate, is an essential input for all biomass growth and hence for all ecosystem services and associated jobs and livelihoods. Improved water resources and intact ecosystems ('natural infrastructure') can mutually reinforce each other and generate additional benefits.

A3.2 Opportunities to improve water, energy and food security

A nexus approach can support a transition to sustainability, by reducing trade-offs and generating additional benefits that outweigh the transaction costs associated with stronger integration across sectors. Such gains should appeal to national interest and encourage governments, the private sector and civil society to engage. A number of opportunities emerge from the evidence presented in this paper. These include the following.

Increased productivity of resources

Sustainable and inclusive intensification, and decoupling of economic development from resource use - both fundamental to a Green Economy - can be achieved through technological innovation, recycling (e.g. productive sanitation)[15] and reducing wastage. The nexus focus is on system efficiency, rather than on the productivity of isolated sectors.

Waste as a resource in multi-use systems

Cross-sectoral management can boost overall resource use efficiency. In multi-use systems in particular, waste and by-products can be turned into a resource for other products and services, e.g. in green agriculture,[16] wastewater-energy integration or multi-use reservoirs.

Stimulating development through economic incentives

Innovation to improve resource use efficiency requires investment and reductions in economic distortions. Economic instruments for stimulating investment include, e.g., pricing of resources and ecosystem services, water markets and tradeable rights, and payments for ecosystem services. A nexus approach can also help to avoid 'sunk costs', i.e. investments that lock development into non-sustainable pathways.

Governance, institutions and policy coherence

Regulation and collective action can help to guide investments and innovation to minimise negative externalities and share benefits equitably. Enabling conditions for horizontal and

[15] Productive sanitation systems safely recycle excreta, other organic waste products and water to crop and other biomass production, in order to increase overall resource use efficiency.

[16] A green agriculture or 'greening of agriculture' aims at simultaneously increasing farm productivity and profitability, reducing negative externalities, and rebuilding ecological resources through practices from conservation agriculture, such as minimum tillage, biological pest control and soil fertility enhancement, crop rotation and livestock-crop integration (UNEP 2011b).

vertical policy coherence include institutional capacity building, political will, change agents and awareness-raising. Additional opportunities can be realised if the nexus is addressed coherently across all scales through multi-level governance.

Benefiting from productive ecosystems

Improved ecosystem management and investment in natural capital can provide multiple ecosystem services and increase overall benefits. Natural infrastructure can complement human-made 'hard' infrastructure to a greater extent, and can even deliver some services more efficiently. Green agriculture or a shift towards integrated 'agro-ecosystems' and landscape management can provide additional benefits, such as carbon sequestration and resilience to climate risks, while improving food security.

Integrated poverty alleviation and green growth

Sustainable use of resources strengthens a wide range of ecosystem services and maintains the human 'life support system', on which the poorest depend most directly. Provision of clean water and energy would immediately improve the health and productivity of the 'bottom billion'. Green agriculture can generate more rural jobs and increase diversity and resilience of production systems.

Capacity building and awareness raising

Capacity building and social learning can help to deal with the increasing complexity of cross-sectoral approaches, and also to level the playing field among the nexus sectors and actors. Awareness raising (and supporting governance) can promote sustainable lifestyles and consumption patterns. New and targeted trans-disciplinary nexus research, fully integrated assessments of water, energy and food at all scales, and Green Economy metrics and indicators will enable quantitative trade-off analyses.

Towards a Green Economy

The concept of a 'Green Economy' is yet to be clearly defined. According to UNEP,[7] a Green Economy is an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Its carbon output and pollution is low, and its resource use efficiency is high. In a Green Economy natural capital is valued as a critical economic asset and as a provider of benefits for the poor. The Green Economy approach 'seeks, in principle, to unite under a single banner the entire suite of economic policies (...) of relevance to sustainable development'.[8] Hence the Green Economy itself is the nexus approach par excellence. To succeed, a Green Economy must go beyond sectoral solutions and actively address the water, energy and food security nexus, in-line with human rights-based approaches. However, there are still large gaps in knowledge on interactions, feedbacks and adaptation options across the nexus.

Appendix 4 The physical situation of Myanmar's water resources

A4.1 Current status of water resources

The purpose of this appendix is to give a more concise overview and description of the physical setting of Myanmar's water (and land) resources. It is based on the first findings from documentation and information received during visits with government officials and various experts and during workshops with stakeholders as well as from reading of background information.

With respect to the description of the physical setting a number of references is available [2], [3], [4], [5].

Figure A 2 Physical setting of Myanmar's water resources

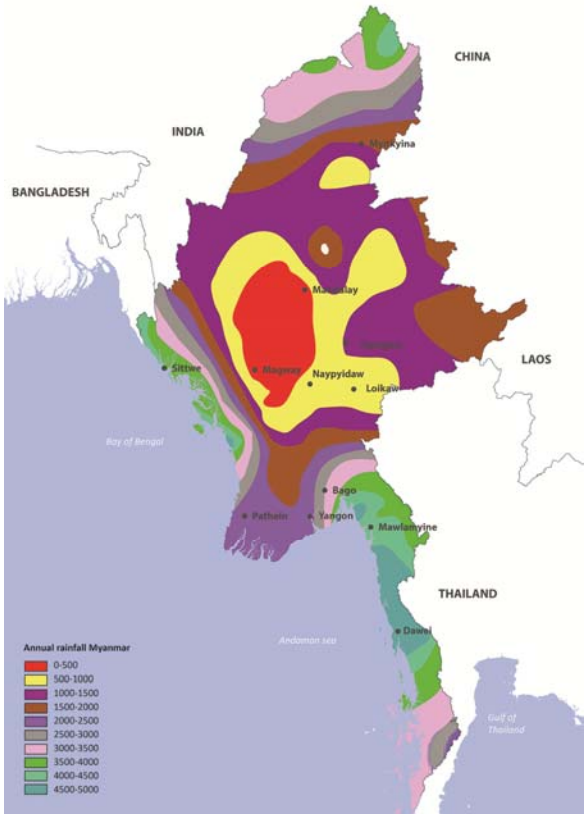


Figure A 3 Annual Rainfall in Myanmar, *source MoT, DMH*

A4.1.1 Mountainous area

Physical setting

The high mountains are located in the Northern part of Kachin State, Chin State and the Sagaing Region and form the link with the Himalayan mountain ranges of China and India. The mountains and hills in Shan State in the East are bordering China, Laos and Thailand. Hilly areas are found throughout the country and particular in the South East bordering Thailand. See also the topographic map of Myanmar on page 9. The mountains and hills take

up the larger part of the Myanmar territory. With most of the rainfall falling in the mountainous area, they constitute the largest water resource in the country.

Deforestation

Over the years heavy deforestation has taken place in various parts which, due to the steep slopes and heavy rainfall, has led to serious erosion of the mountain slopes. On page 146 Figure A 4 this is clearly visible. It also shows however that the main part is still covered with intact forest. This is contrary to the mountainous area across the border in China.

Instead of the water being absorbed by the thick forests and forest soils and subsequently fed to the groundwater, the result has been that rainwater runoff has become more direct whilst taking along large amounts of sediment from the mountain slopes. The increase in the rainfall-runoff relation has resulted in higher floods with shorter duration and increase in sedimentation in the lower reaches of rivers. This again a.o. has already shown negative effects on the operational life of hydropower and irrigation supply reservoirs (rapid increase of dead storage), flood safety, navigability of the rivers and bio-diversity.

From an IWRM point of view, land and water conservation in the mountains and hills is to be considered core to Myanmar's water resources management.

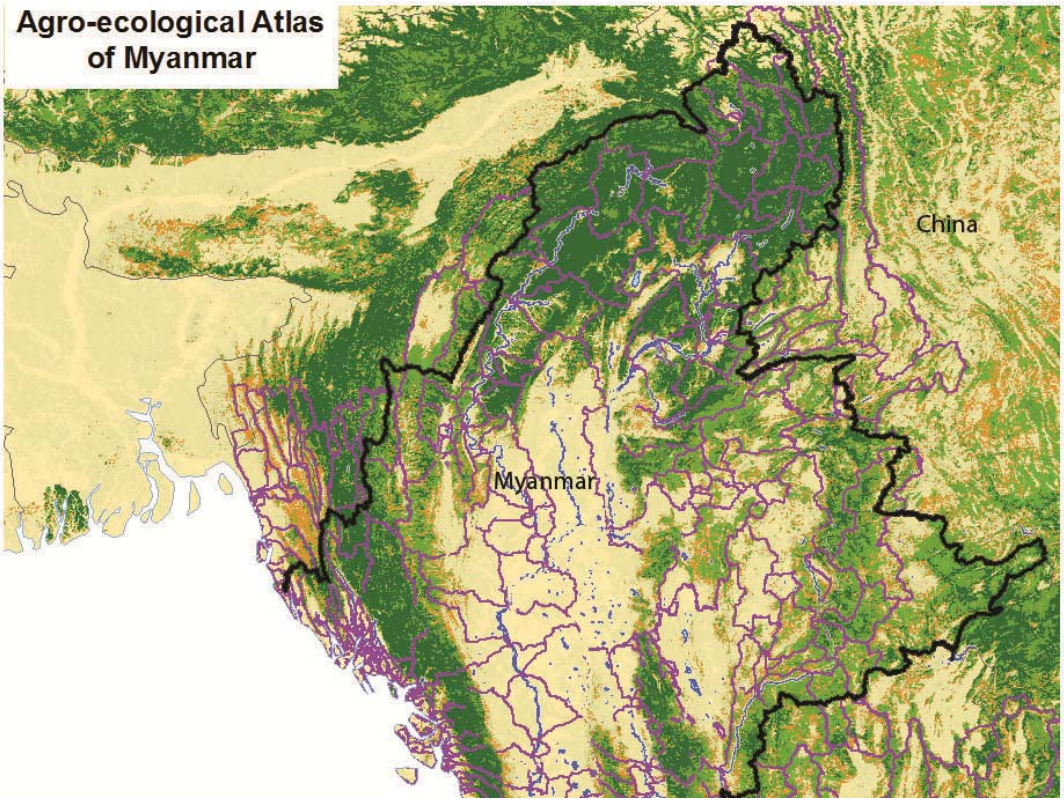


Figure A 4 Agro-ecological Atlas of Myanmar *[source Earl Saxon, Forest Inform]*

Impact of hydropower and mining

Most of the larger hydropower dams are located in the mountain area near the Chinese borders and a good number are planned to be built in the future.

Also mining is prominent in these regions. Myanmar has vast reserves of oil and gas (both onshore and offshore) and minerals and metals, including gold, tungsten, copper, nickel, tin, lithium and precious stones.

Both, the hydro power projects as well as the mining projects, show negative effects on water resources and ecology both from a quantitative and qualitative point of view.

Some major natural lakes are also located in the mountains and hilly areas. Apart from being major fresh water bodies the lakes often have also a great value as cultural heritage sites. Best known is Inle Lake but also Indawgyi Lake in Kachin should be mentioned. Reportedly degradation of water quality and quantity of the lakes has started demanding measures on IWRM to mitigate the negative impacts of development. Inle Lake suffers siltation and pollution from pesticides and fertilisers. Indawgyi Lake is being polluted due to gold mining operations.

Other issues in the mountain area

Commercial wood cutting, single purpose hydropower production, slash and burn agriculture are presently ongoing practices in the mountainous areas. They are taking place with virtually no measures to mitigate the obvious negative effects. As indicated above land and water conservation is to be central in IWRM for the mountainous areas. Measures related to integrated watershed management including improved forest management through measures on good governance (enforcing forestry law), reforestation, rural water supply, improved agricultural and livestock husbandry, etc. can be identified.

Watershed management falls under the responsibility of the Watershed Management Division of MOECAF. This division is undertaking planning and implementation of watershed management with the objective to systematically conserve watersheds in Myanmar. Political and financial support seems required. Good watershed management is core to integrated water resources management.

The following measures are applicable:

- **Good governance** in forest management.
- **Planned reforestation** will be required to stop erosion of the mountain slopes. With continued erosion taking place, reintroducing vegetation cover will eventually become impossible and thus create bare mountains with neither any ecological nor economic value. Forestry is the responsibility of the Ministry of Environmental Conservation and Forestry (MOECAF).
- **Watershed management** in which both the environment and improvements of the farmer's livelihoods in poor and highly degraded watersheds are addressed is to be considered. This can be done through promoting an integrated and replicable model of sustainable rural development of which minority groups in the mountain may be the first beneficiaries.

  Activities may focus on alternative livelihood and watershed protection. Interventions can comprise orchards and livestock, improving living condition by water supply and renewable energy, improving farmlands by terracing and reducing erosion and run-off by soil retention structures and reforestation and/or afforestation to increase vegetation cover. The WB and ADB have extensive experience in large scale projects of similar nature in adjacent countries.

- **Eco-compensation** schemes may need to be set up where (downstream) water quality needs to be preserved for e.g. tourism or water supply of major urban areas (similar to protected water recharge areas). This may be required for preserving tourist locations such as Inle Lake. Eco-compensation not only shares characteristics with payments for ecological services, but also encompasses fiscal transfer schemes between regions to improve the apportioning of funding for and clarify responsibilities and tasks on environmental management, especially on watershed ecological services.
- **Revision of Reservoir Operational Rules** of hydropower and irrigation schemes towards multi-purpose use. This to balance between optimums for hydropower generation, irrigation and drinking water supply, maintaining environmental flows in the rivers for ecological conservation and restoration and requirements for sufficient draft for ships in river channels for inland water transport.
- **Environmental protection of mining sites** and mitigation of pollution of river beds to bring the quality of river water within proper environmental flow conditions and avoid complex and expensive river water treatment for rural and urban drinking water supply. A prerequisite is proper environmental laws and an efficient enforcing mechanism.
- **Planning for sustainable (small) hydropower schemes**. E.g. in sub-catchments Chindwin River and Thanlwin River. It is noted that the Government of Myanmar is promoting small scale hydro power. (in Myanmar referred to as "micro hydropower"). As a matter of fact Myanmar has tried to promote the latter earlier, however, it has not been taken forward due to limited knowledge and difficult access to new technologies.

A4.1.2 Central Dry Zone

Physical setting

The Central Dry Zone (CDZ) region, straddling large parts of Mandalay, Magway and lower Sagaing divisions, is one of the most food insecure, water-stressed, climate sensitive and natural resource poor regions in Myanmar. The CDZ region has the second highest population density in Myanmar but remains one of the least developed.

Access and availability of water resources are key determinants of rural poverty with livelihoods largely dependent on the southwest monsoon.
Principal crops in the CDZ consist of oil seeds and legumes, chillies, and vegetables grown as rain fed, upland crops during the wet season. Rice cultivation depends on irrigation, even during the monsoon season. Seasonal water shortages caused by low and erratic annual rainfall patterns and sandy and fragile soils that are at high risk of water and wind erosion limit paddy rice cultivation, render rain fed agriculture a high risk endeavour, and contribute to low agricultural production.
Under such uncertain climatic and rainfall conditions, the provision of functional canal irrigation systems is critical to safeguarding crops (source ADB 2013).

Irrigated Agriculture

Irrigated agriculture in Myanmar consists mainly of basin irrigation schemes with water supply from:
(1) Flash floods - spate irrigation (t.b.i)
(2) Multi-purpose dams

(3) Irrigation reservoirs and ponds
(4) Pumping from lakes, rivers and groundwater
(5) Tidal river water supply
(6) Rain fed

Already since centuries irrigation schemes were developed in Myanmar. Over the last decades the area was increased by building reservoirs which receive water from local rivers and streams. In addition to the reservoir also the primary and secondary irrigation system has been put in place. In the CDZ irrigated paddy is cultivated mainly in the Mandalay, Sagaing and Magway regions.

Some of the areas with basin irrigation suffer from salinity problems. The reason seems twofold. One is the geology of the region in which fragile saline soil types are encountered. The other one and possibly aggravating the natural soil conditions is the poor or complete lack of a drainage system starting from field to main drains. (Extent and severity further to be investigated)
In addition to the reservoir fed schemes also pumped schemes have and are still being constructed. Some of them pump water from the Ayeyarwady River (e.g. irrigation scheme next to Old Bagan). Reportedly the electric pump schemes suffer from irregular availability of the power supply. Another problem is the morphological dynamics of the rivers, causing pumps to fall dry (To be further investigated).

New irrigation schemes generally include only the reservoir and/or pump infrastructure plus the feeder canals till field level. The farmers are responsible for the field ditches. No provision is made for the drainage system which normally is to be regarded as an integral part of a proper irrigation scheme.
In some of the dry parts wadis exist where spate irrigation is practiced (to be further investigated).

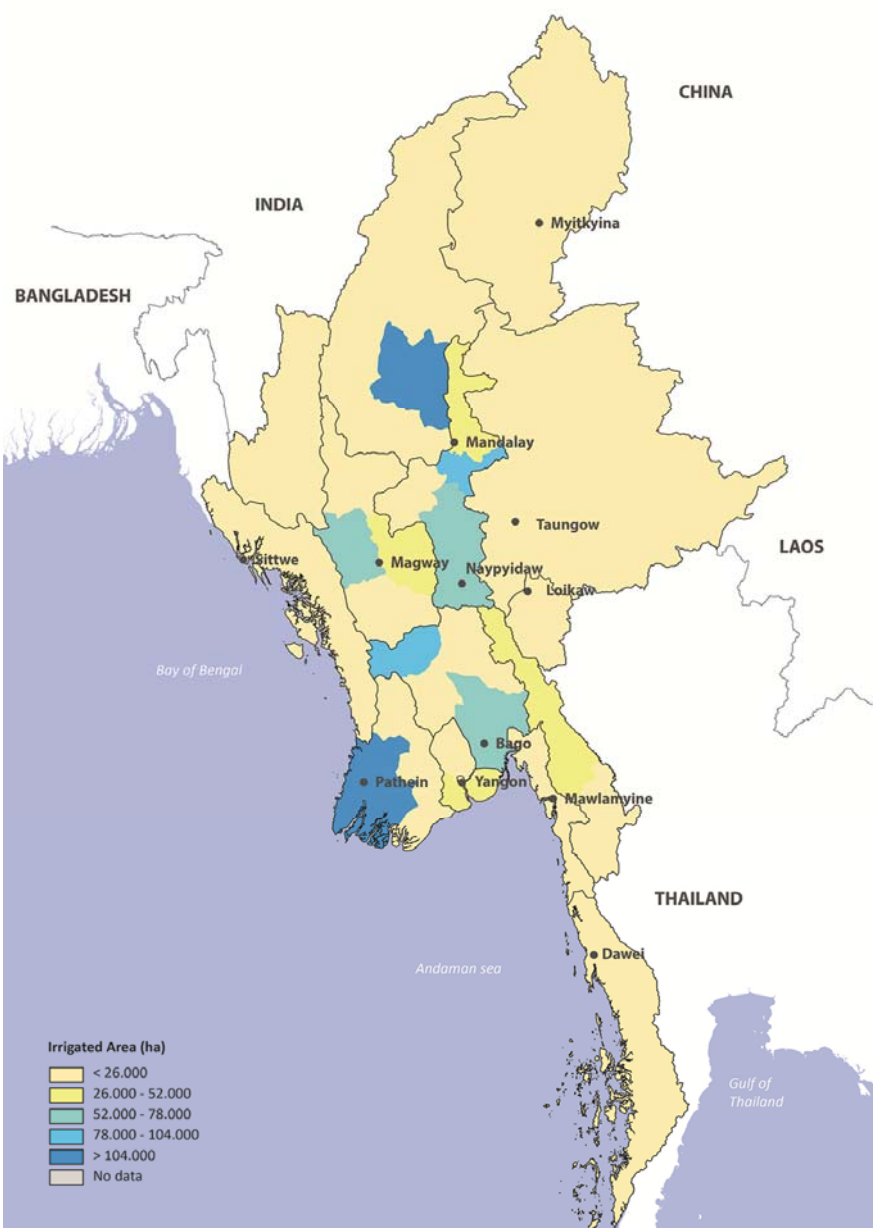


Figure A 5 Irrigation and water resources

Urban and Industrial Development

The dry zone also sees an intense urbanisation in the area of the new capital Nay Pyi Taw (NPT) and more particularly around the city of Mandalay. Mandalay located at the cross roads of the Asian Highway connecting China, Thailand, India and the world through the deep sea harbour of Sittwe, aims to become an important logistical and industrial hub. As an example, apart from existing industrial zones, it has the ambitious Mandalay Myotha Industrial Development ongoing. Both urban and industrial developments will increasingly draw on the available local water resources, groundwater and surface water, and will pose particular concern on water quality aspects. Currently there are 18 Industrial Zones and 7 new planned Industrial Zones and strategically located within the entire transportation system.

Issues in the dry zone

From the IWRM perspective also in the CDZ land and water conservation is to be the main focus.

- **Land and water conservation of vulnerable soils**. Improved agricultural practices to avoid soil erosion from water and wind.
- **Rehabilitation of irrigation and strengthening WUA's and WUG's** Irrigation Command Area Management with extension to watershed management in the upstream catchment from irrigation reservoirs and ponds. ADB has initiated the formulation of such projects.
- **Drainage system improvement** dry zone irrigation schemes. Construction of drainage schemes from field drainage to main drainage. The aim is to improve leaching conditions of irrigated areas to mitigate negative effects of salinisation.
- **Flanking integrated planning to industrial and urban zones development**. Urban and industrial planning tends to focus on economic and demographic aspects only. Integrated planning with concern for the environment is given little attention though (obligatory?) superficial ESIAs are prepared. Examples at Dawei and Myotha development near Mandalay show that in particular water management aspects, both quantitatively and qualitatively, initially only focus on immediate need and the best economic solutions for the areas themselves. This leaves a high risk for the surrounding area and sometimes region. This was however recognised at Dawei where a water supply scheme was stopped and redesigned to be more sustainable for the region as a whole. Proper integrated regional and urban planning, including planning for IWRM, and implementation should accompany each of such developments which in itself are generally positive for development when planned and implemented taking all other aspects into account as well.

A4.1.3 Ayeyarwady Delta

Delta Alliance has made an evaluation of the Ayeyarwady Delta in an assignment of Global Water Partnership (2013) The summary of their findings has been copied to this report as it reflects the best view on the delta within for the integrated water resources management strategy for Myanmar at this moment.

Potential and vulnerability of the Ayeyarwady Delta

The Ayeyarwady Delta will inevitably factor significantly into Myanmar's economic development and emergence as a major regional trade route. At present, however, the Ayeyarwady Delta is still largely undeveloped and the uncoordinated exploitation of its

resources in some (upstream) areas may pose serious threats to the health of the delta. Thus one of the country's major challenges will be to develop effective, cross-sector management of this system in order to ensure that its development will be sustainable and that decisions made now will not bring later regret, as can be seen in deltas elsewhere.

Delta ecosystems like the Ayeyarwady Delta have a substantial adaptive and resilient capacity. In contrast to e.g. inland forests, which require decades to centuries to reach a climax succession stage, delta ecosystems, such as mangroves and marshes develop fairly quickly into rich habitats once the environmental conditions are favourable again. Worldwide successful examples show the importance of good knowledge of the basic physical and ecological processes, early involvement of local stakeholders leading to a participatory planning process and an integrated and sustainable approach to manage and develop the delta to cope with the new economic situation in Myanmar.

At present the Ayeyarwady Delta already demonstrates the first signs of significant changes (exploitation of the mangroves, overfishing, river bank erosion and deterioration of water quality). However, using the ecosystem approach, deltas can be used by the local people without compromising the integrity of these systems or overexploiting their natural resource. This approach is also advocated by the Convention on Biological Diversity (Wildlife Conservation Society, 2013) and denotes a strategy for the integrated management of land, water and living resources. The strategy promotes conservation and sustainable use in an equitable way. At the same time it is stressed that additional measures should be adopted like improving conservation awareness, fighting poverty, improving the weak systematic biological monitoring systems, stimulate grassroots support for conservation and strengthen law enforcement.

Ensuring the integrity of the linkages between delta and the river usually requires upstream measures. Although the highly dynamic estuarine ecosystems and their species are adapted to seasonal changes in freshwater flows, upstream activities that permanently change the total flow (such as dams, deforestation, climate change) may have significant consequences.

Pressures in occupation layer

Pressure on space. With some 230 inhabitants/km^2 the delta is one of the most densely populated regions in Myanmar.

Vulnerability to flood. Most of the delta is still active with unstable river branches and the delta is prone to tropical cyclones with high storm surges. Floods are a permanent threat.

Freshwater shortage. Due to upstream developments, climate change and sea level rise, critical low flow conditions of the Ayeyarwady River tributaries are likely to increase. Increase of salinity intrusion in the coastal areas is making existing water supply sources (domestic and agricultural) and freshwater ecosystem vulnerable.

Pressures in network layer

Ageing infrastructure. Management of embankments and irrigation systems is a recurrent problem. Infrastructure to support transportation, water supply, communications, and power supply is rather poorly developed.

Summary of pressures in base layer

Coastal erosion. Riverbank and coastal erosion is one of the major issues.

Loss of biodiversity. Especially the mangrove forests are highly valuable but also under high pressure from encroachment and exploitation. It is also vulnerable to accelerated climate change and sea level rise.

Salinity intrusion. Salinity and its seasonal intrusion gradients are dominant factors for coastal system, fisheries and agriculture. Therefore, any changes on present spatial and temporal variation of salinity will affect the biophysical system of coastal area.

Cyclonic storm surge. Due to its geophysical setting the Ayeyarwady Delta is visited by cyclone-induced storm surges and incidentally these cyclones have devastated the coastal area (1974 and 2008). Nargis (2008) resulted in 84,537 casualties and 53,836 people missing.

Summary of governance issues

Cooperation between (scale) levels and sectors of government. Efforts are underway to improve core governance systems and to improve sectoral governance.

Cooperation between government and private sector. The privatisation of public sector industries need to be further developed.

Involvement of stakeholders and citizens. Stakeholder consultation at planning and implementation phase of a project in different parts of the country needs to be further encouraged.

Approaches for dealing with risks and uncertainties. To reduce loss of lives and property, Myanmar needs to focus on the development of flood forecasting and warning systems. Coastal area has already been practiced the early warning system for cyclonic storm surge and got the benefit.

A4.1.4 Main rivers of Myanmar

An overview of the main river basins is given in Table A 1 and Figure A 6. Myanmar's major river system consists of the Ayeyarwady River, the Chindwin River, the Sittoung River and the Thanlwin River. The headwaters of the Ayeyarwady River are located in the high mountains of Kachin State. The Chindwin River has its upper catchment in the Sagaing Region and Chin State. The third major river of Myanmar, the Thanlwin, originates from the mountains in Shan State and China. All the rivers debouch in in the Andaman Sea. The Mekong River, which forms for a short stretch the border between Myanmar and Laos to continue to Thailand and beyond, seems of less direct importance for Myanmar.

Table A 1 Myanmar's main river basins (ref. Myanmar-Dutch Seminar on "Water Sector Capacity Building and Possible Collaboration" 6th July 2012, Irrigation Department. (Head Office), Yangon, Myanmar).

River Basin No.	Name of the River Basin	Drainage Area (10^3 km^2)	Avg. Annual Surface Water (km^3)	Ground Water (km^3)
1	Chindwin	115.30	141.293	57.578
2	Upper Ayeyarwady	193.30	227.920	92.599
3	Lower Ayeyarwady	95.60	85.800	153.249
4	Sittoung	48.10	81.148	28.402
5	Rakhine State	58.30	139.245	41.774
6	Taninthari Division	40.60	130.927	39.278
7	Thanlwin	158.00	257.918	74.779
8	Mekong	28.60	17.634	7.054
	Total	**737.80**	**1081.885**	**494.713**

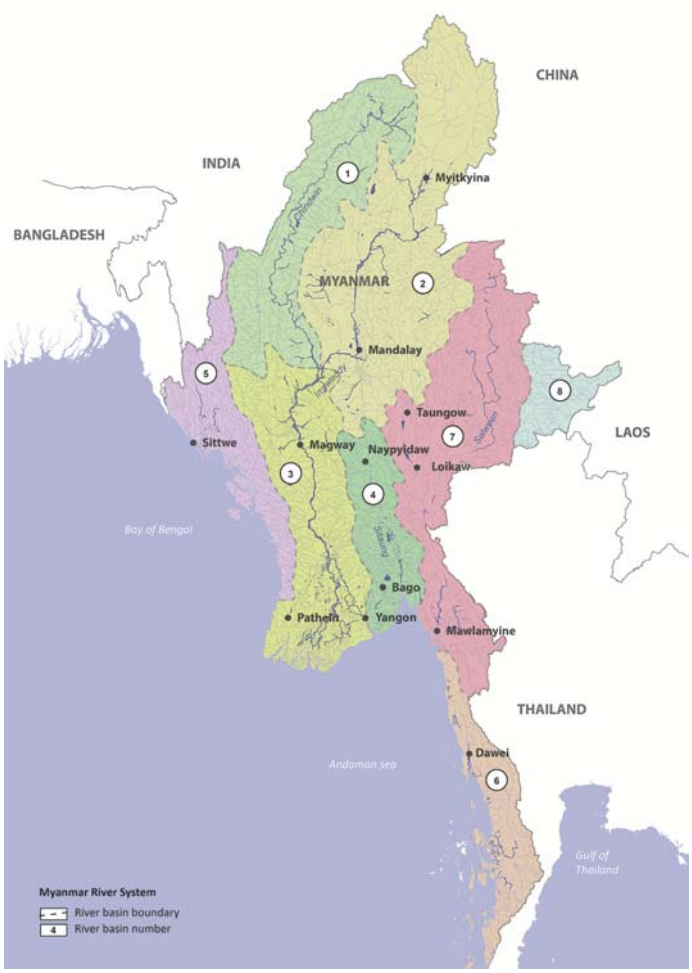


Figure A 6 Myanmar's main river basins (ref. Myanmar-Dutch Seminar on "Water Sector Capacity Building and Possible Collaboration" 6th July 2012, Irrigation Department. (Head Office), Yangon, Myanmar).

River training for navigability

The Ayeyarwady and Chindwin Rivers are the main navigable rivers of Myanmar and maintained and monitored by DWIR. Other rivers like Thanlwin and Sittaung are also used for shipping but only for short distances by small vessels and boats (typically less than 10 DWT). During recent years the inland waterway navigable length has become shorter and shorter. In Table A 2 an overview is given of the rivers and associated navigable length.

Table A 2 Navigable length of inland waterways *(Source : DWIR 2014)*

Name of River	Navigable Length (km)
Ayeyarwady	1,534
Chindwin	730
Thanlwin and other rivers in Mon State	380
Delta Region	2,404
Rivers in Rakhaing State	1,602
Total Length (km)	6,650

There is one government agency, namely Inland Water Transport (IWT), under the management of the Ministry of Transport. IWT is responsible for both long haul passenger and freight services, and cross-river ferry services in various places along the rivers. Statistics in 2011 show IWT could carry about 5 million tons of freight along the main rivers. It is about 1.5 times the volume carried by Myanma Railways. Additionally, there are some private barges which carry bulk cargo (such as fuels, crops, stones for road construction, fertiliser) along the rivers. The total volume of shipments handled in all the domestic shipping services was about 6.687 million tons.

During the low water season, from November to May, many of the inland water transport routes do not provide sufficient water depth for inland waterway vessels to operate safely. Improving river channels and navigation aids would benefit all providers of inland water transport services, IWT vessels and private vessels as well.

The Waterways Department was organised and founded in 1972 by combining the Dredging and River Conservancy sections of Department of Marine Administration, Ministry of Transport and Communication and parts of Hydrographic Surveying section of Port Corporation, Ministry of Transport and Communications *[http://www.mot.gov.mm/dwir].* In 1999, the Department was extended and reorganised as the Directorate of Water Resources and Improvement of River Systems (DWIR). The main responsibilities of DWIR are to:

- improve the navigation channel and to stabilise the inland river ports.
- protect the river bank erosion.
- cooperate with other organisations in demarcation of danger water level.
- utilise the river water for domestic and agriculture all the year round.
- protect bank erosion of border rivers.
- observe the long-term existence of the cross river bridges by river engineering points of views.
- manage the prevention of the river water pollution.
- achieve adequate depth for maximum loading capacity of the vessels.

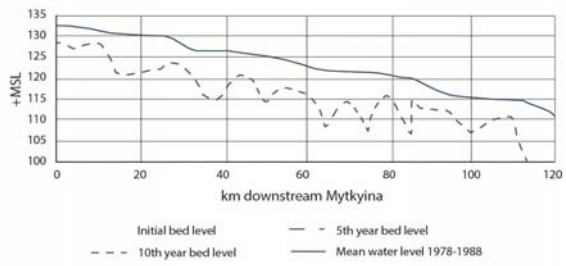


Figure A 7 Navigable depths *[source MoT, DWIR]*

The Ayeyarwady River is typically a lowland type of river. This is caused by the flat Myanmar central area with a river gradient of less than 0.1 m per 10 km). Despite the inherent tranquil character of the river in terms of flow velocities, the Ayeyarwady demonstrates a strong seasonality due to the very distinct water level variation, with a high water level that may exceed the low water level by about 10m as an order of magnitude.

The Ayeyarwady and Chindwin Rivers are the principal arteries of riverine transport in Myanmar; they traverse the country in a north-south direction. The upper part of the Ayeyarwady River consists mainly of alluvium-covered basins where it has cut relatively narrow channels through hill ranges. The river flows smoothly into the dry zone, past the city of Mandalay. At Pakokku the Chindwin River, the most important tributary, joins the Ayeyarwady River through several mouths. From here the Ayeyarwady flows through the plain until Yangon, 150 km from the sea, where the delta begins. The length of the Ayeyarwady and Chindwin Rivers are 1,650 km and 840 km, respectively. The Ayeyarwady and Chindwin are morphologically fast reacting rivers.

Figure A 8 Chindwin and Ayeyarwady

In view of the objective to improve the navigability and to identify a long-term master plan development of the rivers, emphasis has been placed on structures which would guide the river into a single channel of alternating left and right bends with the minimum length of straight sections between the bends. Once the correct alignment was obtained, a low water channel of appropriate width could be designed to provide the appropriate least available depth.

River training and dredging works should in view of above mentioned be carried out gradually in time to avoid too abrupt changes in the river configuration which would upset the dynamic equilibrium. Sufficient time must be allowed for the river to adopt a new morphological equilibrium. When changes are too abrupt, adverse conditions, either upstream or downstream of the river section being improved, may cause the river to abandon the desired low water channel alignment entirely and breach through the flood plain in a secondary channel. Less drastic adverse effects that may occur include the formation of shallow areas in adjoining river stretches and an overall instability of the channel system.

The implementation must be phased, primarily because of the reasons outlined above. Since the river system is bound to change during the period of implementation of river works, the systems changes must be monitored and documented carefully. This may guide modifications to the works and yearly river maintenance requirements. Because of these changes, it should be realised that master planning is of importance and will be a continuous on-going activity.

Figure A 9 Myanmar, potential for deep sea ports

Erosion and flood control

Living along the main rivers is characterised by recurrent disaster, caused by annual monsoon flooding and unpredictable local bursts of often substantial riverbank erosion. Riverbank erosion, apart from direct loss of land, is also a main cause of flood disaster when embankments eroded during the monsoon season. As such riverbank erosion has significantly reduced the reliability of existing flood embankments while delaying the construction of systematic embankment lines elsewhere. Over time disaster incidence and damages grew with a growing population. While regularly many parts of the country are flooded, the number of people affected is steadily increasing. With growing population and economic activities

disaster response and recovery reaches a point where the related cost become higher than proactive prevention through systematic structural interventions.

The relationships between disasters, growth and poverty are both direct and indirect. When a disaster strikes, it immediately puts an end to economic and social activities, because the organisation of such activities becomes dysfunctional. Secondly, disasters such as floods or cyclones may disrupt communications and the infrastructure and consequently peoples' employment and income may be adversely affected for a period. Most importantly, natural disasters create tremendous human misery, including death, both when they occur and in their aftermath. Often it is the poor who fall easy prey to disasters and it is also they who may take the longest to recover from the adverse effects. Also, during a natural disaster the poor are more numerous among those killed because they are least prepared to face such events and they are generally more concentrated in the hazard-prone areas of Myanmar. Death of the earning member of a poor family brings lasting misery to its members. Thus the gains in poverty reduction suffer a setback. The other direct effects due to natural disasters include damages caused to residential housing, housing goods, crops, fisheries, and livestock. Damage done to transport and communication facilities, capital assets including stocks of food both at the household and the state level have significant indirect adverse effect. The indirect impact and the second-round effects of natural disasters in Myanmar are often hard to estimate. Poverty along the main rivers is characterised by a lack of stability and consequently a lack of investment. This means practically that there is limited access to the areas, the agricultural production is low due to the higher risk of experiencing losses, and at the household level the recurrent occurrence of disaster keeps the families poor.

Hydropower

Myanmar has abundant energy resources, particularly hydropower and natural gas. The hydropower potential of the country's rivers, which drain the four main basins of Ayeyarwaddy, Chindwin, Thanlwin, and Sittaung, is estimated to be more than 100,000 megawatts (MW) [*according to Myanmar, Energy Sector Initial Assessment, Asian Development Bank, October 2012*].

Larger hydropower dams

It is reported by Ministry of Electric Power in January 2014 that a number of hydropower dams are planned, being constructed next to the existing dams;

The details of the existing major hydropower dams and the ongoing project development and construction of hydropower dams and planned dams as received from the MoEP are listed in Table A 3 and Table A 4.

It needs to be noted that the list includes, under "Ongoing Hydropower Projects in Myanmar", all possible projects which are or have been considered. Some of the projects have been halted by the Government (e.g. Mysone) or are under strong debate within the Government or by the general public and may not materialise.

Table A 3 Hydropower projects

Ongoing Hydropower Projects in Myanmar

Station	Installed Capacity (MW)	Annual Energy Generation (GWh)
Upper Paunglaung	140	454
Nancho	40	152
Yeywa	790	3,550
Upper Yeywa	280	1,600
Shweli-3	1,050	3,500
Phya	40	120
Kun	60	190
Shwegyn	75	262
Bawgata	160	500
Thahtay	111	386
Ann	10	44.53
Upper Kengtawng	51	267
Manipur	380	1,903
Upper Bu	150	534
Baluchaung-3	52	334
Thaukyegat-2	120	604
Upper Sedawgyi	64	236
Saingdin	76.5	236
Anyaphya	9	38
Upper Baluchaung	29	120
Htakha	6	30.3
Thagyet	20	95.4
Myitsone	6,000	29,400
Chipwinge	99	320
Yenam	1,200	6,650
Kaunglanhpu	2,700	14,730
Hpizaw	2,000	11,080
Wutsok	1,800	10,140
Chipwi	3,400	17,770
Laza	2,700	14,396
Upper Thantwin	1,400	7,338
Dapein-1	240	1065.1
Dapein-2	168	775
Tamanthi	1,200	6,685
Shwezaye	660	2,908
Hutgyi	1,360	7,325
Nao Pha	1,000	5,290
Mantong	200	924
Ngawchanghka	1,055	5795.5
Gawian	100	552
Wu Zhongze	60	327
Hkankawn	140	269
Tongxinqiao	320	1,746
Lawndin	435	2,402
Shwell-2	520	2,814
Lemro(1)	600	3,676
Lemro(2)	90	539
Ywathit	4,000	21,789
Nam Tamhpak	180	920
Nam Kha	200	937
Nam Lwe	452	2,328
Keng Tong	96	536
Wan Ta Ping	25	138
So Lue	165	742
Mong Wa	50	274
King Yang	28	155
He Kou	88	483
Nam Pawn	585	3,015
Htu Kyan	105	551
Hseng Na	45	234
Tha Hkwa	150	776
Palaung	105	536
Bawlake	180	918
Tanintharyi	600	3,476
Tasang	7,110	35,446
Mawlaik	520	3,310

Existing Hydropower Projects in Myanmar

Station	Installed Capacity (MW)	Annual Energy Generation (GWh)
Baluchaung 2	168	1190
Kinda	56	165
Sedawgyi	25	134
Baluchaung-1	28	200
Zawgyi-1	18	35
Zawgyi-2	12	30
Zaunghu	20	76
Thapanzeik	30	117.2
Mone	75	330
Paunglaung	280	911
Yenwe	25	123
Kabaung	30	120
Kengtawng	54	377.6
Shweli-1	600	4022
Yeywa	395/790	1775/3550

Table A 4 Existing dams

	Installed capacity (MW)	Annual energy generation (GWh)
Existing	1,816	9,606
Ongoing	45,752	235,896
Planned	305	1,600

Micro hydropower

In recent year's environmental and socio-economic impacts due to construction of large hydro power dam schemes have become increasingly important and has already delayed or cancelled some of the larger hydro power schemes. The majority of these larger dams is financed and constructed by Chinese developers which are not always appreciated by the Myanmar Government in their newly adopted approach of becoming less dependent from China. The above developments are amongst others reason why interest in mini hydropower (also known as small scale hydro power) has increased. It is noted that some 10 years ago Myanmar has also tried to develop mini hydro power, however, due to constraints of the institutional setting at that point in time it has not been taken forward.

Over the past 5 years, some 26 micro and 9 mini-hydropower power projects have been developed by MEPE, with installed capacity ranging from 24 kilowatts (kW) to 5,000 kW. These projects have included border areas, aimed at improving the social and economic conditions of poor rural households and remote communities. These mini-hydropower projects also facilitate cottage industries and enhance agricultural productivity through improved irrigation.

Table A 5 provides the list of the planned micro-hydropower power projects in border areas. Village-scale hydropower projects range from primitive wooden wheel types to a variety of small modern turbine systems. Research on micro-hydropower plants, led by MOST, includes the design and construction of different types of turbines and synchronous generators for micro-hydropower plants. [according to Myanmar, Energy Sector Initial Assessment, Asian Development Bank, October 2012].

Table A 5 Installed hydropower capacity

Project	Installed capacity (KW)
Mepan Chaung	1,200
Tumpang Hka Chaung	6,000
Kang Hkawang	1,200
Kyu Hkak Chuang	320
Nam Mae Sai	6,000

source: www.aseanenergy.org

Appendix 5 Complementary materials capacity development

A5.1 Existing capacities and capacity gaps

A5.1.1 Expert group

Four alumni and members of the expert group returned the questionnaire. This cannot be considered a good representation of the expert groups capacity, but for now it is the best available. As could be expected all expertise is considered (very) important for the expert group. The least scoring expertise are design, modelling and operation and maintenance. More relevant is the assessment whether the expertise is currently sufficiently available in the Expert Group and this is only partly the case, except for the subject-specific knowledge (such as hydrology, navigation or agriculture).

Table A 6 Expertise importance and availability in Expert Group
(based on questionnaire filled out by four members)

Thematic / sectoral expertise	Importance	Available
Subject-specific theoretical knowledge, e.g. hydrology, hydraulics, ecology, fisheries, navigation, agriculture	++	+
Subject-specific theoretical knowledge, e.g. economics, social sciences, political science, law	++	+
Design skills	+	+/-
Policy formulation skills	++	+/-
Computational / Modelling skills	+	+/-
Operation and maintenance	+	+/-

++ Expertise is very important, + Expertise is moderate important, empty Expertise is not or limited important

IWRM expertise	Importance	Available
Integration of sectoral and spatial interrelationships (e.g. hydropower-agriculture-fisheries, upstream-downstream)	++	+/-
Understanding of procedures and institutional arrangements	++	+/-
Basin planning process	++	+/-
IWRM instruments and tools (e.g. (S)EIA, DSS)	++	+/-
Monitoring and implementation	++	+/-

++ Expertise is very important, + Expertise is moderate important, empty Expertise is not or limited important

A5.1.2 Key Ministerial departments

With respect to the vertical leg of the T-shaped competency profile (thematic/sectoral expertise), all departments indicate that subject-specific 'hard' knowledge is very important. Some indicate that besides the engineering knowledge they also find 'soft' knowledge of e.g. economics, social sciences or law very or moderate important. The other thematic/sectoral expertise like design, computational skills, operation and maintenance or policy formulation skills are also found moderate to very important depending on the mandate of the department (see Table A 7).

Table A 7 Importance of thematic / sectoral expertise *(based on questionnaire filled out by Department staff)*

	Ministry of Agriculture & Irrigation		Ministry of Electric Power		Ministry of Environment, Conservation and Forestry		Ministry of Livestock, Fisheries & Rural Development		Ministry of Transport
	Irrigation Department	Water Resources Utilisation Department	Department of Hydropower Implementation	Department of Hydropower Planning	Env ironmental Cons ervation Department	Forest Department	Department of Rural Development	Department Meteorology & Hydrology	Directorate Water Resources and Improvement of Rivers
Subject-specific theoretical knowledge, e.g. hydrology, hydraulics, ecology, fisheries, navigation, agriculture	++	++	++	+	++	++	++	++	++
Subject-specific theoretical knowledge, e.g. economics, social sciences, political science, law	++	+	+	++	++	+			+
Design skills	++		++	+	+	+	++		++
Policy formulation skills	++	+	+	++	++	+			

	Ministry of Agriculture & Irrigation		Ministry of Electric Power		Ministry of Environment, Conservation and Forestry		Ministry of Livestock, Fisheries & Rural Development		Ministry of Transport
	Irrigation Department	Water Resources Utilisation Department	Department of Hydropower Implementation	Department of Hydropower Planning	Environmental Conservation Department	Forest Department	Department of Rural Development	Department Meteorology & Hydrology	Directorate Water Resources and Improvement of Rivers
Computational / Modelling skills	+	+	++	++	+	+		++	++
Operation and maintenance	+		++		+	+	+	+	++

++ Expertise is very important, + Expertise is moderate important, empty Expertise is not or limited important

With respect to the horizontal leg of the T-shaped competency profile (integrative requirements) the departments indicate that they find this very important. In order of importance, the expertise should include, monitoring and implementation, IWRM instruments and tools (e.g. SEIA and Decision Support Systems), sectoral and spatial integration, basin planning processes and understanding of procedures and institutional arrangements (see Table A 8). The Department of Rural Development sees little to no importance in most of the IWRM expertise.

Table A 8 Importance of IWRM expertise *(based on questionnaire filled in by Department staff)*

	Ministry of Agriculture & Irrigation		Ministry of Electric Power		Ministry of Environment, Conservation and Forestry		Ministry of Livestock, Fisheries & Rural	Ministry of Transport	
	Irrigation Department	Water Resources Utilisation Department	Department of Hydropower Implementation	Department of Hydropower Planning	Env ironmental Cons ervation Department	Forest Department	Department of Rural Development	Department Meteorology & Hydrology	Directorate Water Resources and Improvement of Rivers
Integration of sectoral and spatial interrelationships (e.g. hydropower ⇦⇨ agriculture ⇦⇨ fisheries, upstream-downstream)	++	+	++	++	++	+		++	++
Understanding of procedures and institutional arrangements	++	+	+	++	++			+	+
Basin planning process	++	++	++	++	+	+		+	+
IWRM instruments and tools (e.g. (S)EIA, DSS)	++	++	++	++	++	++		++	++
Monitoring and implementation	++	++	++	+	++	+	+	++	++

++ Expertise is very important, + Expertise is moderate important, empty Expertise is not or limited important

The departments were also asked to indicate their role in the key water issues[17] of Myanmar and with which departments they cooperate in those issues. As could be expected several water issues require the involvement of different departments, indicated by a small role (see also box below on closely related mandates). All departments indicate they have (large) role to play in water resources planning and allocation, while wetland and mangrove protection and water supply and sanitation is the responsibility of just a few departments (see Table A 9).

Table A 9 Involvement department in key water issues *(based on questionnaire filled in by Department staff)*

	Ministry of Agriculture & Irrigation		Ministry of Electric Power		Ministry of Environment, Conservation and Forestry		Ministry of Livestock, Fisheries & Rural Development	Ministry of Transport	
	Irrigation Department	Water Resources Utilisation Department	Department of Hydropower Implementation	Department of Hydropower Planning	Environmental Conservation Department	Forest Department	Department of Rural Development	Department of Meteorology & Hydrology	Directorate of Water Resources and Improvement of Rivers
Flood management	++		+	+	+	+		++	++
Erosion control	+		+	+	+	++		+	++
Watershed & forest management	+		+	+	+	++		+	+
Irrigation and drainage rehabilitation	++	++			+			+	+

[17] The key water issues were based on the Master Class Sharing IWRM experiences and IWRM training workshop, organised in March 2014 and the report 'Myanmar IWRM Strategic Study - Report on First Findings'.

	Ministry of Agriculture & Irrigation		Ministry of Electric Power		Ministry of Environment, Conservation and Forestry		Ministry of Livestock, Fisheries & Rural Development	Ministry of Transport	
	Irrigation Department	Water Resources Utilisation Department	Department of Hydropower Implementation	Department of Hydropower Planning	Environmental Conservation Department	Forest Department	Department of Rural Development	Department of Meteorology & Hydrology	Directorate of Water Resources and Improvement of Rivers
Water resources planning and allocation	++	++	++	++	++	+	+	+	++
Wetland and mangrove protection					++	++		+	+
Water supply and sanitation *	+	+					++		

++ Large role, + Small role, empty No role

A5.2 Examples of competency profiles of key departments

A5.2.1 Ministry of Agriculture and Irrigation

Irrigation Department

Responsible for supplying water to farmers and are involved in the whole cycle from survey, hydrology, design, construct and implementation (operations and maintenance) of irrigation works. For the irrigation works they make also use of (multi-purpose) dams which they also design, construct and maintain. Construction is carried out by regional teams and the operation and maintenance also by their state and regional offices. Rest is responsibility of head office. Also responsible for flood protection of rivers and coast and maintaining the natural lakes as these are considered natural reservoirs.

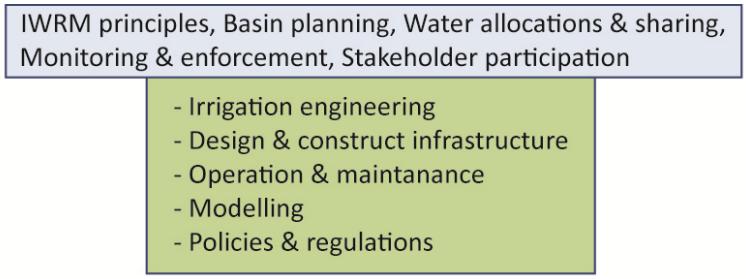


Figure A 10 Current competency profile (strong vertical part, with need for wide horizontal part)

Water Resources Utilisation Department (MoAI-WRUD)

WRUD is responsible for water supply by pumping water to farmers and is involved in the whole cycle from survey, hydrology, design, construct and implementation (operations and maintenance) of irrigation works. For irrigation works it relies on groundwater and surface water. Its work is in the dry zone mainly. Some of its works comprise also drinking water supply to villages.

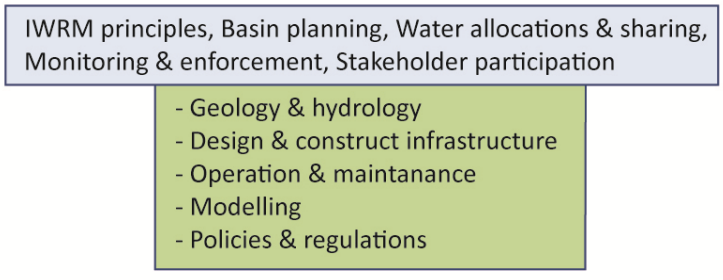


Figure A 11 Current competency profile (strong vertical part, with need for wide horizontal part)

A5.2.2 Ministry of Electric Power

Department of Hydropower Implementation

Responsible for approval of plan, review feasibility report and during construction time monitor - oversee the construction. When government project they will also construct, but have contracters (in past mainly from China) for some aspects (e.g. machineries). They check e.g. geological,

hydrological, structural feasibility. Now also need to do environmental impact assessments and get approval from department of environmental conservation. At head office mostly civil engineers, while at regional construction offices more mechanical and electrical engineers.

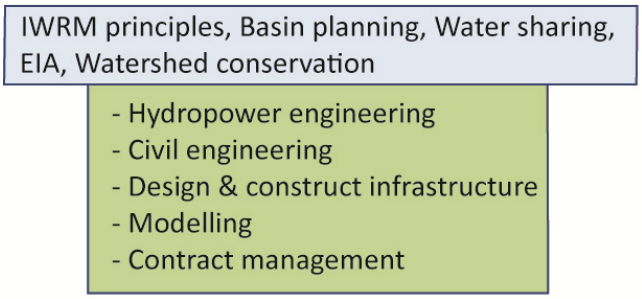


Figure A 12 Current competency profile (strong vertical part, with need for wide horizontal part)

Department of Hydropower Planning

Responsible to invite developers (government, local entrepreneurship or foreign investment) to jointly implement hydropower projects, negotiate terms and conditions with them and have contracts signed. Upon signing of the contract the project will be handed over to the hydropower implementation department. So they are engaged in making MoU - MoA - Joint Venture Agreements. Currently most of staff is civil engineer, don't have professionals on contracts and/or legal issues (and don't seem to miss either).

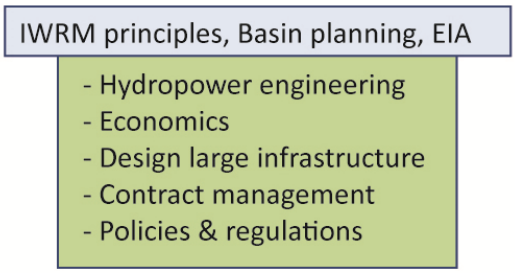


Figure A 13 Current competency profile (strong vertical part, with need for wide horizontal part)

A5.2.3 Ministry of Environmental Conservation and Forestry

Environmental Conservation Department

Responsible for the protection of the environment. National level is very much involved in making the legislation and developing standards, e.g. pollution control and EIA. Focus is currently on pollution by industries and some with the large cities (YCDC, NCDC and MCDC). Actual monitoring and enforcement is then something the regional offices have to do, but currently lack the skills and equipment.

Figure A 14 Current competency profile (weak vertical part, with need for wide horizontal part)

Forest Department

Approximately 46% of the country is covered by forest and 30% is designated as forest reserve. For this 30%, the forest reserve, the department is responsible for sustainably managing the forest while optimising its productivity. Watershed management in these areas is also their responsibility as well as in the Critical Watershed Areas throughout the country. The Watershed Management Division is responsible for e.g. planting, erosion control, community participation and greening activities in those areas.

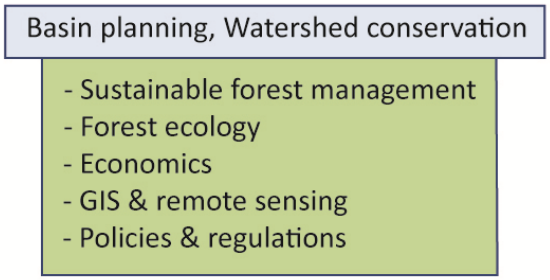


Figure A 15 Current competency profile (strong vertical part - small horizontal part)

A5.2.4 Ministry of Livestock, Fisheries and Rural Development

Department of Rural Development

The Water Supply and Sanitation Division of this department is responsible for water supply and sanitation to the rural areas (approx 70% of population Myanmar). Currently cover approx 50% of the villages, meaning 1 supply point per village. After construction rural community is responsible for operation and maintenance of the system. Survey conducted with UNICEF and Ministry of Health indicated approx 40-50% of the water supply is safe for consumption. Most of their staff is civil or mechanical engineer.

Figure A 16 Current competency profile (strong vertical part - small horizontal part)

A5.2.5 Ministry of Transport

Department of Meteorology and Hydrology

Observe and collect hydrological data such as water levels, discharge, rainfall, evaporation, sediment. Issue water level forecast, flood warning, bulletins and minimum water level alerts (also publish on website) to higher authorities, relevant departments and organisations. Historic data can be purchased. They are indirectly involved in IWRM related competencies as they provide relevant data.

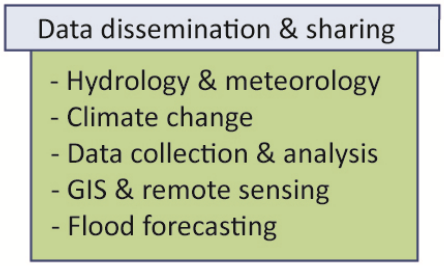


Figure A 17 Current competency profile (strong vertical part - small horizontal part)

Directorate of Water Resources and Improvement of River Systems (DWIR)

They aim to improve the navigation channel and to stabilise the inland river ports. Additionally they improve the navigation channel (achieve sufficient water depth) and to stabilise the inland river ports and protect river bank erosion. For this they carry out river engineering works when necessary (groynes, dredging, straightening, etc). Main problem is the drought restriction on the Chindwin and Ayeyarwady river due to insufficient water depth during the dry season. They are also are responsible for preventing river water pollution and managing the utilisation of river water for domestic and agricultural water use.

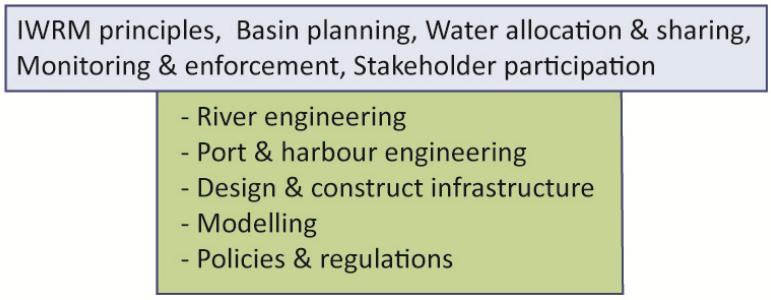


Figure A 18 Current competency profile (strong vertical part - with need for wide horizontal part)

Inland Water Transport

Responsible for transportation (navigation) of cargo and passengers all along the inland waterways of Myanmar and repair and maintenance of the barges, vessels and docks.

Further excluded from capacity development strategy.

A5.3 Learning modalities

Case studies / projects. Learning through case studies or (research) projects allows for application of theories. By working through a problem a deeper understanding of the concepts, ideas and/or limitations will be reached. The case method can be used in a very effective way in order to move professionals up the cognitive skills ladder from the low skills levels of *knowledge*, *comprehension* and *application* to the higher and more desirable skills of *analysis*, *synthesis* and *evaluation*.

Class room / online teaching. Class-room teaching is a more formal form of learning in groups guided by a teacher. Class-room teaching is often face-to-face, but can also be over a distance via e-learning (synchronous (at the same time), or asynchronous. To facilitate the different learning styles of learners and to address the mix of competency categories, class-room teaching should make use of different teaching methods such as lectures, assignments/exercises, role plays, and discussions. In role play games, participants take on the role of a stakeholder affected by an issue and study the impacts of the issues from the perspective of that stakeholder. Role plays are an effective modality for emphasising the "real-world" aspects when learning a new topic. Class-room teaching can also be offered over short periods (hours, days) or longer periods.

Coaching. The different learning modalities can be combined with coaching, whereby often more senior colleagues serve as a sounding board for junior staff, making recommendations for interacting with other colleagues, programmes etc, and providing access to resources. Through these mechanisms junior employees become quickly familiar and productive in a new organisation.

Exchange visits. Exchange visits can also be instrumental for creating improved knowledge and understanding by allowing professionals to interact with others working on similar, related or even different subjects in for instance another river basin.

Field visits. A journey by a group of people to a place that allows for observation and reflection of the subjects taught. On these days out with the group, people share and discuss what they have learned and there is an enormous potential for creating improved knowledge and understanding.

On-the-job / learning by doing. There is really only one way to **learn** how to do something and that is by actually doing it. Learning, and in particular learning to implement IWRM, often takes place "at work". Different approaches for on-the-job learning can be used, like allowing

employees to apply on-the-job what they have learned in a class-room teaching, e.g. by given them the right assignments, by involving them in working groups, or let younger staff participate in projects, e.g. coached by more seniors (see coaching).

Self-learning. Self-learning is "learning on your own" or "by yourself". Self-learning is often complemented with other learning modalities. A distinction can be made between short periods of self-learning (hours, days) or longer periods, dependant on the entrance competency level of the learner and the required level.

Working groups. This is a learning modality related to workshops, seminars and conferences, but more formal. In working groups professionals work together on a specific assignment e.g. working group on data and modelling for water management, working group on scenario studies for river basin development, or working group on water governance.

Workshops, seminars and conferences. Such events are critical for sharing and creating knowledge. Water management does not take place in isolation rather each theme/sector and field of knowledge involved will be strengthened through the interactions with others working on similar, related or even different subjects. When professionals get together and share and discuss what they have learned, there is an enormous potential for creating improved knowledge and understanding.

Appendix 6 Bagan River Training

A6.1 River evolution in project area

The focus of the project is on the river reach next to Bagan. However, the channels, islands and bars in the reach interact with their upstream and downstream neighbours. So, in order to stabilise the islands and bars near Bagan, it is necessary to control their neighbours. The communication is mainly through the migration of channels and bars, and is interrupted by sections with no bars and stable channels. This is the case at the city of Pakokku, around 20 km upstream of Bagan, and at the city of Chauk downstream of Bagan (see figure right). At Chauk, the river is confined by a resistant geological unit, whereas near Pakokku, the river is forced towards the south bank by a stable island.

The Irrawaddy River is monsoon-dominated, with high discharges of around 30,000 m³/s in May to October and low discharges in the other months of around 3,000 m³/s. This relatively large difference in discharge results in a seasonal water level difference in the order of 7 metres near Bagan.

The Ayeyarwady River can be classified as a braided river with low braiding intensity. In large parts of the river, the river has multiple parallel channels, with relatively stable inhabited islands and highly dynamic sand bars in between. Other reaches have a single channel with alternate bars. Dependent on discharge and dynamics of adjacent bars and channels, a reach can switch between single-channel and multi-channel.

The river bed is dominated by fine sand with a grain size of around 0.25 mm. In combination with high discharges, this results in high sediment transport rates. The non-vegetated bars can migrate 100's of metres per year; and bar initiation, bar evolution and bar disappearance occurs relatively rapidly. Although the islands are relatively stable within the period of decades, the edges of the islands consist of bare sand and are highly mobile

Geological structures, for example resistant bed-rocks, have large influence on the course of the Irrawaddy River as they locally confine the river and prevent bank erosion. This is also the case in the project area, where the West-bank of the river is resistant bed-rock.

The morpho-dynamics upstream of Bagan from 1989 to 2013 has been assessed. In front of the city Pakokku, a relatively stable island was present, pushing the main channel towards the southern river bank. A couple of km's further downstream; a more or less stable bar was present along the south bank, probably forced by the shape of the non-erodible southern bank line. Between that bar and the channel knick point near Bagan, the bars and islands were relatively dynamic and instable. Nevertheless, a sort of instable alternate bar pattern could be seen, with bars in the inner

bends and main channel in the outer bend. At the knick point the channel was stable and attached to the non-erodible west bank during the entire period from 1989 to 2013.

Downstream of the knick point from 1989 to 2013 it can be observed that a large island directly downstream of the knick point was relatively stable. Furthermore, the secondary channel between the island became smaller after 1989 and partly aggregated. At the same time, the main channel became increasingly attached to the non-erodible west bank. Downstream of the large island, the islands and bars were relatively dynamic. Nevertheless, the main channel remained along the west bank.

A6.2 River beautification measures

A number of interventions are being considered such as:

- River training works and dredging;
- Dutch "Room for the River" concepts;
- Navigation improvement;
- Provisions for irrigation and water supply;
- Flood and erosion control works;

Interventions fit in phased development of Ayeyarwady River as no-regret measures and should have no negative socio-economic and environmental impact. Examples of possible interventions are shown in the figure below.

Hydropower groyne

Dredging

Bank protections

Irrigation and water supply

River beautification and trourism

Branche closing

A6.3 Conceptual designs

Initial conceptual designs have been prepared. The design consists of two parts: 1) upstream of the knick point and 2) downstream of the knick point. A knick point is defined as a point in the river where a natural phenomenon (e.g. a river bend, or a rocky threshold) determines the change of river flow. The main focus is on the river section downstream of the knick point.

Upstream of the knick point

The design of the upstream section is focused on stabilisation the islands and stimulation/forcing of one dominant main channel. In order to achieve a single channel, the instable alternate bar pattern will be stabilised. This requires local protection of the bars and islands, which prevents chute cut-offs. Furthermore, groins with hydropower turbines can be built in the secondary channel to limit flow through the secondary channels.

Downstream of the knick point

The design of the downstream section is focused on forcing of the main channel to flow along the non-erodible west bank, and to attract more discharge through the main channel. This is achieved by stabilisation of the islands and bars and by partly closure of the secondary channels by groins with hydropower turbines. Water reservoirs will be formed upstream of the dams, which is beneficial for irrigation and drinking water supply. The islands need to be stabilised by bank erosion protection at the upstream and probably along the main channel, thus the west-side of the bars and islands.

In the design, natural deepening of the main channel is stimulated by concentrating the discharge to the main channel. In the secondary channels, mini hydropower turbines in groynes are proposed, to generate electricity during the wet season and to store water for the dry season. These groynes allow sufficient flow through the secondary channels to generate hydropower and prevent flooding, while stimulating discharge through the main channel during low discharge to enable navigation.

In order to prevent extensive sediment deposition in the secondary channels, which is a general problem of secondary channels and hydropower groynes, training works are proposed to guide the flow and sediment transport. The entrances of the secondary channels will be positioned at the outer bends of the main channel, which reduces the sediment inflow to the secondary channel significantly. The main channel is fixed by spurs and bank protection to reduce the natural shifting of both the main channel and the entrances of the secondary channels. At the same time, advantage is taken of the natural sinuous shape of the main channel to prevent new 'short cut' channels and enable natural maintenance of the main channel.

The conceptual design is thus based on:

- One stable main channel that meets all requirements for navi-gation, and has capacity for high discharge during the wet season (flood risk reduction).
- Stable secondary channels with downstream groins for hydropower, irrigation and drinking water supply. The groins are low enough to allow overflow during high discharge.
- Stable islands (bank protection and agriculture).

A possible layout of interventions is show in figure overleaf.

It is emphasised that further studies are required to arrive at a pre-feasibility report required for next steps in preparing the Term Sheet and Financial Closure.

A6.4 Revenue generating mechanisms and stakeholders

The envisaged revenue generating mechanisms could consist of the following flows of income:

- Electricity for city, tourism and/or irrigation scheme;
- Water for irrigation schemes;
- Optimised flood protection and improved accessibility for tourism and people and thus reduction of investment cost along the river locations;
- Improved navigation and thus reduction of transport cost;
- Due to sustainable intervention scheme reduction of maintenance cost.

The pilot project should be based on a Public Private Partnership where public (Myanmar Governmental authorities, Dutch Government via e.g. DGGF financial instrument) and private (potential Myanmar SME developers and investors, Myanmar fleet operators and tourism industry and Dutch initiators) should work closely together.

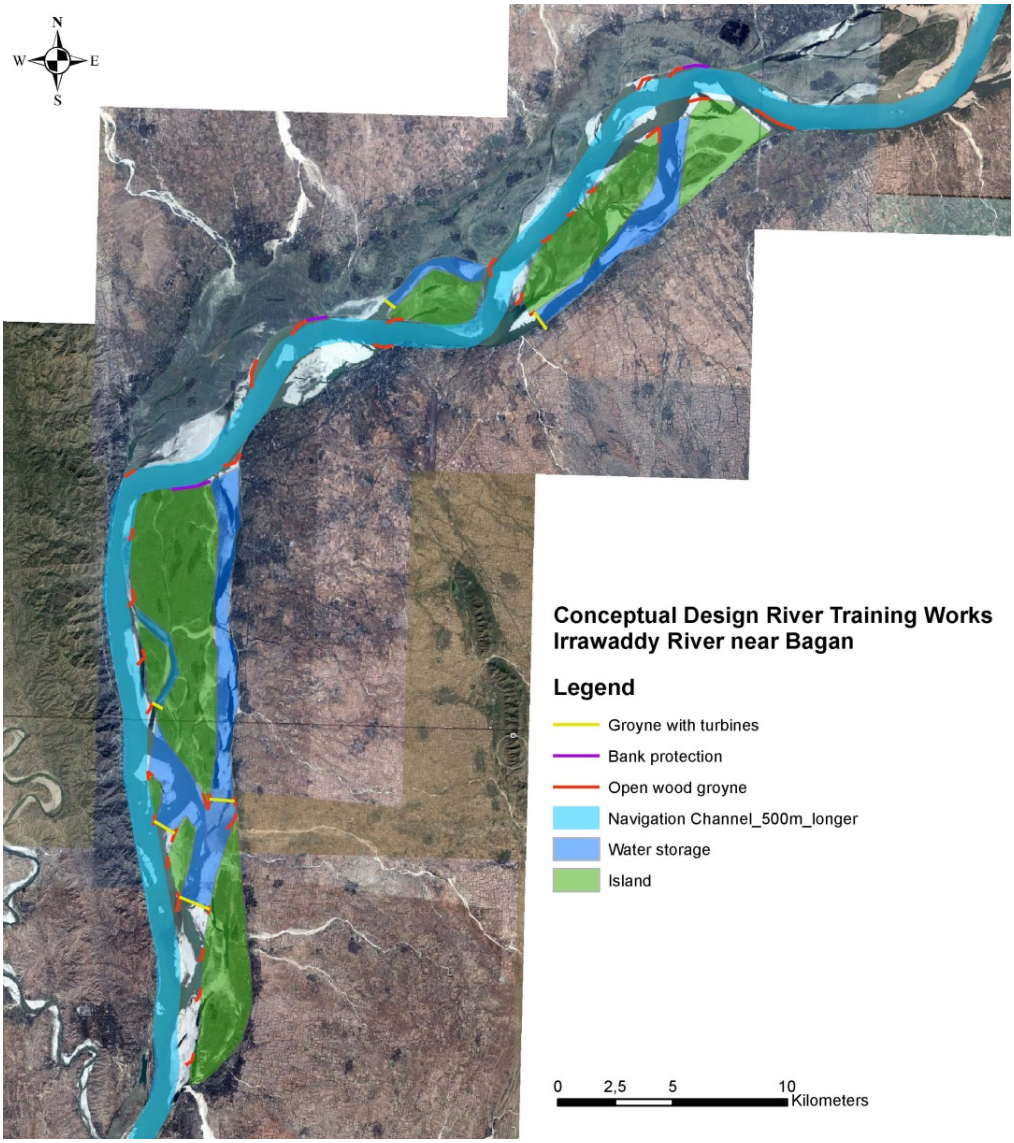


Figure A 19 Ayeyarwady near Bagan, flow from north-east to south-west [source HaskoningDHV, 2014]

A6.5 Financials

At this point in time it is envisaged that the CAPEX of the pilot project would be some 15 – 20 M Euro with an annual OPEX of some 0.5 M Euro. The funding could come from private developers from Myanmar and possibly the Dutch Good Growth Facility (DGGF) facility from the Netherlands which will be in operation as per July 2014.

As said, it is emphasised that further studies are required to arrive at a pre-feasibility report to assess bankability and eventually preparation of a Term Sheet and Financial Closure. It is also emphasised that the pilot project should fit into the IWRM approach and proper socio-economic and environmental assessments need to be conducted.

Appendix 7 Meiktila Lake

A7.1 Introduction to a royal lake

Lake Meiktila is situated in the Mandalay Region on the crossroads of the Bagan-Inle Lake route and the Yangon-Mandalay route.

Lake Meiktila dates back to the 11th century of the Bagan Period. It was constructed over 900 years ago by the Burmese King Anawrahta for irrigation purposes in this dry but fertile area in the Central Dry Zone. It Over the next few hundred years several kings improved and expanded the lake and its irrigation system to the historic monumental irrigation system and lake it is. Over 600.000 people in the Township Meiktila depend on this lake and irrigation system for their livelihood. The lake and surrounding water system serves as a retention reservoir for rain during the rainy season, so that it provides water to this area in the dry season. Meiktila holds a special place in the heart of Myanmar people through a famous lullaby.

A7.2 Siltation of the lake

Over these 900 years Lake Meiktila was famed for its clear water. However, that started changing with more economic development of the area as from the British era until today. Severe deforestation along the tributaries led to enormous amounts of silt deposited in the lake. The lake now comprises of a north lake and a south lake, separated by an overflow. While the southern lake is still deep and clear, the northern lake has turned into shallow water with marshland (see Figure A 20).

Figure A 20 Meiktila Lake, silted up, fishermen

Because of the siltation the amount of available fresh water for drinking water, irrigation purpose and potential new services has decreased considerably. An additional problem is poor dam control and single purpose management of the system. There is insufficient cooperation between all the institutes, other stakeholders and users. Water usage is not planned in the future and potential new services are not recognised. Also there is no agreement on priority and water shares for periods of water shortage. Coordination on water resource management is lacking. This inhibits the social and economic development of the Township Meiktila.

Lake Meiktila, in its total context, would be an ideal project to put the IWRM strategy into practice. The following paragraphs briefly describe what the study team has learned about the lake during some internet research, limited field work, a few water quality samples and a workshop with over 60 stakeholders (representatives of different ministries, NGO's, school teachers and local politicians of different parties) in Meiktila.

A7.3 Current Situation

The physical system

Lake Meiktila is situated in the central dry zone. It is made up of a sequence of artificial lakes, created by constructed dams, connected by natural rivers and (man-made) channels. It was built to maintain fresh (rain) water into the area, especially for drinking water and irrigation purpose. Other uses are some (illegal) fisheries, minor discharge of domestic water and some (unconfirmed) industrial waste water.

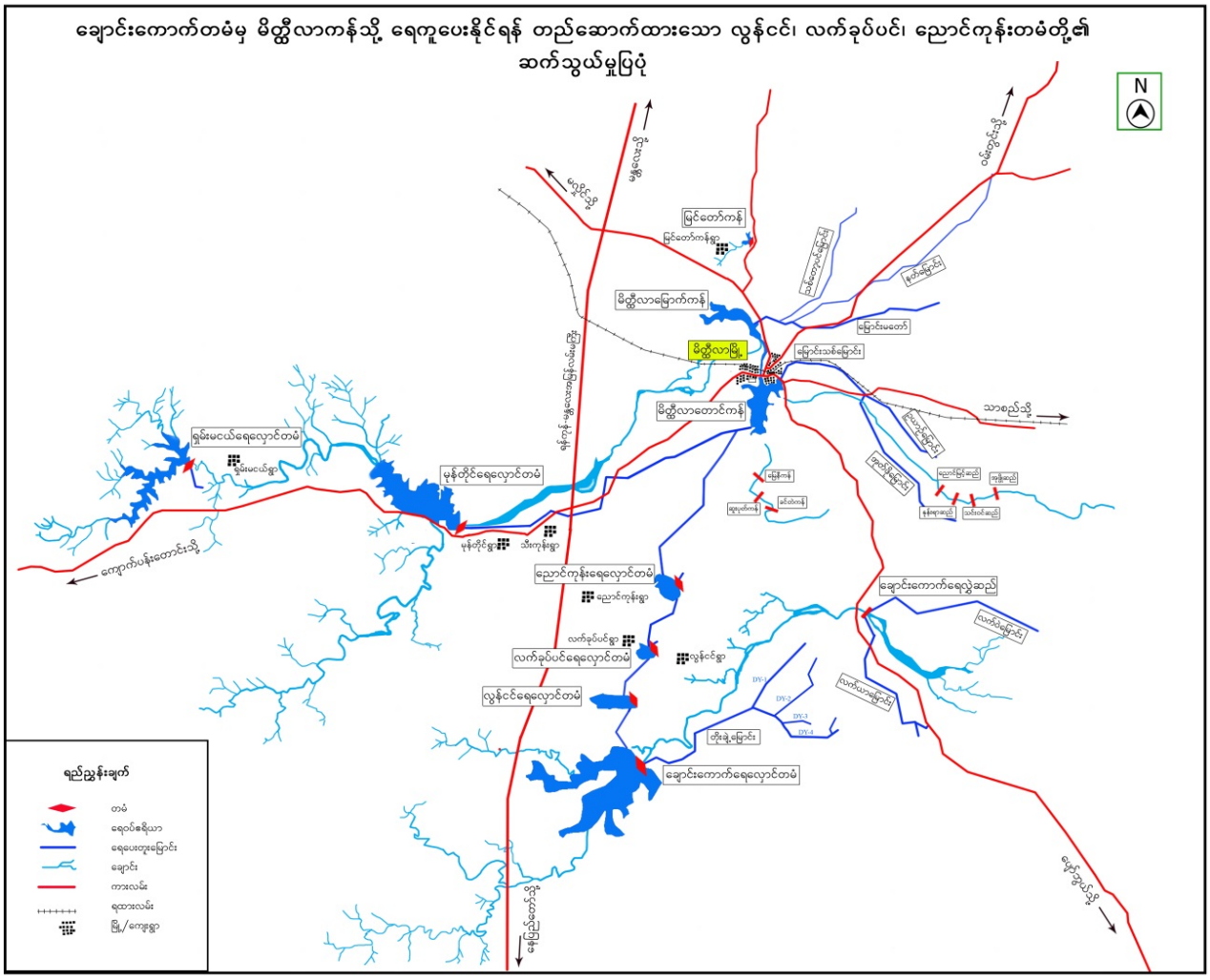


Figure A 21 Schematic map of the irrigation system of Meiktila *[source: MoAI, ID]*

The main cause of the siltation is estimated to be deforestation along the creek and canal system leading into the Northern lake. This part of the lake has become shallow with very high turbidity, hence reducing the amount of water available for its users. A first estimation is that the total silt volume in the lake is about 25 million m^3.

It is expected that the lake is not significantly polluted by fertilisers and pesticides. However, water quality analyses on these substances are very rare. Recent samples from the Northern Lake show no reasons for concern. However only 'standard' parameters were analysed. At the Southern lake the Township, in 2014, has built a drinking water treatment plant for 30.000 households. Samples were taken but no serious pollutants were found. A textile factory is discharging its waste water into a channel downstream of the lake from which farmers take irrigation water. The impact on the water quality is not known. It is expected that urban solid waste (organic and non-organic) will flow into the lake during the rainy season, thus polluting the water.

There have been some attempts to re-plant trees in order to reduce siltation, but so far these measures failed. It is unclear why.

Socio-Economic Qualities of Meiktila

The city of Meiktila accommodates several military squadrons and various universities. The region is an important agricultural area with its main market in Meiktila and Mandalay. Main crops are paddy rice, beans and onions. There is much trade and a textile factory. The area attracts some tourists, mainly from Japan, visiting Japanese burial grounds from the Second World War The Township is strategically located at a junction of 2 highways in the proximity of Bagan, Mandalay and Mount Popa.

During the workshop a subgroup of stakeholders discussed the socio-economic opportunities for this area. They explained that rehabilitation of the existing lake and irrigation system can lead to an expansion in agriculture by 10.000 acres. There was also a great deal of interest in agro/food processing industry, agribased industry, technology, solar and wind power and reviving the air transport.

Water Governance

The first restriction the study team encountered was the lack of data. There is almost no data about the lake available. A hydrological balance is lacking and water quality data are scarce and unreliable. The amount of sediment and its quality is unknown. There are no geotechnical data of the lake bottom and embankment. The study team observed disagreements about facts among the stakeholders that participated in the workshop. A comprehensive survey of the lake and surroundings is needed to make transparent decisions about the management of the lake.

Meiktila is a township and district in the Mandalay Region. Most ministries have a local office here. The Irrigation Department of the Ministry of Agriculture and Irrigation operates the irrigation system. There are monthly meetings between departments to share knowledge of each other's activities and interests.

There is some form of stakeholder consultation with the farmers. It was explained that per irrigation channel one farmer is chosen for consultation, mainly about water needs for their crops. The study team also knows that the Ministry of Livestock, Fisheries and Rural Development uses a bottom up process to prioritise projects for drinking water improvements.

There did not seem to be dialogue with other users, such as the fishermen, the military base and the textile factory. For a proper and sustainable management of the lake all stakeholders should be involved in decision making processes.

Like anywhere in Myanmar, there is inadequate legislation and enforcement to protect the lake against pollution. Policy and protocols on how the lake water should be managed and shared are not available. Without these guidelines there can be no good and transparent water management.

A7.4 Proposed Strategy

Building blocks

The case of Lake Meiktila is a good opportunity to put the building blocks of this IWRM strategy into effect with respect to lake watersheds. Meiktila is of particular interest as township level development with IWRM at lake watershed level as driving force. The key elements are:

- Monitoring, data collection, modelling and data transparency;
- Capacity building for both the lake managers as the lake users;
- Integrated lake catchment approach to reach a multi-purpose and feasible improvement;
- Step by step improvement of the current socio-economic situation through water security (i.e. water availability; water quality; water safety).

There are certainly quick wins to be named: a collective and controlled solid waste management, enhanced control of domestic waste water and encouragement of water savings.

Monitoring, data collection, modelling and data transparency

Transparency, accountability, responsibility, between the government and the people was the main message that resulted from the workshop. Decision-making needs to be based on reliable data. The following is deemed necessary:

- Data on water quantity (water balance; present and future water use for all purposes);
- Data on water quality (lake water; drinking water);
- Soil map (dam protection/stability, the dam is vulnerable for flooding, and nobody actually knows how the soil mechanics of the dam react under pressure);
- Information on watershed area:
    - Topography, land use map and vegetation map;
    - impact assessment of deforestation. (little is known about the effect of deforestation on erosion and sedimentation of the canals, while everybody suspects that this is a major cause of the deterioration of the northern lake.;
    - Impact of climate change (for example paddies that were used successfully 30 years ago, now don't get enough irrigation water).
- Developments around the lake (town development, industrial development);
- Technological information in order to provide good measures for maintenance;
- Flood prediction and protection data, based (to begin with) on an analysis of historical data.

For a good analyses of the lake problems and to determine possible solutions (e.g. dredging) an environmental impact assessment (EIA) is proposed. An EIA can support a transparent decision making process and may be a good tool to involve all stakeholders in this process.

An important side effect can be the introduction of EIA in the capacity development program.

Capacity building for both the lake water managers as the lake users

There are several forms of capacity building required:

- Training on IWRM for the staff that is involved in any aspect of the lake water management or water use would greatly increase mutual understanding of the issues. Probably an increase in staff and budget are required to perform their tasks better.
- Training on stakeholder participation would be beneficial to get more results from their stakeholder consultation efforts.
- A regular course on IWRM on the relevant Universities in Meiktila would train potential future water managers.
- Information on water use and pollution prevention on schools and in public places, such as libraries would increase the water awareness and perhaps eventually result in some water savings.

The first step in taking structural measures is a technical, social, economic and environmental feasibility study for rehabilitation of the lake and irrigation system.

The financial / economic feasibility of the measures need proper assessment. It can be expected that economic benefits could outweigh related costs, especially if the focus is on rehabilitation of the existing irrigation scheme at relatively low cost, which could lead to improved yields and an expanded irrigated area. Financial feasibility however will be more difficult to achieve as the current irrigation water tariffs are heavily subsidised by the Government of Myanmar and are not charged on a volumetric basis but rather on a per acre/crop/harvest basis. The latter can cause excessive water use and neglected operation & maintenance.

The second step is developing a concrete plan for (phased) implementation, containing:

- IWRM Plan for the entire catchment of Meiktila Lake, through participation, containing well balanced decision of water use, now and in the future (say 5 years with an outlook on 10 years)
- Lake design plan (size, shape, depth, bank design)
- Dredging works, including potential re-use of the sediments.
- Reforestation plan
- Water governance improvement
- Management and maintenance plan
- Pollution prevention measures (licensing and water treatment)
- Costs and financing options
- Special consideration is to be given to a phased implementation with a list of quick-win/ no-regret measures and measures to be implemented in or over a longer term.

A7.5 Financing

As the majority of the measures are expected to have limited direct revenue generating capacity, it is expected that the financing for the bulk of the investment will need to be sourced from public sources. As the Government of Myanmar capital expenditure budget is constrained [18], development partner concessional loans and preferably investment grants are the most likely financing sources. In order to be eligible for such funding, clear socio-economic benefits will need to be demonstrated.

[18] For example, the annual capital expenditure budget for the water resources department within the MECFA is USD 10 million only *for the whole country*

Nevertheless, the following subprojects have been identified which could attract private sector interest and finance to some limited extent, if financial feasibility can be demonstrated:

- Operation & maintenance contract of the new water treatment plant, possibly inclusive of rehabilitation and extension, of the existing water distribution network in Meiktila.

  Reduced non-revenue water, combined with improved service levels can lead to an improved willingness to pay from the existing water consumers and hence an improved commercial performance. These operational & commercial improvements combined with an existing water tariff at a sufficient level might make this subproject financially viable.

- If a market exists for dredged soil which can be re-used either as fertiliser or as construction material, private companies might be interested to get a concession – and even pay for it – to dredge the Northern Lake. A hybrid structure can be thought of in which interested private sector are paid against performance whereby part of their costs are set off against proceeds of the dredged material. This can be done directly in which the dredging company carries the demand risk for the sale of the dredged material or indirect in which the public authority sells the dredged material and uses the proceeds to pay the dredging contractor.

- A final project idea is to engage a private contractor to operate and maintain the (improved) irrigation system whereby water sales to irrigation users are used to off-set its costs. As the current irrigation water charges are low, likely this structure can only work if government is topping up the water charge with a performance based system (i.e. linked to continuous water availability for end users) which properly incentivises the private O&M contactor to improve its operations while ensuring improved services to end users.

Appendix 8 Paddy Land Development in the Ayeyarwady Delta

This appendix has been copied from the Delta Alliance scoping report about the Ayeyarwady Delta. Delta Alliance (WUR and Deltares) have written this report in assignment of Global Water Partners. The headings of the different sections have been adjusted to fit in this document.

A8.1 Agriculture

A8.1.1 Importance of the agricultural sector

Agriculture is traditionally a very important driver for the Myanmar economy. Although the Ayeyarwady Region occupies only 5 percent of all national land in the Union, it is known as the rice bowl of the country as it produces most of the rice requirements of the country. Annual rice production of Ayeyarwady Region of about 6 million tons accounts for 30 percent of total production in Myanmar of which about 22 million tons annually (FAO, 2001/2002). This situation is mainly due to increase of farmland area, especially, 25 percent increase between 1990 and 1994.

The increase of the rice production in the Ayeyarwady Delta got an important boost in the period 1976 - 1988 with the implementation of the Paddy Land Development Projects 1 and 2 (World Bank Projects).

Table A 10 Land use in the Ayeyarwady Region 2012 – 2013 [source Irrigation Department]

Type	Area in ha	%
Cultivatable 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	100.00

The projects consisted mainly of the construction of polders in the lower delta provided with embankments, sluice gates and drainage systems, hence protecting the land from salt water intrusion. For instance in Pyapon District the paddy cultivation area increased by the construction of 7 polders from 12,000 hectares in 1976 to 34,500 hectares in 1985. In the Laputta District the embankment enclose an area of 42,000 hectares.

Rice accounts for 97 percent of total food grain production by weight. Through collaboration with the International Rice Research Institute (IRRI), 52 modern rice varieties were released in the country between 1966 and 1997, helping to increase national rice production to 14 million tons in 1987 and to 19 million tons in 1996.

In addition to rice farming, aquaculture, poultry and pig farms are being operated. Moreover, some areas (like Labutta Township) are famous for salt production. Some vegetables are grown for home consumption and the surplus as other source of income. Rice is followed by black gram as winter crops.

Cash crop production like vegetables is an important income source mainly for landless farmer. For instance, some farmers in Labutta North Polder cultivate cauliflower, cucumber, water melon,

pumpkin, leaf on small scale farm land. According to the farmers, profit of vegetable production is higher than paddy production.

Table A 11 Crop area in 2011-2012 for Ayeyarwady Region [Source Irrigation Department]

Name of Crops	- 2011-2012 (hectare)	
Paddy	1,933,654	
Monsoon		1,473,564
Summer		460,090
Corn	6,280	6280
Oil Seed Crops	96,672	
Ground nut		46,545
Sesame		10,900
Sunflower		39,227
Pulses	547,127	
Black gram		455,295
Green gram		89,910
Pigeon pea		1,922
Cotton	126	126
Sugar cane	117	117
Total	2,583,976	2,583,976

Livestock is an important asset and work force for farmers. Most of farmers own water buffalo, pig and/or poultry. It is reported that many villages in the Ayeyarwady Region have inadequate work force due to the loss of huge numbers of water buffalos caused by Cyclone Nargis.

A8.1.2 Agricultural practices

Agricultural are generally still very low tech. Land preparation (by ploughing) is hard work for the farmer due to very hard soil dried up by strong sunshine in dry season. Usually, the water buffalo is used for ploughing at the beginning of the monsoon season. Use of hand tractor is limited because of its low availability in the village area, financial deficit and also low quality of machinery (or low durability against hard soil).

A distinction has to be made between the rain fed monsoon paddy and the irrigated summer paddy. For the monsoon paddy only local rice varieties and low input levels are applied. Data obtained from the Irrigation Department indicate that for monsoon paddy in the Ayeyarwady on average only 32.5 kg/ha of fertiliser is being used. The High Yielding Varieties (HYV) are

not suitable for the rather uncontrollable water levels in the paddy fields during the monsoon season. Also the taste of the local varieties is preferred above the one of the HYV.

Due to unavailability of fresh water in the lower delta the irrigated summer paddy can only be cultivated in the middle and higher regions of the delta, unless special water conveyance canals are constructed for the transport of fresh water from upstream tidal reaches of the river. Better water control permits the use of HYV and the application of higher input levels of fertiliser and pesticides.

A8.1.3 Crop Yields and Prices

Cropping yields are still low. According to the Agricultural Census 1985-86 to 1995-96, average cropping yield of paddy in Ayeyarwady Region is 3,250 kg/hectare. Information obtained from the Irrigation Department in the Pyapon District during the mission indicates an average production of 55 baskets/acre (2,890 kg/hectare) for rain fed monsoon paddy and 95 baskets/acre (4,990 kg/hectare) for irrigated summer paddy. Potential cropping yield of local variety is originally low because of low response to fertiliser, etc.

Therefore, application of HYV (High Yielding Variety) to a larger extent is necessary, if drastic increase of paddy production is required. For applying HYV, constraints like i) high investment cost, ii) unstable paddy price and iii) unverified appropriateness and cropping technology of HYV in field, should be solved to reduce farmer's risk. In addition, the quality (taste) of HYV is considered low by the people compared to the local varieties. Under the above mentioned situation, improvement of both production amount and quality is indispensable to secure stable supply of high quality rice for the country and to grow paddy as an export crop.

A minimum price for rice is guaranteed by the Government. Because of its quality the price of the local varieties is considerably higher than for HYV. The prices can triple in the course of the season. Due to low storage capacity, lack of farmer organisations, need for cash for daily life and reimbursement of credits, the farmers tend to sell their products for a low price directly after the harvest. The large variation in price during the year provides high margins for the merchants. This issue should get special attention in view of the desired improvement of the resilience of the rural communities.

A8.1.4 Agricultural Damage by Cyclone Nargis

Inflow of saline water into paddy fields by Nargis decreased agricultural production instantly. According to farmers in Labutta North Polder, cropping yield of paddy of immediate crop after Nargis attack was decreased to 10-20 baskets/acre equivalent to minus 50-75 percent from 40-50 baskets of cropping yield before Nargis (local variety) (JICA, 2011). However, cropping yield of 2009 cropping season has recovered with a yield of 40-50 baskets/acre. By puddling the soil and subsequent surface drainage the salt deposit in the soil could be removed. Main farming constraints are lack of input of farming tools, draft animal, fertiliser and access to agricultural finance. These constraints became worse after Cyclone Nargis. Especially, the number of farmers without draft animal increased from 4 percent to 35 percent.

A8.1.5 Polders: Embankments, Sluices and Drainage System

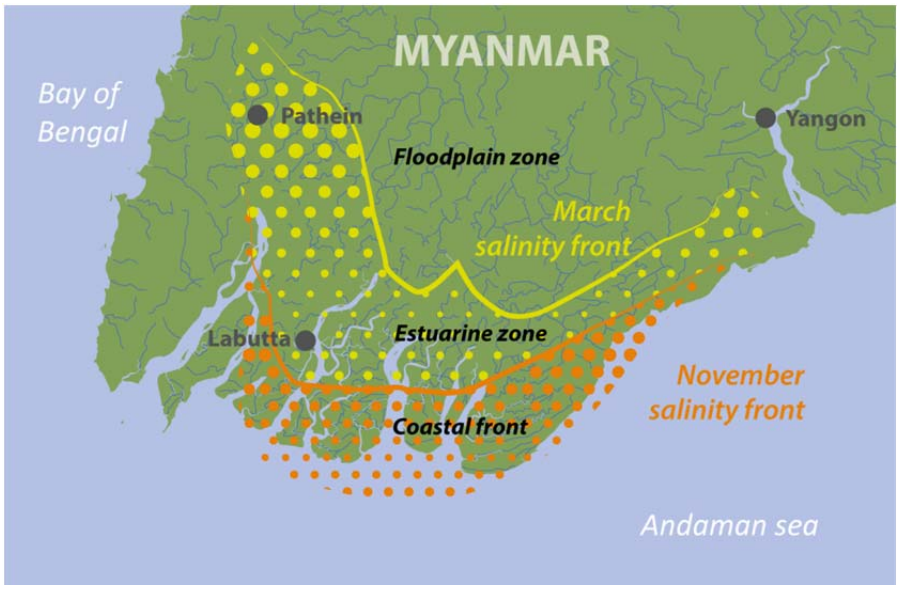


Figure A 22 Average salinity intrusion in the Ayeyarwady Delta (1 ppt line) [source: MyFish 2012 and Delta Alliance, December 2013]

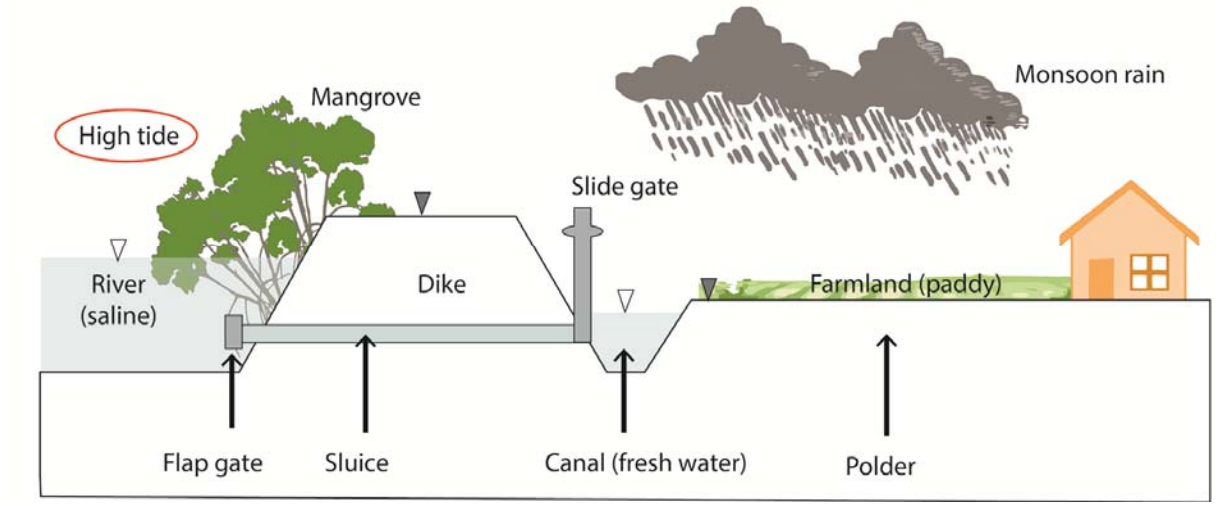


Figure A 23 Functioning of a polder in the lower delta *(JICA, 2011),*

The monsoon paddy cultivation in the lower delta is only possible if the land is effectively protected against intrusion of saline water through the construction of polders mainly consisting of embankments, sluice gates and drainage systems. **Figure A 22** presents the progressive salinity intrusion in the delta during the dry season.

In view of the precipitation quantities supplementary irrigation is not needed during the monsoon season. There is also no need to store abundant rainwater during the rainy season. Contrary, due to the heavy rainfall intensities, the role of the drainage canal 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. The old river courses are functioning as major drainage channels

and small artificial drainage canals are connected as required in the areas with embankment. Whereas in the areas surrounded by polder dykes, artificial drainage canals are predominant.

Figure A 24 Embankments (red lines) in Ayeyarwady Region *[source MoAI, ID].*

In the final stage of the rainy season the slide gates of the sluice located end points of the drainage canal are closed to store the fresh rainwater in the drainage canals. However, the salt water intrusions are occasionally found through the degraded slide gates and also through leaking flap gates; hence the water impounded in the drainage canal is contaminated with salty water.

A8.1.6 Irrigation

As the average annual rainfall can be more than 3,000 mm and concentrated in the rainy season from May to October, no irrigation is practiced for rainy season paddy cultivation in the area. At the end of the monsoon season the fresh rainwater is stored in the drainage canal for irrigation, livestock and miscellaneous purposes for the dry season.

In the lower delta irrigation is practiced during the dry season from November to April in the limited paddy fields located nearby the larger drainage canals by pumping the water from the canal. Diesel pumps are used and lifted water is conveyed through small ditches or in plot to plot method.

There are however also several special polder areas where irrigation water is conveyed from the intake of the upstream reach of the tidal river where the water is fresh and free from salt water contamination (JICA, 2011). For instance in Labutta North polder, the irrigation water in the dry season from October to April is conveyed from the sluice gate intake located 16 miles (26 km) from the north boundary polder dyke in the upstream of Ywe River. The irrigation water is conveyed through the feeder canal and it is filled into the drainage canals. Then the irrigation water is to be supplied to the field along the drainage canal by pumping. The project was completed in the year 2000, and the beneficial area is 2,500 acres (1,000 ha). However, it seems that the project did not accomplish the initially proposed target of the irrigation area and paddy production.

Tidal irrigation during the dry season is extensively practiced in the middle delta, while in the upper delta irrigation takes place by gravity (in case of upstream intake) or pumping.

A8.1.7 Problems with Agricultural and Rural Infrastructure

JICA (2011) identified the problems with agriculture and rural infrastructure after Nargis as follows:

1) *Low height of polder dyke:* Emergency rehabilitation work to restore the crest elevation of the dyke to its original height before the Nargis has been completed already by the Government (Irrigation Department).

2) *Poor water tightness of sluice gates:* Salt concentrations of water in the drainage are too high due to saline water intrusion through damaged sluices. This seriously affects farming in the serviced areas. In addition, inundation of farms occurs due to poor drainage caused by uncontrolled sluice gate in wet season.

A8.1.8 Problems on Farming

As far as the present farming system in the Ayeyarwady Delta is concerned, the World Bank study (August, 1999) described it concisely as follows:

"The Ayeyarwady Delta of southern Myanmar is a fragile and intricate ecosystem of mangrove swamps and tidal estuaries. Non saline arable areas are limited and becoming scarce due to the erosion of riverbanks, saltwater intrusion, and increasing soil salinity. Poor water control and drainage works contribute to periodic flooding and crop losses. Most poor households cultivate a single crop of traditional monsoon paddy. Better-off farmers are able to grow early maturing, high-yielding varieties of paddy benefit from an additional winter crop such as groundnuts or soybeans. In the very few areas where irrigation facilities are available, summer paddy is grown. Marginal farm households cannot afford to use chemical fertiliser or manure and suffer from declining crop yields. In some townships such as Laputta, Bogalay and Mawlamyaingyun, it is estimated that more than half of the population is landless. Many marginal farmers engage in fishing and crabbing. Those who fish typically do not own fishing gear or boats and depend on fish traders for such resources. Some households raise pigs, chickens, or ducks. Others crop during the slack growing season by borrowing from more well-off farmers; loans are paid back through labour or through a portion of paddy crop. The effective interest rate charged by fish traders, rice traders and others in these loan

arrangements typically amount to 10 per cent a month"

According to JICA (2011) the major problems on farming in the Nargis areas can be summarised as follows:

1) *Poor farming techniques:* Since natural soil condition of polder areas have been deteriorated, adequate farm management is essential to reduce such risk. Most of farmers in polder areas have practiced traditional farming such as "use of ordinary (low quality) seed", "inadequate use of fertiliser", "non-regular row transplanting method", etc. which have kept the productivity low.
2) *Lack of support on farming technique:* the number of staff of the Myanmar Agriculture Service MAS (now change its name as Agriculture Department), which is the responsible agency to provide extension services to farmers, was drastically decreased during the past 10 years. Consequently it has resulted to the slowing of agricultural developments.
3) *Lack of farming inputs:* Lack of seed, fertiliser, animal-power and agricultural finance have become serious especially after Nargis. Inputs such as seed and fertiliser are required at every cropping season on a permanent basis. Therefore, supply of these inputs should be secured to realise agricultural recovery and further development in the polder areas on medium and long-term basis. Lack of adequate agricultural loans is also a serious issue and farmers have to consider private agricultural loans, which require very high interest rates. As a consequence some farmers are forced to sell their paddy immediately after harvest in order to repay their loan.

In addition, the lack of farm-to-market roads or roads in general in the southern delta should be added as a serious constraint.

A8.2 Fisheries

A8.2.1 Fisheries in the Ayeyarwady Delta

The fishery sector is the most important sector in the Ayeyarwady Delta after the agriculture sector. The fishery sector maintains a high per capita consumption of about 43 kg/year according to the statistics of year 2008-2009. The main fishery resources in Myanmar include:

- fresh water through
  - fish culture
  - leasable resource
  - open fisheries
- marine fishery through:
  - in-shore fisheries
  - off-shore fisheries

These fishery practices take place in three main ecological zones in the delta which are related to distance to the sea and salinity level:

- a floodplain zone characterised by freshwater or a very low salinity maximum, the presence of freshwater fish species, large scale fencing for fishing and an unknown percentage of migratory species;

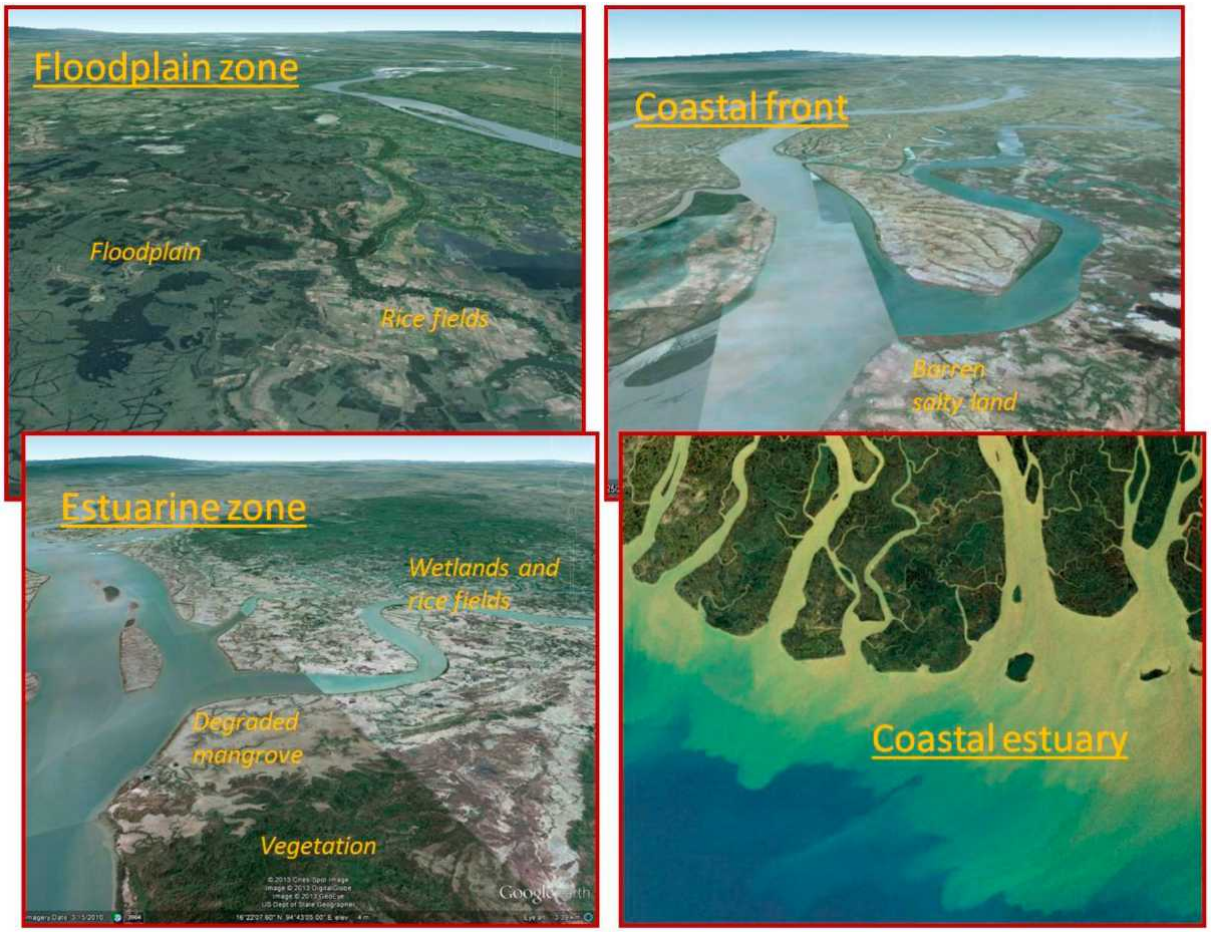


Figure A 25 Ecological zones *[source; MyFish, 2012]*

- an estuarine zone characterised by multiple waterways, temporary brackish water, typically estuarine species, degraded mangroves along waterways and a patchwork of rice fields, trees and villages;
- a coastal front characterised by a very flat land, quasi- permanent brackish water, salty soils, almost no vegetation and fishing activities targeting the coastal and marine zones.

A JICA (2011) study confirmed that fishery stands as the second important source of income after farming in all survey villages located in survey areas of six townships in the delta. Fishing and processing of fishery products provide an opportunity for landless people to earn income for their livelihood. Based on information from the key informants' survey, prawn is the most important source of income in the aquaculture industry in the villages and is given first priority for earning income. Dry prawn, fried fish and prawn paste making industries are performed in most of the surveyed villages.

The FAO report (2003) on Myanmar Aquaculture and Inland Fisheries gives the best overview of current fishing practices and developments. The MYFISH report (2012) on 'Delta draft scoping report ''Improving Research and Development of Myanmar's Inland and Coastal Fishery' provided a recent update.

In this MYFISH report (2012) it is concluded that there is an increasing loss of connectivity in floodplains due to the extension of rice farming. Like in the Mekong, there is a trade- off between rice production development and sustainability of the capture fish resource.

In the past years, in the diversity of catches and in biomass; the main species characterised by a strong reduction are snakeheads and catfishes. It seemed that the fish species composition looks richer in the floodplain zone than further downstream, which is surprising (the biodiversity of estuarine zones is generally much higher than that of rivers since they combine representatives of the freshwater, brackish and estuarine faunas. Similarly the contribution of migratory species to the biodiversity and to fish yields in this ecological zone is not clear. This zone is characterised by substantial collective efforts in the past to restock water bodies in order to sustain the productivity (lease holders must invest into restocking, and hatcheries provide fingerlings). However water bodies are stocked with mainly aquaculture farmed species (rohu, tilapia, catla and silver barb), and there is no assessment of: (i) the efficiency of the restocking efforts, or (ii) their impact on the natural biodiversity.

There is clearly an opportunity for research on the effect on natural productivity of current restocking efforts and on possible improved options in terms of stocking densities, stocking periods, species stocked, water bodies to be stocked, etc. However, there is also a risk that this research ultimately demonstrates that either the former efforts were not effective, which would not be politically welcome, or that they were actually effective, which would not be very useful in terms of applied research.

From a national perspective the fisheries economics of the estuarine zone are clearly more influenced by coastal and marine fisheries than by local catches, however local fisheries and the lease system play an important role for small shareholders and local communities. The respective role of changes in policies, in competition and in the resource base are not clear and deserve clarification; from that perspective research in biology could focus on medium to long- term trends in species composition, catches and dominance.

Table A 12 Inland and marine fisheries production (in thousand metric ton, rounded figures)

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

Dwellers of the coastal zone are clearly among the poorest of the delta; they suffer from harsh natural conditions and from a social and economic disintegration following Nargis.

Aquaculture production in Myanmar has grown in the past decade, see also Table A 12. Commercial fish farming, including some large scale fish farms, have grown successfully in

Myanmar in recent years, but now appear to be facing considerable difficulties in sustaining commercial operations. Large scale aquaculture production in Myanmar is characterised by low productivity and low diversity. The main focus of the production system is on the slow growing, low value commercial species. Ponds are typically large (often 20 hectares by pond) with slow grow-out periods of between 18 to 24 months. Pond resources are not efficiently used. Farms provide seasonal low levels of employment. The low productivity of the aquaculture system is compounded by increasing input costs (feed, labour and electricity) and low outputs benefits raising concerns about the long-term sustainability of the model, the species economics and markets. Large scale export oriented enterprises have reverted to selling on domestic markets, practices in themselves which may be influencing competitiveness of smaller scale commercial producers. Commercial aquaculture enterprises could provide employment, food security and extension and inputs that can support a small scale household oriented aquaculture development. Hatcheries appear to be underperforming, and carp breeding and hatchery programs need revitalisation.

Employment opportunities in fisheries and aquaculture are seasonal in nature.

Production systems for fish are dominated by extensive and semi- intensive ponds, with some marine and cage culture and rice- fish farming. Scale of production varies, but particularly in the Ayeyarwady delta region, large ponds and more commercially oriented enterprises appear to make most significant contributions to fish supply.
Small scale household level aquaculture is surprisingly absent; it can be found with mixed success. Institutional, policy and services appear not yet to be favourable to development of this part of the sector, and it is uncertain whether the present investments will sustain and are able to move to a scale where they can make significant differences to the income and nutrition of the many poor and vulnerable households in the Ayeyarwady delta, or elsewhere in the country (which remains to be investigated).

The Australian Government through the Australian Centre for International Agricultural Research (ACIAR) is funding a $AUD 10 million multi-disciplinary Research, Development & Extension program in Myanmar that is focussed on improving food security and livelihoods for small holders in the Central Dry Zone and Ayeyarwady Delta. WorldFish is the implementing agency for the AUS$ 2 million fishery component of the program and has developed a project for "Improving research and development of Myanmar's inland and coastal fishery" over the next 4 years, which is called MYFish (Myanmar WorldFish). The project has been developed together with a number of local partners and in particular the Department of Fisheries (DoF) and the NGO association the Food Security Working Group (FSWG). MYFish aims to improve the capacity for management of Myanmar's inland capture and culture fisheries and facilitate the emergence of co management of fisheries and small-scale aquaculture as cornerstones of rural food security and livelihoods.

Three project objectives have been identified to achieve this aim:

1. To characterise the fisheries sector in the Ayeyarwady Delta and to assess the scope for fisheries development in the Central Dry Zone.
2. To identify, test and then demonstrate new approaches to increase productivity, efficiency, sustainability and equity in fisheries production systems in the Ayeyarwady Delta and the Central Dry Zone.
3. To strengthen the capacity of Government, private sector and non-government organisations to carry out appropriate research & development for the fisheries sector.

The project has carried out a scoping mission in November 2012 in the Ayeyarwady Delta, with the objective to undertake a rapid assessment of the fishery sector, to develop a

framework for researchable projects and to contribute to a characterisation study of the Delta in 2013.

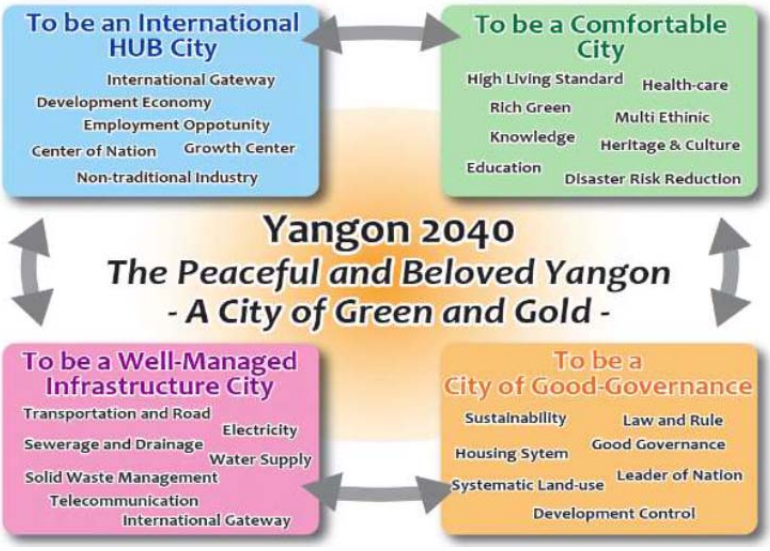
A8.2.2 Problems on fisheries

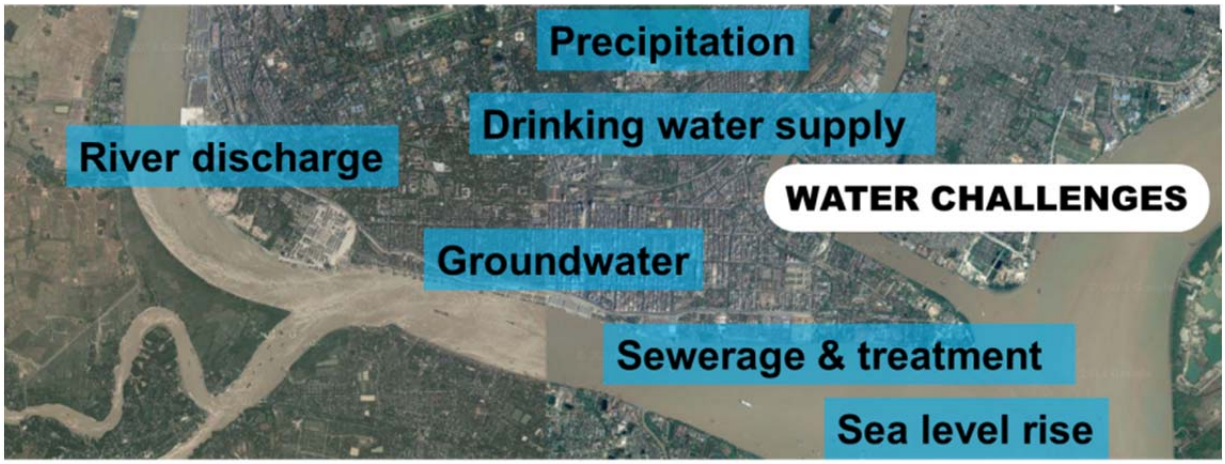
According to WorldFish, the Ayeyarwady Delta has the potential to be as productive as the Mekong Delta. However, pressures (such as overfishing, destructive fishing practices, reduced fish migration routes due to dams) exploitation mangroves, limited research and development and monitoring, increasing water pollution) are now being exerted on fish stocks and the natural resources that support production in the Delta and there are concerns that current fish production, consumption and export earnings levels may become difficult to maintain. Anecdotal information from fishery communities also suggests that fish catches have yet to return to pre-Cyclone Nargis levels.

Appendix 9 Yangon River Front Development

A9.1 Vision 2040

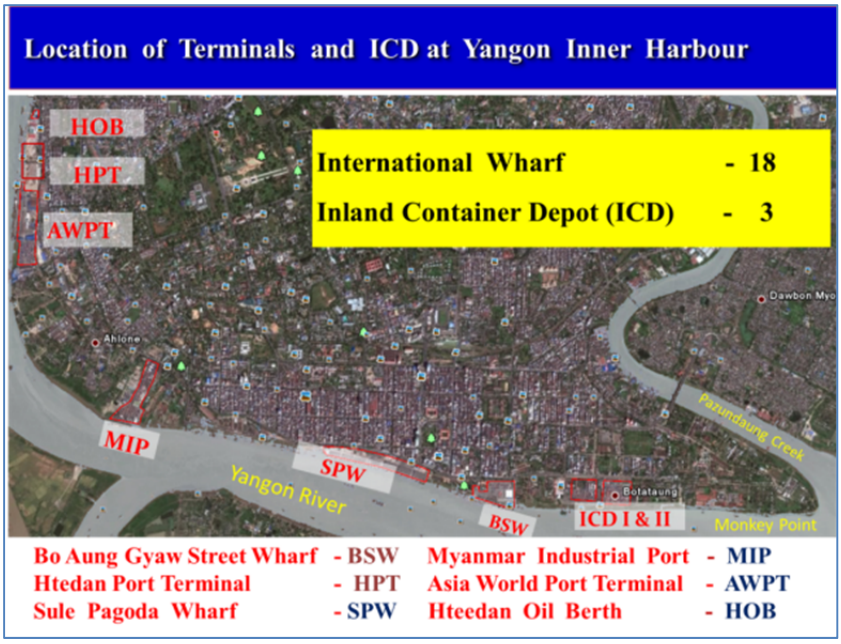
JICA has supported Yangon City Development Committee (YCDC) with the elaboration of a vision on Yangon 2040. The city is expected to grow from 5,5 million at this moment to 11,7 Million of which 8,5 million will be living in the city limits. This brings enormous challenges related to all urban functions. Taking in to account the already existing challenges in the Central Business District (CBD), prompt response is required to facilitate a sustainable development. A broad range of water related problems occur. Water supply (quality as well as quantity) is not always reliable. It is not clear how much groundwater is subtracted and if land subsidence already is or will become a problem. The storm water drainage system often proofs to be insufficient causing many flood related problems during the rainy season. A large part of the city drains towards the CBD area. River discharge or sea level rise are not so much a risk but with climate change and the foreseen urban development south of the river this could well become a risk. The sewerage system in the CBD has been constructed by the British, is close to a century old, overflows regularly and there is only minor treatment before the sewerage water is being discharged in to the Yangon river. The city is in its first steps to take climate change adaptation measures and the recreational and amenity value of the river has hardly been taken in to account up to now. The concepts of living with water is yet to be introduced. The CBD area is located at the river and future developments provide ample opportunities for all the above, or, if not taken in to account sufficiently, will aggravate already existing problems. To find proper solutions, an integrated approach is required. Only than the future riverfront will not be a result of a series of patchwork initiatives.





A9.2 Description actual developments in CBD

The actual port area of Yangon city covers most of the river front area of the CBD. It is expected that in the long run, these functions will be relocated to the Thilawa Special Economic Zone (SEZ). That means that land use at the river front area of the CBD will gradually change. This will provide ample opportunities to integrate this area in the urban functions. It will provide residential, commercial and recreational activities. The responsible authority is the Myanmar Port Authority (MPA) that resides under the Minister of Transport (MOT). They manage land use up to 50 metres land inwards from the highest experienced water level and they own most of the lands covered by port functions including the terminals. The MPA has recently developed a vision for the river front. This master plan, however, only covers harbour functions. The integration of urban and harbour functions was not one of the objectives of the master plan.



Property prices increase and already project developers are stepping in to gain position in the development of this area. Unsolicited proposals of developers are being discussed with the MPA.

MPA has a key position in the development of the area as they own most of the land near the river. Discussions between MPA and YCDC are ongoing in relation to what is allowed and what is not allowed in these areas, regulation exists but is not always clear as most of the regulations are obsolete and do not cover the issues of this era. The absence of a clear vision on the future development of the CBD and the

functions that should be facilitated by the river front area hampers the integration of the river front in the urban functions and its water system.

A9.3 Stakeholders

Different authorities are responsible for the development of such a vision or master plan. The MPA is to be included for they own most of the property and manage the actual harbour function. YCDC is responsible for the development of the urban functions. The DWIR is responsible for the river management. Furthermore, the Yangon Heritage Trust should be involved as their mission is to conserve Yangon's rich architectural heritage. Further assessment will be part of the next step to assure that all key stakeholders will be involved.

Important is to involve project developers and financiers to ensure that the development is of interest to them and that financial schemes will provide the required means to ensure a water system that facilitates and has added value for these developments.

Discussion with MOT should lead us to the stakeholder that has to be in the lead for this initiative. At this moment it seems as MPA and YCDC are most willing to participate but are not outspoken about who should coordinate such an initiative.

A9.4 Opportunities

Sound integrated water resources management could be a catalyst for coordinated development. The river offers ample opportunities to be integrated and to assure that the riverfront becomes an example of a resilient area prepared for climate change and built upon a thorough analysis required for a proficient water supply, sewerage and drainage system.

Water supply should be available on a continuous basis, water treatment should and can be improved with the new developments and risks related to storm water flooding as well as from the river can be minimised. These circumstances will facilitate an economically sustainable development along the Yangon River.

A broad vision for the city has been developed; however, a detailed elaboration for the river front is required.

A9.5 Financial opportunities

Such a coordinated, integrated urban development approach will improve the attractiveness and liveability of the CBD. A more appealing living environment attracts demand from residents and businesses alike for living and office space, and will catalyse associated services. It thus creates substantial added value through higher property prices and increased business activity. This offers attractive private sector opportunities, which will result in private sector investments. This private sector investment can be catalysed through public-private partnership arrangements, offering an opportunity to finance water related public infrastructure.

Worldwide substantial experience in PPP arrangements exist, which can unlock this potential. The following indicative listing of examples look promising for the Yangon river development:

1. Set up an urban development company which is responsible for the implementation of the integrated river front strategic development plan. Main public stakeholders like YCDC, MPA and possibly private parties can participate in it by injecting equity, and/or bring in land in exchange for equity. Proceeds of the sale or lease of land & development rights can be used to cross fund public infrastructure fitting within the riverfront development plan.

   Example: the development of the Amsterdam "Zuid-As" in the Netherlands (Infrastructure and Business) is a typical example of such a development company which combines the stakes of multiple stakeholders in one development company.

2. Organising solicited integrated urban development competitions with particular emphasis on integration of water & climate resilient requirements, fitting in the riverfront development plan. Current practice is to wait for developers to submit proposals. By turning around this process in a competitive procedure, more value for money will be created, as competitive pressure is likely to promote innovation resulting in better plans and better financial offers for the development rights. Also, the public party can much better ensure that the developments fit in its overall strategy, by including minimum (output) specifications in the bidding document package.

   Example: the “Kop van Zuid” urban development in Rotterdam, is an innovative approach in which an integrated urban development plan was tendered out on a competitive basis to a number of developers.

3. Organising design competitions to maximise (private sector) innovation capacity, resulting in better development plans.

   Example: quite recently, the U.S. Department of Housing and Urban Development (“HUD”) has successfully launched such a design competition to tackle the aftermath of hurricane Sandy: the “Rebuild by Design”. This design competition attracted wide international acclaim and resulted in 10 innovative proposals, with quite a number of Dutch companies' amongst the winning consortia.

The Yangon riverfront development offers many opportunities for Dutch businesses and public institutions. Dutch architects and urban design companies are internationally recognised, specifically in the development of water related, climate resilient integrated urban development plans. Opportunities exist for Dutch developers & contractors, if the quality of urban development projects, specifically integration with water issues, plays an important role in the bidding procedure. The municipalities of Amsterdam and Rotterdam have experience in setting up dedicated urban development companies, either public-public or public-private. The city of Rotterdam has developed a climate resilience strategy, currently under implementation, and is internationally active in this field (Ho Chi Minh City).

A9.6 A first step towards a resilient water river front

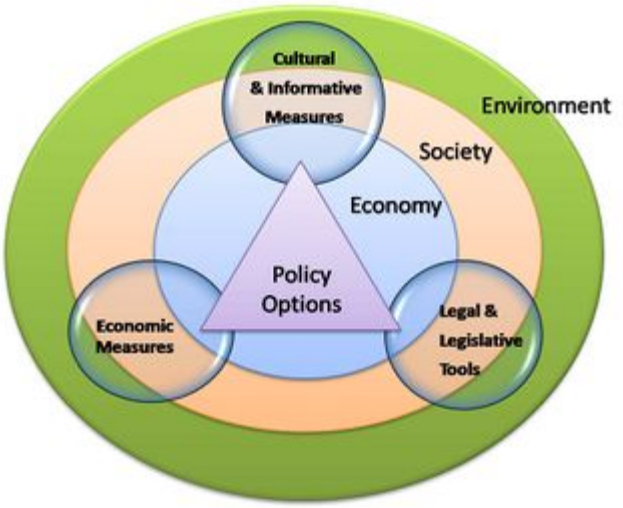
To arrive at a first reconnaissance of a master plan it is important to talk to the stakeholders and to bring them together to exchange ideas and identify common ground. This also includes interaction with companies (planning, investment, design, construction, operation) from the Netherlands that have experience in river front development. The latter could be done in the Netherlands and could lead to innovative ideas and an inventory of interests. Further identification of opportunities should be done with stakeholders in Yangon. A series of two multipurpose missions could provide the additional information required to bring this initiative further and draw up results from brainstorming, maps with functions and some general conclusions. These missions should include at least expertise on urban planning, urban water systems, water technology, ppp and other financial arrangements.

-Capacity building and knowledge exchange in these fields of expertise will be another added value that stakeholders can make good use of. Also governance is an important issue when related to urban river front development. The initiative could also lead to recommendations in relation to monitoring and data collection, hence, covering all the requirements for learning by doing.

Appendix 10 Dawei Integrated Coastal Spatial Plan

A10.1 Introduction to integrated coastal spatial planning

The coast of Myanmar is still pristine to moderately developed, but specific areas are expected to develop fast. Uncontrolled development will lead to cluttering of the coast resulting in lower social and economic value, for example because of negative impacts of development on each other, unsuitable infrastructure (energy/water), unsuitable transport chains, flood risk, sedimentation / navigation problems, pollution of sea and beaches. Even though there is a lot of development activity expected all along the coast, there is no bigger plan to steer these development for the best socio-economic and environmental result. Specific areas with interlinked developments on the coast are in need of integrated coastal spatial frameworks to support long-term development in a safe and sustainable way. An integrated spatial plan sets down where development/construction may take place and what may be built, under what conditions. An integrated **coastal** spatial plan combines good coastal zone management with spatial planning. The fixed components of a spatial plan are: the rules and regulations for the area concerned and an illustration (planning map) that indicates and explains the various zones.



A10.2 Pilot Integrated Coastal Spatial Plan for Dawei

Dawei is a city in south-eastern Myanmar and capital of Tanintharyi Region on the northern bank of the Dawei River. Dawei is a port at the head of the Dawei River estuary, 30 km from the Andaman Sea. As a result the city is prone to flooding during the monsoon season. Dawei is expected to develop fast. Dawei is an ideal area for a pilot on integrated coastal spatial planning, because:

- The potential development of a Special Economic Zone and deep sea port. There is still much debate on the most suitable location for this economic zone. In addition, there is much resistance to the plan because of its environmental and social impact, and there are questions about its economic viability.
- Dawei town and the nearby Maungmagan Beach have good potential for tourism.
- The Islands near Dawei are protected by a marine sanctuary status.

- The development of a deep sea port and infrastructure to Thailand will provide a fast connection to Bangkok. The project is carried out in close cooperation with Thailand. A feasibility study will be carried out by Japanese experts.
- Sediment transport along the coast is likely to impact navigation to the port.
- The area is prone to flooding in the monsoon season.

Figure A 26 Dawei Special Economic Zone, located in Tanintharyi, South Myanmar

The idea behind the pilot Dawei Integrated Coastal Spatial Plan is to combine ecology, economy and social welfare with the characteristics of hydrology and morphology of the sea and coast line. The coastal waters of Dawei are important for navigation, fishing, port developments and eco-tourism. The coast of Dawei is an interesting area to start a pilot on Coastal Zone Master Planning, because of its complex physical, economic, social and environmental situation. Therefore, it might be a good pilot for other regions; lessons learned here can be used elsewhere. Myanmar ministries and experts will have learned from this case about zoning of spatial planning for the coast and how developments interact with each other. A transparent Spatial Plan, developed with both (inter)national and regional stakeholders, will support responsible stewardship.

The key aim of the study is to use the regional strengths and weaknesses and to structure them for the most optimal spatial development. Other goals are:

- Provide analyses of social and economic opportunities and constraints in the Dawei area, both land based and coastal;
- Provide insight in the stakeholders and their spatial (development) requirements, such as infrastructure, transport needs, distance to port, distance to town, nature conservation, clean beaches, (human) resource needs, etc. These are combined with physical and environmental constraints;

- Provide safety advice (floods and other disasters) and information about water resources (fresh water availability, salt intrusion, pollution prevention, coastal currents, sediment transport, waves);
- Providing a strong tool to enable the responsible decision makers to fulfil their role as regulators and facilitators in regards to the management of the Dawei developments;
- Provide the responsible decision makers (Union, regional and local) with a decision support system on which informed decision making is possible.

For this pilot, the Dutch expertise in Spatial Planning ('kuststructuurvisie') would benefit the sustainable development of this area. Dutch knowledge on integrated spatial planning, EIA/SIA, port development, coastal zone management, sediment transport modelling, dredging, stakeholder involvement, etc, may to be brought together. A comprehensive Integrated Coastal Spatial Plan can support the relevant ministries in taking informed decisions.

A10.3 Approach and Feasibility

Phase 1 – A fact finding and scoping mission

The study team proposes to start with a joint fact finding and scoping mission for this pilot in which various Myanmar experts and stakeholders are brought together with Dutch experts. For example:

- Experts in the fields of coastal morphology and marine hydrology, marine and coastal ecology (from the expert group, the consortium, Yangon University, Delft University);
- Economists, spatial planners and landscape architects;
- Experts in planning business and industrial zones;
- SIA and EIA experts (for example the Dutch international branch of the EIA committee);
- Social and water governance experts, including stakeholder management;
- Port developers and shipping companies;
- Dredging companies;
- Hotel companies and other regional tourism businesses,

A four step approach is proposed:

1. Write Plan of Approach for the Fact-finding mission.
2. Fact-finding mission of about a week with the experts consisting of workshops and well-aimed site visits.
3. Draw preliminary report on the Dawei Integrated Coastal Spatial Plan.
4. Wrap-up session with go/no-go recommendation. The Triple Baseline, (a project must be economically viable, environmentally sustainable and socially inclusive), will offer excellent criteria to evaluate the results of the fact-finding. Results of this phase:
    - Preliminary report
    - Outline of funding for further development of the plan;
    - Capacity building and knowledge dissemination. Myanmar ministries and experts will have learned from this case about zoning of spatial planning for the coast and how developments interact with each other. Because of the extensive developments that are planned and the potential conflicts between these developments, this is a brilliant case to really practice with the triple baseline and

with interacting on a union, regional and township level, including the effects of federalisation.

The joint fact-finding results could to be part of the curriculum for the capacity building program as developed by UNESCO-IHE on integrated water resource management.

The Study Team is aware of the complex political, economic, social and environmental situation surrounding the Dawei case, and its high visibility. The assumption is that close collaboration with the EG of the NWRC and the relevant Departments and Regional government will ensure, via the participative approach mitigates the risk of political damage. At the same time, the strategic importance of the Dawei developments makes this an eye-catching showcase for strategic IWRM and strategic planning, based on the triple baseline. It might therefore transport IWRM out of the water domain, and into the overall strategic discussions on the future of Myanmar that are currently going on.

The scoping phase is feasible in the short term, because it requires only a very modest budget. Once the budget is allocated, the project can start immediately. This scoping phase needs to be financed with public funding.

A10.4 Phase 2 – Research and spatial planning process

Phase 2 includes research of the area, the process of spatial planning with the experts and stakeholders and making the spatial plan.

Aspects to research are:

- Wave movements (important for port accessibility);
- Flood risks;
- Coastal morphology (2D modelling);
- Water quality issues with respect to ecology and suitability for swimming;
- Ecological vision of this coast;
- Environmental impacts;
- Stakeholders analyses and strategy.

With this information the process of spatial planning can be started. This phase has good opportunities for private funding.

A10.5 Tripple Bottom Lines and People, Planet, Profit

The key to an Integrated Coastal Spatial Plan is to combine ecology, economy and social welfare. This is especially relevant for Dawei, where there is a real chance of profit overruling people and planet. The strategic importance of the Dawei developments makes this an eye-catching showcase for strategic IWRM and strategic planning, based on the triple baseline.

The process of integrated spatial planning is a good method to check if a plan meets the triple bottom line: economic viability, environmental sustainability, socially acceptable. An Integrated Coastal Spatial Plan reduces the risks of poor investments and expensive

measures. Transparent environmental impact assessments are key components for special master planning. A full EIA and Master Plan can provide conditions for sustainable developments in and around Dawei. In the current situation the development of the Special Industrial Zone and Deep Sea port may not be socially acceptable. The development of an Integrated Spatial Master Plan with full EIA is what many stakeholders want at this moment. They need to be consulted, need to be shown that all stakeholder interest are considered in a balanced way, need to understand the social and environmental impacts from an independent party and need to be ensured that adequate measures are taken to mitigate negative impacts.

Appendix 11 Capacity building on water governance

A11.1 Specific training on water governance

This proposal addresses capacity building needs in Myanmar in water governance. As needs are large, it is designed as a pilot programme in which high level professionals from relevant key national and regional governmental departments and agencies receive training on key concepts in water governance and, under supervision, study in depth one or two cases from different water governance perspectives (institutional, legal, economic; planning and implementation; central to regional levels). The latter will help to identify gaps to be addressed in follow up capacity building activities. Donors will be involved from the start to ensure coordination in this important area, and to help secure funding of these anticipated future steps. This proposed project aims to achieve: immediate knowledge dissemination about water governance; establish a network of communication/cooperation for professionals at key ministries; and develop recommendations for capacity building in water governance for the mid to long term. It is anticipated funding will be provided through the ADB-UNESCO-IHE Knowledge Partnership Fund. Other donors will be involved from the start in order to ensure coordination and help secure funding for mid- to long-term steps to be taken for capacity building on water governance.

The project is based on the following approach:

- The project will focus on broad capacity building in water governance at different levels.
- As capacity building needs are wide, the project will be designed as a first step: it will provide fundamentals in water governance to key participants and will also serve to analyse and scan needs in order to determine the most suitable options for a follow-up phase. Thus the participants of this stage would be ''agents of change'' or ''frontrunners''.
- Participants will be mainly high level participants from the national and regional levels. In addition, and at regular stages, representatives from other regions and from decentralised administrative layers will also be invited to provide input and learn from the process (particular those that will play a role in the case study areas).
- In the course of the project participants will be asked, and guided, to analyse the existing governance framework in Myanmar, to identify governance issues, and to assess how those could be addressed. Consequently, the project will be a combination of conceptual background, illustrated with regional/international examples, and a practical perspective on water governance through the in depth analysis of case studies.
- To focus the analysis, the case studies selected will highlight issues particularly relevant and highlighted in the IWRM Strategic Study. As a result, topics chosen would relate to governance in the dry zone with an emphasis on aspects such as droughts, pollution, permits, implementation, land use and environmental planning. The dry zone Meiktila Lake watershed is likely to be another case study. Focusing on a particular case will allow for an in-depth analysis of water governance from different perspectives (e.g. institutional, legislation, economic, planning and operational management). In addition to a horizontal analysis it will allow for an analysis of vertical interactions - national, regional, local - taking into account local and regional needs and issues. This approach could then be applied to other zones.

Key objectives

I. Immediate knowledge dissemination about water governance
II. Establish network of communication/cooperation for professionals at key ministries
III. Develop recommendations for capacity building in water governance for the mid to long term

More specifically, the objectives include:

- Become familiar with key concepts and principles of water governance, and be able to analyse water governance;
- Understand the current governance and policy regime in Myanmar, based on an evaluation of the existing governance framework (and legislation) and a mapping of the key actors in the water sector, to create cooperation and awareness of inter-linkages between different actors and their mandates, as well as to ascertain changes to be made and how to make them;
- Understand and apply the linkages from policy to implementation at different administrative levels (e.g. how to make master/basin plans and/or the need for stakeholder involvement, monitoring and enforcement);
- Further detail water governance needs, including capacity building needs, to complement the transition to effective IWRM operationalisation and facilitate its implementation in Myanmar;
- Offer a framework for the implementation of recommendations from the IWRM Strategic Study with regard to governance matters;
- Present results to decision-makers and donors, particularly recommendations and guidelines for capacity building with a longer time perspective.

Format and Schedule – 12 (up to 18) months

The format will be a combination of the following elements (to be adjusted during implementation):

- Plenary sessions (workshops) for all participants and for smaller groups
- Parallel sessions and working groups;
- Group assignments on case study areas (1 or 2) plus field visits
- On-the-job;
- Self-learning; and
- Coaching.

The table below presents the different components of the project with a suggested timeline. It is anticipated the first stage (to take place in month 1) will begin at the latest two months after the approval for funding has been secured.

Table A 13 Proposed schedule of activities and timing

Timing	Activity	Comments
October-November 2014	Policy and legal support to the NWRC to finalise the MWFD	Martine Leewis and Zaki Shubber will spend two weeks in Myanmar
Month 1	Recruitment and selection of participants Identification of training and education institutes addressing aspects of water governance or having an interest in acquiring such knowledge Finalising the programme and confirming its timeline	This stage is to begin at the latest two months after funding is approved.
	Review and assessment of existing water legislation and other legislation with water-related provisions	See recommendation n.1 at Annex II
Month 2	Introductory training workshop on water governance - issues and challenges - water governance and IWRM - current governance in Myanmar - concepts, examples (legal, institutional, economic, etc.) - approaches/instructions for case study (group assignments)	Plenary (all participants)
	Special workshop on water legislation	See recommendation n.2 at Annex II
	Development of an action plan for the water legislation reform	See recommendation n.3 at Annex II
Months 3-6	Case study: analysis selected case from different water governance perspectives (economic, legal, institutional) Development of an action plan	Assignment (2-3 groups of participants)
	Coaching sessions related to the case study[19]	1-2 experts
Month 7	Second workshop on water governance - present cases, discuss and get feed-back - advanced water governance topics - preparation next group assignment	Plenary (all participants)
	Local workshop for regional/local stakeholders	Local participants
Months 8-11	Case study (Cont.): solutions, gaps, needs, opportunities for change	Assignment (2-3 groups of participants)
Month 12	Final workshop on water governance - presentation and discussion - way forward / action plan (for water governance general, per organisation, for each participant personally)	Plenary: all participants, decision-makers (NWRC) donors, etc.
	Local workshop for regional/local stakeholders	Local participants

[19] This could include a master class/coaching sessions for the Office of the Attorney General on technical legal issues relating to water legislation.

Expected Outcomes

Expected outcomes related to the key objectives as stated above include:

I. Immediate knowledge dissemination about water governance

The first expected outcome is that all those involved will learn about water governance through the workshops and the case studies that will be considered. The work that will be conducted through the assignments that will happen between the workshops is expected to result in the presentation of concrete recommendations for changes where necessary. An action plan for the reform of water legislation will also be developed at the beginning of the Schedule and recommended as soon possible for implementation.

II. Establish network of communication/cooperation for professionals at the key ministries

The different workshops and case study assignments are also intended to bring together key actors involved in water governance and support the establishment of a network for water professionals at the key ministries and agencies described in the section on the target audience to facilitate communication on water governance and other topics between them.

III. Develop recommendations for capacity building for the mid to long term

As regards capacity building, the following elements should be included in recommendations for capacity building: Who is expected to receive training, what curricula is appropriate for each type of target, where funding/financing of such training may be available.

A11.2 Policy and legal support Water Framework Directive and Water Law(s)

It should be noted that, as a part of the training programme for water governance, there will be particular focus on the legislative aspect: an action plan will be developed for water legislation reform and capacity building in water legislation will also be an element of the programme.

Finally and importantly, a significant step that the National Water Resources Committee (NWRC) is requesting, and that step should be taken immediately, is the strengthening of the legal and policy expertise needed to further develop and finalise the Myanmar Water Framework Directive (MWFD), an umbrella policy document intended to serve as a basis for the drafting of a water act. Specifically, the NWRC would like to receive policy advice from Martine Leewis of Arcadis and legal advice from Zaki Shubber of UNESCO-IHE in the period between October and November 2014. The purpose is for them to support Myanmar professionals finalising the draft MWF. It is anticipated that both experts should spend a fortnight in Myanmar to ensure the desired support and deliver a final draft. Finalising this document is an important element of the governance needed in Myanmar and will be a solid basis for the capacity building programme as a whole.

Appendix 12 IWRM data collection and model development

In order to support the IWRM strategy development in Myanmar IWRM data was collected and analysed and modelling instruments were developed to:

- analyse the impact of measures, strategies and future scenarios as generated by the strategy study;
- capacitate the Myanmar Water Managers in Water Resources Engineering and Management (see Figure A 27);
- provide the planning framework for future decision-making by the Myanmar authorities.

The data inventory and analysis activities (Deltares and TUDelft, 2013) included

- a concise overview of the status of water resources in Myanmar;
- a comprehensive overview of the availability of data and information on water-related topics, sectors and institutional aspects;
- an overview of promising IWRM measures for Myanmar;
- recommendations for the development of a Water Knowledge Centre, to support and facilitate the development and implementation of an Integrated Water Resources Management Strategy.
- initial model developments (see Table A 14 and Figure A 28) to support the development of an Integrated Water Resources Management Strategy;

The modelling activities (Deltares, 2014) focused on the set up and calibration of a number of modelling tools (see Table A 14 and Figure A 28). In this Appendix a brief summary of the models and some output are presented. For more detailed descriptions reference is made to two reports (Deltares and Delft University of Technology, 2013 and Deltares, 2014) and some student reports.

Table A 14 Overview of modelling tools for Myanmar

tool name	brief description	organisation / institute	developed by
Delft3D	Delft3D is a flexible integrated modelling suite, which simulates two-dimensional (in either the horizontal or a vertical plane) and three-dimensional flow, sediment transport and morphology, waves, water quality and ecology and is capable of handling the interactions between these processes. For the Ayeyarwady Delta and adjacent coastal waters a detailed hydrodynamic model has been developed for water circulation and salinity intrusion.	Directorate of Water Resources & Improvement of River Systems (Ministry of Transport, Myanmar) and Deltares	Deltares (open source) http://www.deltaressystems.com/hydro/product/621497/delft3d-suite
SOBEK	SOBEK is a powerful modelling suite for flood forecasting, optimisation of drainage systems, control of irrigation systems, sewer overflow design, river morphology, salt intrusion and surface water quality. The current application is a hydraulic and morpho-dynamic 1D Ayeyarwady River model.	Directorate of Water Resources & Improvement of River Systems (Ministry of Transport, Myanmar) and Deltares	Deltares (open source) www.deltaressystems.com/hydro/product/108282/sobek-suite

tool name	brief description	organisation / institute	developed by
WFLOW	WFLOW is a distributed hydrological modelling platform generating rainfall-runoff for all major river basins and serves as input for RIBASIM and SOBEK	Deltares	Deltares (OpenStreams providing the building blocks that make up integrated hydrological models) publicwiki.deltares.nl/display/OpenS/WFLOW+PCRaster-Python+based+distributed+hydrological+models
RIBASIM	RIBASIM is a generic model package for simulating the behaviour of river basins under various hydrological conditions. The model package is a comprehensive and flexible tool which links the hydrological water inputs at various locations with the specific water-users in the basin. 	Irrigation Department (Ministry of Agriculture and Irrigation, Myanmar) and Deltares	Deltares www.deltares.nl/nl/software/101928/RIBASIM

Figure A 27 Training course on RIBASIM at ITC-Bago

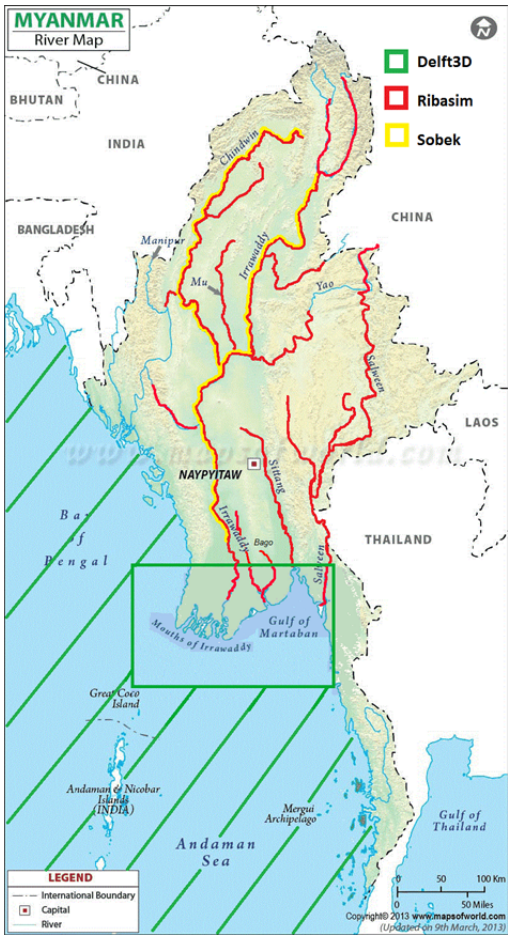


Figure A 28 Overview of developed modelling tools in Myanmar

In Myanmar, available rainfall measuring stations do not cover the entire country. Therefore global datasets are used. A validation has been done by comparing two different global satellite reanalysis products with the available rainfall time series of several ground stations in Myanmar. In Figure A 29 the resulting river discharges (observed versus simulated) in the Lower Ayeyarwady River are presented. The model, as describing the water balances for all major river basins in Myanmar, enables the evaluation of a variety of measures related to infrastructure, operational and demand management and the results in terms of water quantity and water quality. It also addresses the irrigation and hydropower potential, based upon the inventory of all dams, irrigation areas, cropping patters, etc.

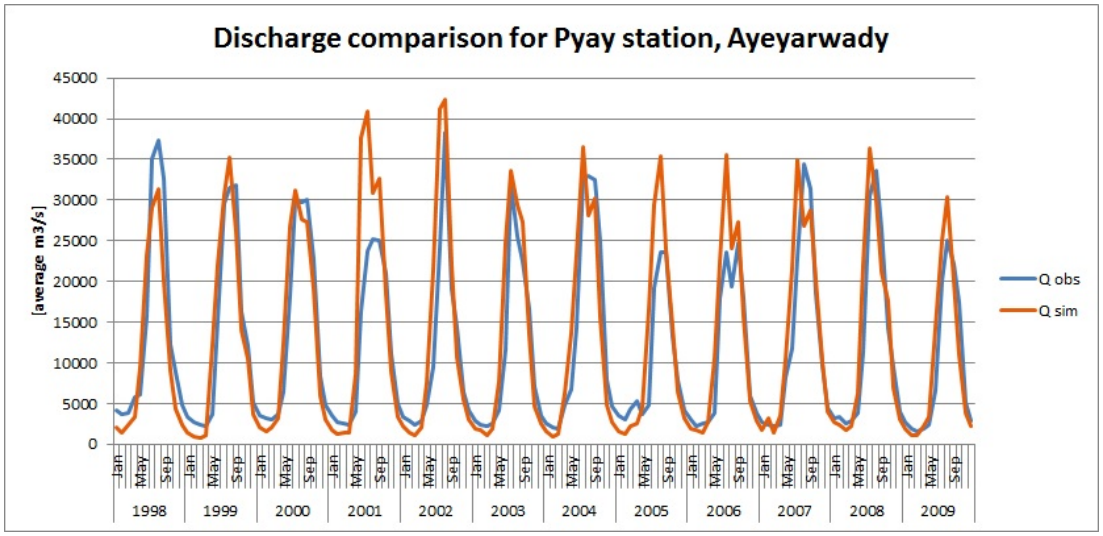


Figure A 29 Simulated river discharges (1998 – 2009) at Pyay station (Lower Ayeyarwady River)

Finally, in Figure A 30 a Delft3D hydrodynamic simulation result (water level) is presented for the Ayeyarwady Delta. The model will be used to address among others flooding, salinity intrusion, sediment transport and coastal morphology and water quality in the Delta.

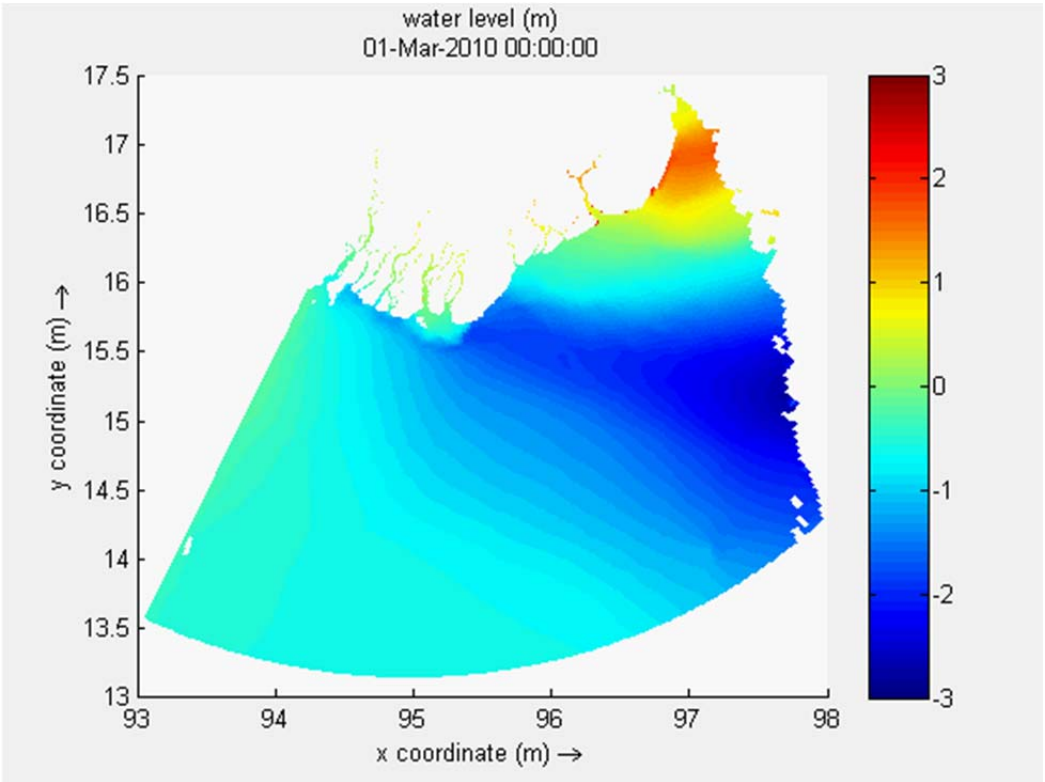


Figure A 30 Delft3D hydrodynamic model representation for the Ayeyarwady Delta

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Colophon

Myanmar IWRM Strategic Study

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partners Myanmar	Ministry of Transport Ministry of Agriculture and Irrigation Expert Group of the National Water Resources Committee
collaboration	Ministry of Environmental Conservation and Forestry, Ministry of Livestock, Fisheries & Rural Development, Ministry of Electric Power, etc....
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