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Environmental objectives and abatement measures for a healthy Bago River,

A contribution to the Bago River Sub-basin Management Plan

SAVE BAGO RIVER

Norwegian Institute for Water Research

REPORT

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Summary

This report is a deliverable of the project, IWRM, Institutional Building and Training, a collaborative effort by the Ministry of Natural Resources and Environmental Conservation (MONREC) and the Norwegian Institute for Water Research (NIVA). An important aim of this project is to pilot test the river basin management approach in Myanmar, and the Bago River Sub-basin has been selected as a pilot case study area. This report presents an important input to a coordinated Sub-basin Management Plan by presenting environmental objectives and abatement measures as discussed in the Bago River Sub-basin Area Committee and in the Bago River Sub-basin Area Non-governmental stakeholder Group. In Chapter 2 we provide a brief description of international environmental policy objectives; in Chapter 3 , the Bago River Sub-basin is described with regard to the bio-geographic and socio-economic context and the main stakeholder groups are presented; in Chapter 4, Myanmar and Bago Sub-basin level environmental objectives and pressures are addressed; Chapter 5 presents current abatement measures in Bago Sub-basin for meeting environmental aims, and the last Chapter 6 presents the process of prioritizing among suggested measures.

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Environmental objectives and abatement measures for a healthy Bago River,
A contribution to the Bago River Sub-basin Management Plan

Preface

Development of River Basin Management Plans (RBMPs) is an important strategy for improving environmental status of water resources, a strategy recognized by a number of international IWRM frameworks, such as the EU Water Framework Directive (WFD), the UNESCO guidelines, and NARBO (Network of Asian River Basin Organizations). Development of RBMPs include several distinct steps of knowledge collation, stakeholder involvement, coordination and decision making, including ingredients such as the characterization of the basin, identification of environmental objectives and decision of a program of measures.

The 'Integrated Water Resources Management – Institutional building and training' (the IWRM project) has selected the Bago River Sub-basin in Myanmar for pilot testing of the River Basin Management Approach for developing a Sub-basin Management Plan. The River Basin Management Approach refers to coordination of sector and environmental authorities and involvement of Non-Governmental stakeholders within the river basin. The main purpose of this report is to present the environmental objectives and abatement measures as discussed by authorities in Bago River Sub-basin and by Non-Governmental Stakeholders. Also, methods and the approach for identifying and prioritizing among abatement measures are reported.

The IWRM project is a collaboration project between the Norwegian Institute for Water Research (NIVA) and the Forest Department (FD) Ministry of Natural Resources and Environmental Conservation (MONREC). The Irrigation and Water Utilization Management Department (IWUMD) Ministry of Agriculture, Livestock and Irrigation is an associated partner to the project. The project is part of the Norwegian – Myanmar Bilateral Environment Programme, 2015-2018 and it is funded by the Norwegian Embassy in Myanmar. The development goal of the IWRM project is to make a significant and positive contribution to the implementation and functioning of Integrated Water Resources Management in Myanmar for inland waters at the national level. The objective is to establish methods and standards for Integrated Water Resources Management and to support initiation of the implementation process.

The report has been prepared by Ingrid Nesheim, NIVA; Zaw Win Myint, FD Bago Region; Nikolai Friberg, NIVA; Marianne Karlsen, NIVA; Eai Chit Thu Mg, FD Bago Region and Toe Toe Aung, Watershed Management Division FD, with input from, Ko Ko Oo, Irrigation and Water Utilization Management Department Bago Region; Htay Aung, Directorate of Water Resources and Improvement of River Systems Bago Region; and the three secretaries of the Non-Governmental Stakeholder Group, Dr. Hein Thant Zaw, Mg Mg Kyi and Aung Myo Htut. We would also like to acknowledge the valuable contribution by Kyaw Min San, Hluttaw member in the Bago Region and the former Bago Region MONREC Minister, and Dr. Zaw Lwin Tun (IWUMD) for their important engagement in this process.

We hope the report will serve as a useful example and practical guideline for both how to develop a River Basin Management Plan and concretely how to report it.

Oslo, 30. April 2018

Ingrid Nesheim

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Abbreviations and definitions

Catchments: Hydrological term for an area from which the water drains to a river.

CSO: Civil Society Organization

DWIR: Directorate of Water Resources and Improvement of River Systems

ECD: **Environmental Conservation Department**

Environmental flow - describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well being that depend on these ecosystems; it is often referred to in relation to an environmental flow management regime specified for regulated watercourses (European Commission, 2015).

EU WFD: The Water Framework Directive 2000/60/EC is an EU directive which commits European Union member states to achieve good qualitative and quantitative status of all water bodies by 2015. http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm#

GAD: General Administrative Department.

Heavily modified water bodies: water bodies which as a result of physical alterations, e.g. such as by irrigation, drinking water supply, power generation, and navigation, are in the EU WFD exempted from the aim of good ecological status.

IWUMD: Irrigation and Water Utilisation Management Department.

IWRM: Integrated Water Resource Management has been defined by the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".

NARBO: Network for Asian River Basins Organizations; NARBO is the Network of Asian River Basin Organizations. Announced at the 3rd World Water Forum in March 2003, NARBO was officially established in February 2004 to promote integrated water resources management (IWRM) in monsoon areas of Asia. The goal of NARBO is to help achieve IWRM in river basins throughout Asia. http://www.narbo.jp/

MNWFD: The Myanmar National Water Framework Directive is a policy framework adopted by the National Water Resources Committee (Appendix A).

MOALI: Ministry of Agriculture, Livestock and Irrigation.

MOH: Ministry of Health.

MOI: Ministry of Industry.

MONREC: Ministry of Natural Resources and Environmental Conservation.

MOTC: Ministry of Transport and Communications.

NGO: Non-Governmental Organization.

Non-governmental Stakeholder Group - refers to the arena for involvement of civil society (CBOs), Non-governmental organizations (NGOs), elected members in Township Development Committees, and Hluttaw members.

NWP: National Water Policy (Myanmar).

NWRC: The National Water Resources Committee (NWRC) is a national APEX body in the water sector of Myanmar. The NWRC consists of Union Ministers, Regional Ministers, Mayors, Permanent Secretaries, Director Generals, and representatives of the Advisory Group. The NWRC will draw up and implement an integrated water management system, and develop a national integrated water management strategy, the NWFD, and the holistic water law.

NWRC AG: National Water Resources Committee Advisory Group.

River Basin: A river basin is an area of land drained by a river and its tributaries.

River Basin Management (RBM) approach; involves managing water uses in an integrated way within boundaries of the catchment. Arguments for this approach are embedded in the ideology of the IWRM concept, that all main water use sectors within the same hydrological unit have the right to take part in decision-making processes of water resource use, as all water use sectors will either impact water resources, or themselves be impacted by water use of others.

River Basin Management Plan: This refers to a management plan for the protection and sustainable use of water within the river basin / sub-basin. The concept is included in the Myanmar NWFD.

River Basin Area; refers to the area of land and sea, made up of one or more neighboring river basins together with their associated groundwaters and coastal waters as the main unit for management of river basin. The "River Basin Area" terminology is a Myanmar parallel to the River Basin District terminology of the EU. The whole River Basin Area needs to be covered by Sub-basin units. It is recommended that the geographic coverage of river basins should be introduced into a government appointed geographic information system (GIS).

River Basin Area Committee (RBAC): refers to the in this project suggested name for an arena which includes sector and environmental authorities at the regional and local level being responsible for developing the River Basin Management Plan. The River Basin Management Plan is commonly comprised of several Sub-basin Management Plans. It is suggested that the River Basin Area Committee commonly includes a chair person, one head secretary, and two co-secretaries. Representation of sector and environmental authorities in the River Basin Area Committee, the coordinating arena within the river basin has to be decided

Sub-basin: Hydrologically an area from which water drains to a river synonymous to terms such as catchment and watershed. In here it is used as a large area draining water to the entire Bago River, consisting of several smaller catchments

SGD: Sustainable Development Goals refer to the global goals as supported by the United Nations, goals which the majority of the worlds national have agreed to. The SGDs (2015 to 2030) replace the Millennium Development Goals (MDGs). https://www.millennium-institute.org/isdg

Sub-basin Area; refers to the management sub-unit within the river basin, it commonly includes the main river and its tributaries, but it often also considers relevant administrative borders.

Sub-basin Area Committee; refers to the coordinating arena for sector and environmental authorities within the Sub-basin Area. The Committee is responsible for development of the Sub-basin Management Plan.

Township Development Committee: includes altogether 5 members with an elected chair and elected two members, and appointed secretary, the Head of Department of township level, and the other member from GAD. The committee is responsible for urban waste management, sewage, urban road maintenance and urban electricity.

UNESCO: United Nations Educational, Scientific and Cultural Organization.

Water body is defined as a management unit, which have definite hydrological, physical, chemical and biological characteristics, shares the same pressures, the same water use criteria and environmental status and aims.

Summary

The river basin management approach for reaching environmental aims takes a holistic perspective as water flows through a catchment from lakes, rivers and groundwaters towards estuaries and to the sea. It involves coordinated decision making across environmental and sector authorities with input from non-governmental stakeholders. The Myanmar National Water Framework Directive (MNWFD) is a policy framework, which aims at implementing the river basin management approach in Myanmar. The MNWFD is inspired by the EU Water Framework Directive (EU WFD) through its focus on good ecological status of water, and on river basin management plans.

This report is a deliverable of the project, IWRM Institutional Building and Training, a collaborative effort by the Ministry of Natural Resources and Environmental Conservation (MONREC) and the Norwegian Institute for Water Research (NIVA). An important aim of this project is to pilot the river basin management approach in Myanmar where the Bago River Sub-basin has been selected as the pilot case study area. The main tool for enabling river basin management is the production of a coordinated River Basin Management Plan. This report presents an important input to the Bago River Sub-basin Management Plan by presenting environmental objectives and abatement measures as discussed in the Bago River Sub-basin Area Committee and in the Bago River Sub-basin Area Non-governmental stakeholder Group. The Committee and the Group represent important established coordination arenas. The abatement measures identified are necessary to protect the water environment and for the safe use of water as required by society. This includes such as, protecting drinking water supplies, recreational uses, abstraction of water for agriculture and industry, and the aim of good ecological status of waters.

A brief description of the Sustainable Development Goals (2015), and the EU WFD (2000) is provided in Chapter 2 as reference to international environmental policy objectives and as background for the discussion of environmental aims in the Bago Sub-basin. The bio-geographic and socio-economic context of Bago are described in Chapter 3. Sub-basin level environmental objectives and pressures identified for Bago, Waw, Thanatpin and Kawa townships by the Bago River Sub-basin Area Committee and in the Bago Non-governmental Stakeholder Group are addressed in Chapter 4. The main pressures are diffuse pollution from sewage, waste and from agriculture.

Chapter 5 presents abatement measures for meeting the environmental aims and gives a brief note on the efficiency of already implemented measures in the Bago District. Suggested measures by the Bago River Sub-basin Area Committee, and by the Non-governmental Stakeholder Group are presented for the five water body groups: areas protected for biodiversity, reservoirs for drinking water and irrigation, Upstream Bago City Area water body groups, Bago City Area water body groups and for downstream Bago City water body groups. An iterative process of several meetings in the Bago Sub-basin Area Committee and in the Non-Governmental Stakeholder Group were supported by the dissemination of minutes from previous meetings to members of the Committee and the Group. This allowed for a process where sector and environmental authorities were able to revisit and discuss abatement measures towards prioritization of abatement measures. The prioritized measures are described with reference to; (i) the purpose of the measure, (ii) the extent that the measure is being implemented, (iii) the funding, (iv) the effectiveness of the measure as considered by the responsible institution, and (v) the timeline of implementation. This chapter also include a section on methods for prioritizing among measures. The last chapter 6 presents some final remarks about the process and the learning experience of pilot implementing the river basin management approach in the Bago River Sub-basin.

1 Introduction

The River Basin Management Approach has been identified as an important strategy for meeting environmental aims by the EU Water Framework Directive (European Commission, 2000), the UNSECO IWRM guideline (UNESCO, 2009), and by the Myanmar National Framework Directive (MNWFD) (Appendix A). The river basin approach adopts a holistic perspective as water flows through a catchment from lakes, rivers and groundwaters towards estuaries and to the sea. It should be developed based on coordinated decision making across environmental and sector authorities, with input from non-governmental stakeholders. The purpose of a river basin management plan is to, based on water quality and quantity objectives, select and decide upon measures necessary to protect the water environment and the water uses required by society. This includes the protection of: drinking water supplies, recreational usage, areas for conservation of biodiversity, and for the aim to achieve a healthy river (good ecological status). Coordination arenas in this pilot include the Bago River Sub-basin Area Committee, and the Bago River Non-governmental Stakeholder Group. Feedback and input from NGS, CBOs and civil society are ensured by means of interaction and dialog with the Sub-basin Non-governmental Stakeholder Group (Zaw Lwin Tun, 2016). Development of a River Basin Management Plan is the main tool within this strategy for reaching environmental objectives.

The Myanmar National Water Framework Directive (MNWFD) is a policy framework, which aims for implementing the river basin management approach in Myanmar (adopted by the National Water Resources Committee, October 2014). This policy framework is inspired by the EU WFD by its focus on good ecological status for all water bodies, and it supports the guiding principles of the Myanmar Environmental Conservation Law (2012).

The IWRM Institutional Building and Training project aims to pilot the River Basin Management Approach in Myanmar. Under this frame, the Bago River Sub-basin has been selected as a pilot case study for introducing coordinated discussions of environmental aims and abatement measures for development of the Bago River Sub-basin Management Plan. A River Basin Management Plan refers to characterization of the river basin, knowledge of the water quality elements, chemical physical parameters, biological parameters, and hydro morphological parameters, economic analysis of water uses, decision of environmental aims, and program of measures. In their report Eriksen et al. (2017), present a characterization of the Bago River Sub-basin. The report outlines: environmental aims and abatement measures for reaching these aims. Together with the Eriksen et al. (2017), these reports constitute two cornerstones for the Bago River Sub-basin Management Plan.

The outline of the report is as following: Chapter 2 presents the International environmental policy objectives in brief as reference for the discussion of environmental aims in the Bago Sub-basin, Chapter 3 describes the bio-geographic and socio-economic context of Bago, Chapter 4 outlines the Bago River Sub-basin Area level environmental objectives and pressures, Chapter 5presents abatement measures and prioritization of abatement measures as discussed, and Chapter 6 presents the concluding remarks about the process and the learning experience of pilot implementing the river basin management approach in the Bago River Sub-basin.

2 International environmental policy objectives in brief

The objective of this chapter to provide a brief description of two international policies, the Sustainable Development Goals (SDG 2015, and the EU WFD (2000) as these provide an important basis for the discussion of environmental objectives in the pilot testing of the River Basin Management Approach in the Bago Sub-basin. We have in this pilot a focus on the EU WFD, as this directive has inspired the Myanmar National Water Framework Directive (MNWFD). The seven directives within the MNWFD reflect the main principles of the EU WFD. The SDG (2015) are the global goals as supported by the United Nations, goals which the majority of the world's countries have agreed to.

The Sustainable development goals

In 2015, the 2030 Agenda for Sustainable Development with its associated Sustainable Development Goals (SDGs) was approved by the United Nations General Assembly (UN 2015). The SDGs (also called global goals for sustainable development) will run from 2015 to 2030 and follow up and replace the Millennium Development Goals (MDGs). The MDGs focused mainly on reducing extreme poverty, hunger, disease and promoting health, gender equality, education and environmental sustainability through eight main goals and associated targets. This galvanized unprecedented global action toward measurable social priorities. While there has been great progress toward achieving some goals such as extreme poverty, progress have been weaker toward goals such as sanitation. Moreover, achievements have been uneven within countries and across the world. Conflict, environmental degradation and climate change also undermine development and reverse progress which have been made (UN 2015).

The MDGs mainly focused on reducing poverty along multiple dimensions in developing countries and have been critiqued for not linking development to the environment strongly enough and for not incorporating developed countries. To meet such criticism, the SDGs are designed to also incorporate environmental objectives and to give sustainable development a higher profile. Here sustainable development adheres to one of the most common conceptualizations that integrates the environment, the economy and the social dimensions of development and the SDGs target for developing as well as developed countries (UNDP 2015). Figure 2.1 presents the 17 individual sustainable development goals.

SDG number 6 'Ensure availability and sustainable management of water and sanitation for all' is an important goal for environmental protection, and acknowledges the importance of water to sustainable development. The principles and priorities within SDG 6 will be of significance for water management across the world. Integrated Water Resource Management (IWRM) is central within SDG 6 and links water with societal sectors and groups for achieving sustainable development (Ait-Kadi 2016). The goal is broken down into six targets that are to be achieved by 2030, see Table 2.1 for further details.

Other relevant SDGs for water management include SDG 15 'Life on land' where target 15.1. states that 'By 2020 ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystem and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements'. Target 15.8. also suggest to 'introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species'. The SDGs are to be achieved by national government, stakeholders and civil society over the next 12 years.

While it is hard to judge how successful the SDGs will be, they will influence the global agenda for water management over the next 12 years and are therefore important environmental objectives.

Figure 2.1. The 17 Sustainable Development Goals Each goal is broken down into a set of targets so that progress toward achieving it can be measured and evaluated effectively. Source: http://www.globalgoals.org/Public Domain.

Table 2.1. Overview of SDG 6 and its associated targets

SDG 6 Ensure availability and sustainable management of water and sanitation for all
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and at least doubling recycling and safe reuse globally
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of fresh water to address water scarcity, and substantially reduce the number of people suffering from water scarcity
6.5 By 2030 implement integrated water resources management at all levels, including through transboundary co-operation as appropriate
6.6 By 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
6.6a By 2030, expand international co-operation and capacity-building support to developing countries in water and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.6b Support and strengthen the participation of local communities for improving water and sanitation management

The EU Water Framework Directive (WFD) (Directive 2000/60/EC), ratified October 23rd 2000, is a highly profiled international framework for the establishment of holistic, watershed based management of water. The principles of the WFD are rapidly being incorporated in countries beyond the EU member states. It emerged as a response to fragmented administrative structures unable to manage and improve water quality within member states. Rather than following existing administrative and political borders, the Water Framework Directive (WFD) uses an ecosystem-based approach and draws on hydrological units so called River Basin Districts for management.

The WFD sets out to protect fresh water, surface water, water ways, ground water, brackish water, transitional and coastal water a nautical mile off land. While the WFD provides a new approach to water management, it states that the member states should keep their current division of responsibilities between actors as stated in laws, regulations and policies. As such the WFD does not provided detailed 'regulation on policy objectives or measures, but leaves a considerable degree of freedom to member states in how they translate the directive to their national and local river basin districts' (Brouwer et al. 2013).

Coordination between actors in charge of water management and other actors is to be achieved through cooperation and consensus building. Hanssen et al. (2014) note that the WFD marked a shift from government to governance in water management and from viewing water as a national issue to a transnational one requiring broad collaboration between several actors and institutional levels. The environmental objectives stated in the framework are highly ambitious. Water bodies are classified as natural, heavily modified or artificial, and a distinction is made between the ecological quality and chemical status of surface water (Brouwer et al. 2013). The ecological quality of water is characterized according to five levels, ranging from high to bad quality. Biological, hydromorphological and chemical indicators are used to assess the ecological quality. This monitoring and assessment of water quality shall be followed by river basin management plans including a program of measures outlining how the objectives are to be reached (Nesheim and Platjouw, 2016). The management plans are to be revised and updated in six-year cycles. The objectives for the WFD are to be achieved in 2027.

3 The Bago Sub-basin and main Bago stakeholder groups

The purpose of this chapter is to describe the bio-geographic and socio-economic conditions of Bago River Sub-basin Area as these are important context factors for the discussion of the environmental objectives and prioritized abatement measures which were undertaken in the Sub-basin Area Committee and in the Non-Governmental Stakeholder group (Chapters 4, 5 and 6). A short description of stakeholder groups and their demands and development trends in the sub-basin are also provided in this chapter.

3.1 Biogeographic, climate and water flow conditions in Bago

The Bago River Sub-basin is located between 95°53´ 30"E – 96°43´30" E longitudes and 16°43´ 15" N – 18°26´17" N latitudes in the southern central Myanmar (Figure 3.1). The Bago River flows from the Pegu Yoma mountain range at an elevation of 800 m.a.s.l. in the north, running south through meandering sections of over 331 km before it reaches the Yangon River near Yangon City (Haruyama 2013). The Sub-basin covers 5,359 km^2 and it is situated between the Sittaung River on the east and the Ayeyarwady and the Myintmakha Rivers on the west. It is connected to the Sittaung River Basin by a 61-km long canal, which represents an important source for local irrigation. Administratively and politically, the sub-basin primarily falls under the Bago District in the Bago Region.

The climate in the Bago River Sub-basin is characterized by tropical monsoon with distinct wet and dry seasons. The cold season lasts from November to January, followed by a dry season from December to April, and a wet season from May to October. Climate studies indicate that the temperature in the basin will increase and that precipitation will first decrease in the coming decades and then increase in long-term perspective, however there are significant uncertainties inherent in the precipitation projections (see Shrestha et al. 2017). Climate change is expected to significantly affect the hydrological processes in the sub-basin with adverse consequences for water management and livelihoods (Shrestha and Ye Htut 2016).

The upper part of the sub-basin, defined as upstream Bago bridge in Bago City, is characterized by forested areas including scrubland, deciduous and evergreen forests. Forestry is located in this area and available GIS data clearly show substantial deforestation during the last 15 years in the central and northern part of the Sub-basin (Figure 3.1). Forest cover have decreased significantly between 2010 and 2015 with a 21 % reduction of open forests and 10 % reduction of closed forests (Bago Forest Department, 2017). Land use in the lower sub-basin, downstream of Bago Bridge, is characterized by agriculture. Overall in the sub-basin, grassland is the most dominant land use type, contributing to more than 32 % of the total area (Eriksen et al. 2017). Terrains in the downstream area are characterized by low lands with less than 10 m.a.s.l. in elevation, and terrains are highly dissected.

The total population in the Bago District was 1,770,785 in 2014, where, 74 % were rural and 26 % were urban. Population density was 133 inhabitants/km^2 (Department of Population, Ministry of Immigration and Population, 2015). The Bago City is the largest city in the Sub-basin and with the highest population density in the area. Flooding is a recurrent yearly problem in Bago City during the monsoon period. Poor drainage systems contribute to the flooding.

The majority of the population within the Bago District are farmers, and typical farm sizes are ten acres (50 % of the total number of farms). The majority rely on subsistence farming and fishing for their livelihood. Of the local population, farmers represent 40 %, fishermen 30 %; and 20 % are self-employed, while the remainder of approximately 10% are in the government service sector (Ministry of Agriculture and Irrigation, 2012). The area includes some small scale industrial activities, more specifically a saw mills, brick manufactories. There are some small-scale gold mining activities, and there are hydropower stations, yet overall industrial activities are few. Economic activities in the Bago District to a large extent reflect the economic activity in the Lower Sittaung Sub-basin Area[1].

Water from the Bago River is diverted for irrigation and for maintaining the water level of the Moeyungyi wetland during the dry season. The main use of water in the district is for irrigation, and 34.000 acres (13759 Ha) /year used for summer rice are irrigated from around the third week of November / first week of December until April/May. If the onset of rains is late, irrigation also occurs for rain-fed paddy at the beginning of planting in June / July. When the onset of rain is early, irrigation often also occurs in September October of rain-fed paddy (personal communication with Ko Ko Oo, IWUMD, 2017). Actual irrigation demand varies within the area and among crops. There are plans to have 100% irrigation of crops. As a general estimate of water requirements for irrigation, 6 acre/feet is needed to irrigate 1 acre of land (statistical data from the Irrigation Department, 2014).

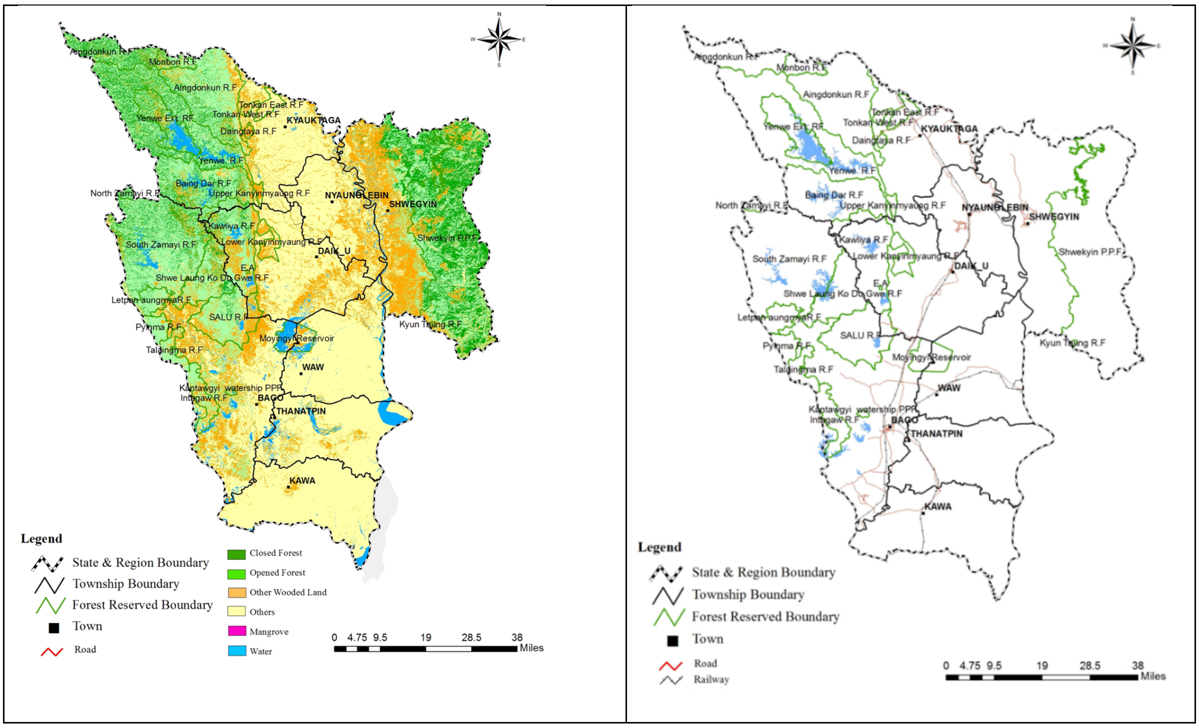

Figure 3.1 Left side, land use, land cover map, Bago District; right side, Bago District administration (Source: Maps 2015; GIS and Remote Sensing Section, Forest Department, MONREC).

[1] The lower Sittaung Sub-basin Area includes the following administrative units: the townships of Bago, Kawa, Thanatpin, Waw, DaikU, Nyaung Lay Bin, and Shwe Gyin Township in Bago District, and in Mon State the Kyaik Hto and Bilin townships within the Thaton District. Within the Sittaung River Basin Area, three Sub-basin Areas were identified in a project workshop in 2015; Upper, Middle and Lower Sittaung River Basin Areas (Nesheim et al. 2017).

3.2 Bago Stakeholder Groups

This section briefly describes the main stakeholder groups in the Bago River Sub-basin. These include: paddy farmers, rice-fish farmers (and fisheries), the forestry, industry and the domestic sectors. Some interest groups in the Bago sub-basin may be having conflicting goals for water management. For example, the domestic and industrial sectors demand for more stable electricity and fisheries, while others have overlapping priorities, such as for example the need to secure safe and accessible drinking water. Stakeholder groups have been identified through interviews with different departments and NGOs and civil society actors. There are no stakeholder group in the sub-basin, which can be characterized based on ethnic or religious aspects.

Overall challenges experienced in Bago include:
- unstable markets with uncertain market price (e.g. floating market prices of products)
- limited market access for products
- limited access to agricultural technology to produce value-added products
- decreased yield per acre due to impact of climate change, pests, unfertilized lands
- shortage of labor due to migration which is derived by insufficient income
- low rate of returns from farms, yet high expenditures related to costs of pesticides and fertilizers
- inferior quality products which reduce access to the export markets and with good prices
- unofficial moneylenders who take high interest rate which could be a main burden in a long run

We provide a short description of the main stakeholder groups below.

3.2.1 Paddy farmers and farmers with horticulture

The majority of the population (40%) in the Bago district are farmers and the agricultural sector is the largest user of water both in terms of households engaged in agricultural production and in terms of the volume of water use. Water is used for irrigation of summer rice paddies from the end of November to the beginning of December and if the onset of rains is late, irrigation also occurs for rain-fed paddy in the beginning of planning in June/ July. When the onset of rain is early, irrigation often also occurs in September October of rain-fed paddy (personal communication with U Ko Ko Oo, IWUMD, 2017).

In the Bago River Sub-basin Area that mainly covers the Bago, Thanatpin, Kawa and Waw townships; paddy is the main economic activity for *82,984 households*, and the total area of paddy in these townships are 687,078 acres (278051 hectares); horticulture is the main economic activity for 16,278 households, and the total area of horticulture refers 65,257 acres (26409 hectares) (data collected from the townships offices for 2016-2017).

In terms of socio-economic levels, approximately 20% of the farmers are considered to have a high income, while 30% have moderate income and 50% haves low income (Source: Bago Department of Agriculture, 2018). Mostly, farmers in the high-income group have access to irrigation, while this varies for the moderate-income group, and few of low income have access to irrigation. With regard to land area, about 40 000 acres received irrigation water from the Zaung-tu dam on the upper side of the Bago River, according to data from 2017-2018 (Irrigation and Water Utilization Management Department, 2018). In the townships of Bago, Waw, Thanatpin and Kawa, about 6,537 acres (2645 hectares) are irrigated in the summer (summer paddy).

Farmers apply pesticides and fertilizers provided by private companies in the area. Most farmers in the high and moderate-income group apply pesticides and fertilizers, but for the low-income group access to these varies.

Farmers have access to loans from the Myanmar Agricultural Development Bank, where they can receive a loan of 100 000 kyats per acre they own (Department of Agiculture, 2018).

3.2.2 Rice-fish farmers

According to the Department of Agriculture (2015) fish are released in the river canals, reservoirs, and ponds during June – August every year. Irrigation practices both support the cultivation of rice and integrated fisheries. There are 2470 acres of paddy fields and about 500 fish per acre are commonly released. In 2015, 22000 fish had been released in the paddy fields as a source of food and the amount of fish has been increasing over the last years

Little official information on rice-fish farmers could be obtained for this report. Below we refer to information obtained from media postings.

Workers sort juvenile fish caught at a fishpond in Bago Region's Thanatbin township last week by Soe Sandar Oo / The Myanmar Times, October 2012. Accessible from https://www.mmtimes.com/in-depth/2733-battle-brews-in-bago-region-over-fisheries.html The article refers to fish ponds owners who collude with fisheries officials to enlarge their ponds and divert water and fish into their enclosures, an illegal activity. The article states that "As a result, there are few fish in the streams and farmers have little choice but to fish the ponds instead." The article refers to a lawyer U Aye Myint representing some farmers in Bago Region, and it is argued in the article that the Department of Fisheries needs to clarify the ownership status of the ponds and then ensure that action is taken against people found to be stealing fish or pond owners found illegally tampering with streams and rivers.

A policy brief on fisheries from 2015 by Ben Belton (MSU), Aung Hein, Kyan Htoo, L. Seng Kham (MDRI-CESD) Ulrike Nischan (IFPRI) Thomas Reardon, Duncan Boughton (MSU) https://pdfs.semanticscholar.org/a75d/523d8acdc83416a62d19ee2b162a54bac575.pdf The policy brief states the following: "Despite a rapid growth in fish ponds, there is little diversity in the production technologies used, or in the species produced. A single type of fish - the indigenous carp, rohu - constitutes roughly 70% of all farmed fish". The study on which the policy brief is based finds that "most ponds are constructed on rice paddy land". It states that, "Fish farming is highly concentrated, with very large farms (including several vertically integrated companies) accounting for well over half of total pond area".

3.2.3 Forestry sector

Among planned actions in the forestry sector is planting new, and regenerate existing forest plantations with a particular focus on community forestry and planting valuable species such as teak. The forestry program will support existing forests with regeneration and enrichment planting. Some of the community forests in Bago Region, will be combined with agriculture (Forest Department, 2017). Mostly the forestry sector are state owned companies, but there are also some privately-owned plantations. The forestry sector applies both fertilizers and pesticides on forest plantations.

Some people also rely on forest products, these refer mostly the low-income group of domestic and agriculture workers, and also carpenters, bricklayers and fishermen. (Department of Agriculture, 2018)

3.2.4 Industry sector

The current industrial sector in the Bago Sub-basin Area is small and mainly informal. Some people have rice mills, and saw mills, brick industries, handmade waving industries, sand and rock mining for construction purposes.

With regard to trends and plans for new industrial activities in Bago; little official information could be obtained from Bago Departments, but the following was generated based on internet search, which indicates that there may be a trend of increased industrialization in the near future.

Hantharwady Development Public Company will invest in Bago Region, Oathar town and Indagaw,. The company has secured state approval to invest a about K250 billion ($184 million) for a mixed-use land development comprising housing and industrial park projects. The housing project covers an area of 266.75 acres in Oathar town and the Industrial park covers 2454.98 acres in Indagaw, both located near the Yangon-Mandalay highway road. Read more at: https://www.dealstreetasia.com/stories/new-land-development-hosing-industrial-park-bago-approved-184-million-80604/

Yeni Industrial Township in Bago Region: The Township is planned to accommodate several focused clusters of light industries: textiles and garments, paper and pulp, printing and packaging and warehousing, with existing and future support infrastructure of rail and road connectivity, sub-station of national electricity grid, dormitory, natural gas sub-station (for power plant), water purification and sewage treatment plants; and social infrastructure including commercial, recreational, institutional and educational facilities as well as residential development. http://goldenglory.asia/our-business/yeni-industrial-township/

Carlsberg has a brewery in Bago Township which was inaugurated by the Carlsberg Group May 2015. It is announced on the website, that, “the facility uses high quality water, the famous Bago rice and imported raw materials, such as malt and hops” (Myanmar Carlsberg website, accessed May 2018).

3.2.5 Domestic sector

Drinking water

It was emphasized in the Bago River Non-governmental stakeholder Group meetings that availability of drinking water is a recurrent problem in the dry season for all the case study townships. According to a study carried out by UNDP Myanmar (2014) in the Bago Region, lack of access to clean drinking water emerged as the most important issue in the region mentioned by 27 % of the respondents, followed by lack of jobs (24 %) and lack of access to electricity (13 %).

Local residents have voiced concerns about private rubber plantations within the Kan Taw Gyi watershed area, that includes an important drinking water reservoir for the Bago Township. It is estimated that around 55 % and 730 acres of the Kan Taw Gyi Protected Public Forests consist of private rubber plantations. The rubber plantations use chemicals which may pollute the drinking water and have harmful impacts on biodiversity.

Women are the main caretakers in the household involving responsibility for provision of water for drinking and for other domestic uses. Provision of water is also the responsibility of some men. Most people in rural areas (outside of the Bago City area), collect water from ponds and wells for drinking and domestic purposes, some also collect rainwater in tanks. Ponds and well are not considered to be far from the village. About 30 % of the people have access to latrines.

With regard to waste disposal, this is the responsibility of both women and the men. Women is responsible for household trash, and men are responsible for larger waste and garbage.

People mostly use decentralized solar energy for electricity, access is limited and unstable.

There are squatters in the area, but data is not available. The squatters live on fallow lands, protected forest areas and roadsides areas.

4 Environmental aims and pressures in Bago

The development of a Sub-basin Area Management Plan (SBAMP) is an important tool for the River Basin Management Approach, which refers to coordinated management within the basin across administrative borders. The approach has been implemented in Europe as part of the EU WFD (European Commission, 2000), and it is an aim according to the Myanmar NWFD to implement this approach in Myanmar (Appendix A). This chapter presents the steps and the process of deciding upon environmental aims and the identifying of pressures as discussed during 2016-2017 in the Bago Sub-basin Area Committee, and in the Bago Non-governmental Stakeholder Group.

The Bago Sub-basin Area Committee consisting of sector and environmental authorities, and the Bago Non-governmental Stakeholder Group consisting of politicians, NGOs, CBOs and private actors have been established as part of pilot testing the River Basin Management Approach in the Bago Sub-basin (Zaw Lwin Tun, 2016). Committee members are mainly staff from FD, IWUMD, DWIR, ECD, DOF, DOA, and MOH, mainly from Bago District level. There are approximately 40 active members, that is members which attend meetings. The MONREC Minister was elected as the Committee chairperson. During the first part of this pilot, this referred to Kyaw Min San, while during the second part, it has been, Dr. Saw Nyo Win); the Forest Department and Zaw Win Myint (FD) the head secretary, and Ko Ko Oo (IWUMD) and Htay Aung (DWIR) were elected as co-secretaries. It was decided to focus discussions on pressures and abatement measures in the following four case study area townships; Bago TS, Thanatpin TS, Waw TS, Kawa TS.

Section 4.1 presents a brief overview of some relevant environmental policies and strategies in Myanmar. Sub-basin level environmental objectives as discussed in Bago Sub-basin Area Committee and in the Bago Non-governmental Stakeholder Group are presented in section 4.2. Section 4.3 presents a summary of main pressures and human impact in the sub-basin. Identification of pressures is based on knowledge of point source and diffuse pollution, and of monitoring of chemical and biological water quality parameters (see Eriksen et al. 2017). Section 4.4 presents water bodies at risk of not meeting the identified environmental objectives.

4.1 Myanmar national level environmental objectives

The purpose of this overview of Myanmar environmental objectives is not to be comprehensive, but rather to present laws and national level strategies of relevance for the discussion of aims and abatement measures in the Bago Sub-basin. Several national environmental strategies and objectives have been adopted in Myanmar the recent years, and we see this as important information related to identification of local environmental objectives. Sub-section 4.1.1 lists main laws relevant for discussion of abatement measures for good ecological and chemical status in water bodies.

The Environmental Conservation Law (2012) is a framework law enabling coordination between government departments, government organizations, international organizations, non-government organizations and individuals in matters of environmental conservation. The law presents basic environmental principles and give guidance for systematic integration of matters of environmental conservation in the sustainable development process; to create a healthy and clean environment and to conserve natural and cultural heritage; to restore ecosystems which are starting to degenerate and disappear; to manage and implement for decrease and loss of natural resources and for enabling sustainable usage. Figure 4.1 presents the guiding principles of the Environmental Conservation Law.

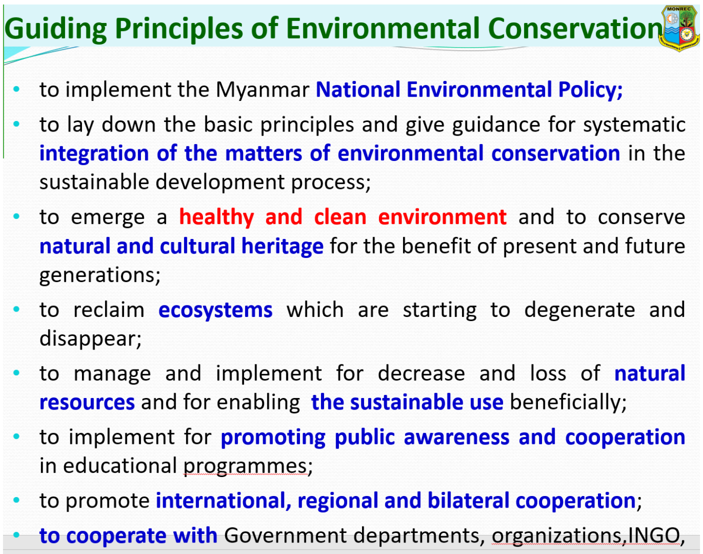

Figure 4.1 Guiding principles of the Environmental Conservation Law.

Myanmar National Water Framework Directive 2014 *(version 2015)* aims to establish "frameworks for all walks of life towards the National Water Law and National Water policy which overarches the Myanmar's water sector in the sense that it prescribes steps to reach the common goals rather than adopting the pretext by tow down approach". The complete document is included in Appendix A.

The seven directives stated:

(1) *Good status for all ground water and surface water*
(2) *National Water Budget (Available Water Quantity*
(3) *The ecological and chemical status (continuous water quality monitoring*
(4) *Cooperation between the Union Government and Regional Governments*
(5) *Spatial management of river basins*
(6) *Transgressions (River water transfer projects)*
(7) *Restructuring Process*

The MNWFD is a policy framework and the primary reference document for the work in the Bago River Sub-basin Area, and for development of the Bago River Sub-basin Management Plan.

The National Wetlands Policy (draft, 2017)

The policy specifies that wetlands include all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.

The policy specifies the following aims: (i) to raise awareness and understanding of the importance of wetlands and for sustainable development of the country; (ii) enhance participation from the governmental departments, non-governmental organizations, local communities and private sector in wetlands conservation, management and wise use; (iii) the mainstreaming of considering wetland resources in development planning; (iv) protect wetlands of national significance by conservation measures; (v) strengthen sustainable use of goods and services obtained from wetlands; (vi) will practice wise use and conservation of wetlands in line with the Ramsar Convention.

The National Climate Change Policy includes the vision for Myanmar to be a climate-resilient, low-carbon society that is sustainable, prosperous, and inclusive, for the wellbeing of present and future generations. It refers to the goal that Myanmar by 2030 is achieving climate resilience and is engaged in low-carbon, resource efficient and inclusive development as a contribution to sustainable development (MONREC, 2017b). Six focus areas have been identified, among which several have interlinkages with water environment (Figure 4.2). Hence the objective of climate resilience, and low carbon strategies also need to be considered when developing sub-basin level management plans.

Figure 4.2. Focus areas identified in the National Climate Change Policy, draft version. (Source: MONREC, 2017).

National and city waste management Strategy and Action Plan (NWMSAP) (*draft*) Mission: To develop and implement the holistic / integrated waste management strategy based on principles of inclusiveness, zero waste and circular economy to achieve a greener, cleaner and healthier environment.

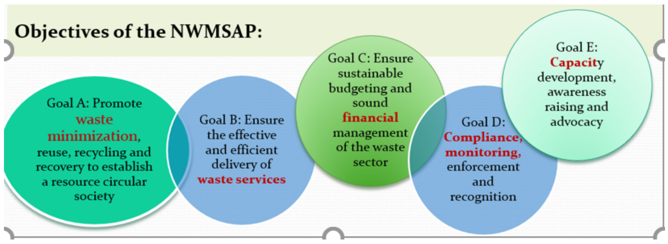

Figure 4.3 Objectives of the national and city waste management strategy and action plan, draft version. (MONREC, 2016).

4.1.1 Myanmar environmental laws

We present in Table 4.1 an overview of important Myanmar laws regarding water management. A broader overview of laws and policies for environmental management can be found in Nesheim and Platjouw, 2016.

Table 4.1 Important Myanmar laws for water management.

Laws	Responsible departments
Underground Water Resources Law (1930) http://www.myanmarconstitutionaltribunal.org.mm/lawdatabase/sites/default/files/myanmar_code/2015/09/4-1930%20THE%20UNDERGROUND%20WATER%20ACT.pdf	
Aquaculture Law (1989) http://www.myanmartradeportal.gov.mm/index.php?r=site/display&id=754	Department of Fishery, MOALI
Forest Law (1992) http://displacementsolutions.org/wp-content/uploads/THE-FOREST-LAW-1992.pdf	Forest Department, MONREC
Protection of Wildlife and Protected Areas Law (1994) (http://www.dwir.gov.mm/index.php/legislation-regulation/the-conservation-of-water-resources-and-rivers-law)	National Wildlife Conservation Division, MONREC
Fertilizer Law (2002) http://www.asianlii.org/mm/legis/laws/tflspadcln72002562/	Department of Agriculture, MOALI
Water Resources and Rivers Conservation Law (2007) http://www.dwir.gov.mm/index.php/legislation-regulation/the-conservation-of-water-resources-and-rivers-rule	Directorate of Water Resources and Improvement of River Systems, MOTC
Environmental Conservation Law (2012) http://www.myanmar-law-library.org/law-library/laws-and-regulations/laws/myanmar-laws-1988-until-now/union-solidarity-and-development-party-laws-2012-2016/myanmar-laws-2012/pyidaungsu-hluttaw-law-no-9-2012-environmental-conservation-law-english.html	Environmental Conservation Department, MONREC
Regions/States Fresh Water Fishery Law (1991) http://extwprlegs1.fao.org/docs/html/mya63898.htm	Department of Fisheries, MOALI
Environmental Impact Assessment Procedures (2015) https://www.aecen.org/sites/default/files/eia-procedures_en.pdf	Environmental Conservation Department, MONREC
Pesticide Law (2016) http://www.myanmar-law-library.org/law-library/laws-and-regulations/laws/myanmar-laws-1988-until-now/union-solidarity-and-development-party-laws-2012-2016/myanmar-laws-2016/pyidaungsu-hluttaw-law-no-14-2016-pesticide-law-burmese.html	Department of Agriculture, MOALI
Irrigation Acts (2016); former Canal and Embankment Acts from the British Colonial period around 1904-05 which are updated and combined into the Irrigation Act.	Irrigation and Water Utilization Management Department, MOALI

4.2 Identification of Environmental objectives in the Bago Sub-basin

The Bago Sub-basin Area Committee, consisting of environmental and sector authorities, was formed in 2015 as a result of two workshops that discussed piloting the River Basin Management Approach in the Sittaung River Basin (Zaw Lwin Tun et al., 2016). The Bago River Sub-basin was identified in the project as a case study area for implementation of practical water management practices. A Non-governmental Stakeholder Group for input and feedback from NGOs, CBOs and civil society was formed as part of a parallel workshop in Bago (Zaw Lwin Tun et al., 2016). The Bago Committee and the NGS Group have met regularly, each in total of four times to discuss environmental aims, pressures, and abatement measures and prioritized abatement measures (Figure 4.4). Bilateral meetings have taken place with the Chairperson and the secretaries of the Committee and with the secretaries of the Group.

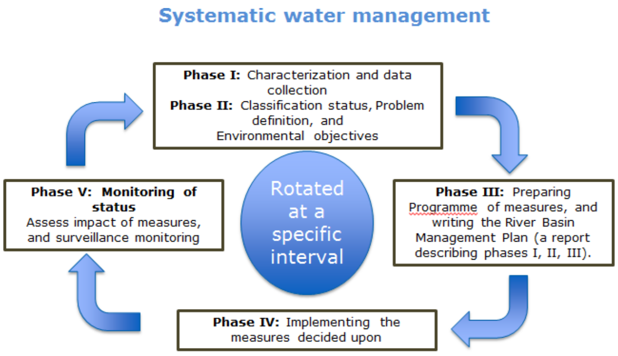

Figure 4.4 Systematic water management according to the EU WFD.

A framework for a sustainable development goal and environmental objectives was presented by the IWRM project team to the Committee and the Group as an introduction to discussions (Figure 4.5). The framework presented reflects the Sustainable Development Goals (Figure 2.1), while reference is made to the objectives of good chemical and biological status of the EU WFD and the MNWFD[2] (Appendix A). The framework being discussed by the Committee and the Group, includes an overall long term sustainable development goal, "Safeguarding living oceans, rivers and lakes for the benefit, safety and enjoyment of present and future generations". Five supportive environmental objectives are seen as necessary for achieving the overall goal. The sustainable development goal is formulated holistically and overarching. It may be discussed whether this overall goal should be the same as that of the Wetland Policy; or that of the National Water Policy[3].

The environmental objectives refer to aims which can be addressed and achievements monitored. The environmental objectives which are presented in the sub-sections below, each focus on different characteristics of the water environment (Figure 4.5).

[2] The main goals of the MNWFD are: 1. getting Myanmar rivers healthier, waters cleaner and more beneficial for all purposes; 2. getting the citizens involved in a peaceful way; and 3. getting Green Economy momentum quickly and achieve Green Growth shortly.

[3] The goal of the National Water Policy 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.

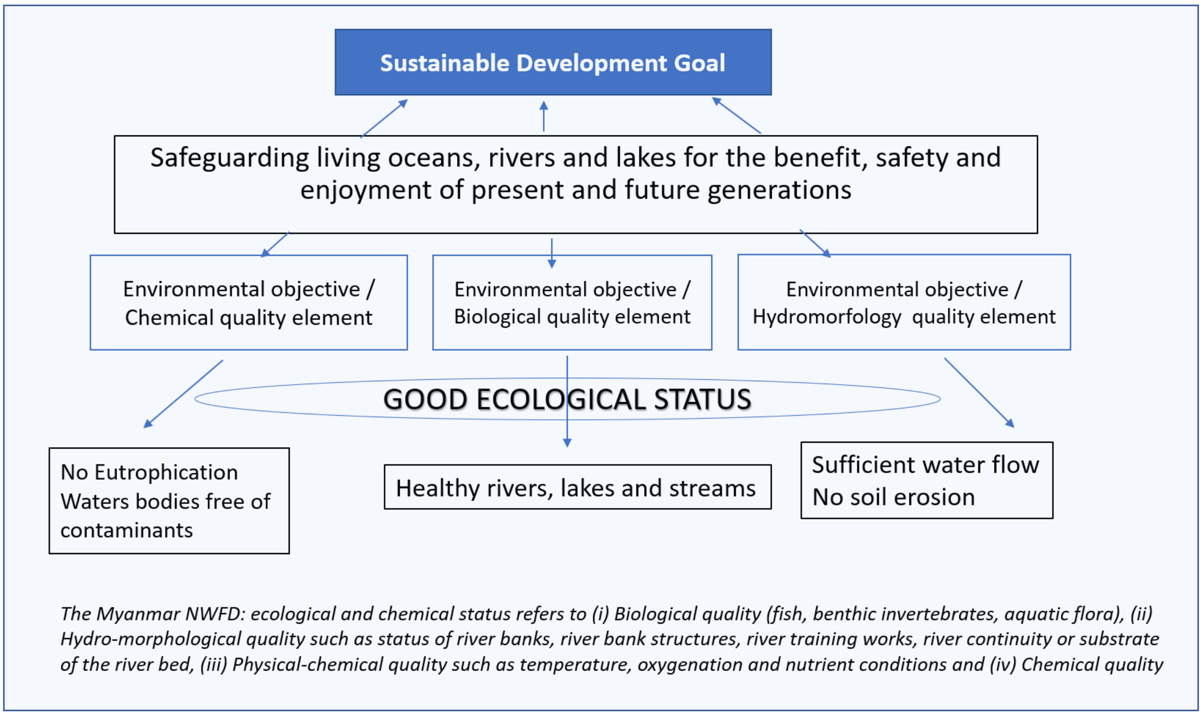

Figure 4.5 Illustrates how the sustainable development goals with sub-objectives links to the specific objectives of the Myanmar NWFD.

Identification of short term environmental objectives is recommended. However, the identification of short term objectives was not aimed for in this pilot, as such discussions needed experience based knowledge of impact of measures from Myanmar. The alternative to discussing short term objectives, is the discussion of realistic abatement measures for implementation (Chapter 6 and 7).

An annual follow up of progress towards environmental objectives is advised. This should include a progress report, is based on sufficient monitoring, to assess the degree that abatement measures improve surface water quality. Discussion of possible remediation of measures may follow for reaching environmental objectives. A "traffic light" system to track and redirect the progress of reaching the environmental objectives (Figure 4.6) may be used. This simple system may serve as a visual reflection of an ecological status situation for decision makers, stakeholders and non-governmental organizations.

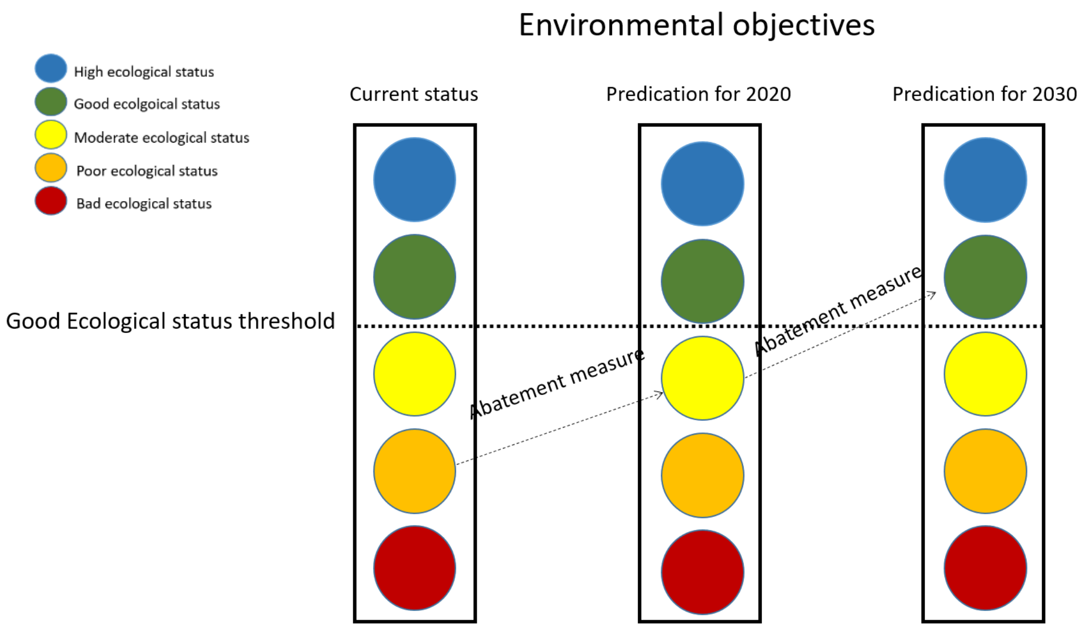

Figure 4.6. A "traffic light" system to serve as a visual reflection of ecological status of water bodies situation for decision makers, stakeholders and non-governmental organizations.

4.2.1 No eutrophication

The objective of "no eutrophication" is in the project defined as: *"The concentrations of eutrophying substances in soils and water will not have a negative impact on biodiversity, human health, or deterioration of water quality in ocean, rivers and lakes".*

This objective is related to the chemical water quality element of the EU WFD, and directive 3 of the Myanmar NWFD. Nutrient levels are an important parameter for classification of ecological status in lakes and reservoirs (EU WFD). Ecological status classes for nutrients is under development in Myanmar (see Mjelde et al., 2017; Eriksen et al., 2017).

High nutrients levels in a water body and in particular nitrogen and phosphorus cause eutrophication. Eutrophication is the enrichment of a water body with nutrients, and it is most commonly induced by the discharge of phosphate-containing detergents, fertilizers, or sewage, into an aquatic system. Eutrophication may lead to depleted of oxygen levels a situation which cause death of fish and other aquatic animals. High nutrients levels induce growth of algae, some of which may be toxic.

4.2.2 Water bodies free of contamination

The objective, "water bodies free of contamination" is in the project defined as, *The occurrence of contaminants developed by society shall not affect human health or biological diversity in terrestrial and aquatic environments.*

This objective is a parallel to Directives 1 and 3 in the Myanmar NWFD: «Chemical quality, refers to environmental quality standards, these standards "specify maximum concentrations for specific water pollutants», and it is related to the Myanmar Drinking water standard.

The EU WFD recommends a combined or dual approach to pollution control. This encompasses the use of chemical quality standards for water bodies, and that of emission limit values for any discharge of effluents to them, i.e. source control. Control of chemical substances is targeted at toxic effects on ecosystems, and it refers to a priory specified substances. 33 specified substances (prioritized substances) are specified in the EU WFD as representing a significant risk to or via the aquatic environment (2000/60/EC) (WFD)[4]. This list of substances is re-examined by the European Commission (EC) every four years. The list includes organic contaminants (e.g., hydrocarbons, organochlorine compounds, organic solvents, pesticides, and chlorophenol) and toxic metals and one organometallic compound (tributyltin).

According to the EU WFD, good chemical status for a water body is obtained when the concentrations of the priority substances in water, sediment or biota are below the Environmental Quality Standards (EQSs). Monitoring the progressive reduction in contaminants, trend studies, whether spatial or geographical, should be envisaged through the measurement of contaminants in sediment and biota.

4.2.3 Healthy rivers, lakes and streams

The objective, "healthy rivers, lakes and stream" is in the project defined as, *Biodiversity and their variety of habitats in lakes, rivers and transitional must be ecologically sustainable.*

Related to this objective, the Myanmar NWFD lists the following biological quality elements for assessing healthy rivers; lakes and streams: fish, benthic invertebrates, aquatic flora. The National Wetland Policy (2017), specifies that "status classification" should be determined with reference to the natural condition of lake. The EU WFD evaluates ecological status with reference to selected biological quality elements (Mjelde et al. 2017). All together five biological elements are included in this classification; phytoplankton, aquatic macrophytes, phytobenthos, bentic invertebrates and fish.

Aquatic macrophytes are primary producers and considered to be excellent indicators for ecological status assessment of lake ecosystem and slow-flowing rivers because they respond to nutrients, light, toxic contaminants, metals, herbicides, turbidity, and water level change (Mjelde et al. 2017). This makes aquatic macrophytes the most relevant biological element for assessment of eutrophication, acidification, salinization and hydromorphological changes.

Phytobenthos are one of the biological quality elements required in the EU WFD. Phytobenthos is the most relevant primary producers in rivers, especially in fast-flowing sites, some countries include this element also in lakes.

Benthic macroinvertebrates (organisms that inhabit the bottom substrates of freshwater habitats, for at least part of their life cycle) constitute important links between primary producers, detrital deposits and higher trophic levels in aquatic ecosystems. Benthic macroinvertebrates are sensitive to organic enrichment, pollution by toxic chemicals, acidification, and abstraction of water. It is a relevant indicator in rivers, but also in lakes (Eriksen et al. 2017).

Fish is a recommended element for both rivers and lakes, and are primarily sensitive to abstraction of water and morphological alterations, and overfishing.

[4] Article 16 of the WFD sets out for the European Union (EU) a strategy against pollution of water by chemical substances.

4.2.4 No soil erosion

The objective, “No soil erosion” is in this project defined as the aim to, *Protect soils adjacent of rivers, streams, and lakes to reduce erosion, transportation of pollution and use the natural filtration provided against anthropogenic pressures*.

This objective has a parallel in the hydromorphologcal quality element of the EU WFD. Hydromorphology is defined as an important supplementary component in determining the ecological status of running waters, and it is specified as the hydrological and geomorphological conditions of rivers and streams. Erosion causing soil degradation, sediments and siltation with fine particles is a major problem in many rivers, especially in areas with changed land-use (deforestation) and agriculture. Action to reduce erosion and control the sedimentation processes is needed many places. Adequate assessment of stream and river hydromorphology requires consideration of any modifications to the flow regime, sediment transport, river morphology, lateral channel mobility, and river continuity. Erosion and sediment management, have however, little focus in the EU WFD. See more information on about hydromorphological assessment at the “Reform project” website, http://www.reformrivers.eu/news/152

Completely natural water courses which are not subject to human influence or requirements do not need sediment management.

4.2.5 Sufficient water flow

The objective, “Sufficient water flow” is in this project defined as, *sufficient to secure ecosystem services for biodiversity and human security in a living and thriving river system.*

The parallel to this objective is included in the Myanmar NWFD in both Directive 1 and Directive 2; Directive (1), Good status for all ground water and surface water is defined as, clean and sufficiently stored' for all ground water and surface water (rivers, lakes, transitional waters, and coastal waters) in Myanmar; Directive (2), National Water Budget (Available Water Quantity) The Water Framework Directive stipulates that, the national water budget must be estimated under the current hydrological and meteorological conditions taking into consideration of the climate change impacts already visible. It states that surface and groundwater must achieve “good quantitative status” by 2030.

In the EU WFD, the concept of sufficient water flow parallels the concept of environmental flow which is specified and described in the EU WFD Guidance Document No. 31 (European Commission, 2015). Environmental flow is a widely accepted term that covers the quantity, timing, duration, frequency and quality of water flows required to sustain freshwater, estuarine and near-shore ecosystems and the human livelihoods and well-being that depend on them. Proper definition and efficient implementation of ecological flows require a significant amount of hydrological data (modelling approaches may to some extent supplement insufficient monitoring data). Sufficient hydrological information should be collected to estimate the current flow regime and how it deviates from the natural flow regime. It is recommended to include in a water management regime means to ensure implementation of ecological flows (Nesheim et al. 2016).

It may be noted that the EU WFD has included the concept of heavily modified water bodies which are exempted from the aim of good ecological status. These are water bodies which as a result of physical alterations, e.g. such as by irrigation, drinking water supply, power generation, and navigation, cannot receive good ecological status. The WFD refers to criteria for less stringent environmental objectives: New sustainable human development activities; Actions or policies aiming to protect fundamental value for citizen's lives (health, safety, environment); Artificial or heavily modified water bodies being described (Article 4.3).

4.3 Human impact and pressures as identified in Committee meetings, and Non-governmental Stakeholder Group meetings

Pressures and prioritized water management issues were discussed in the Bago River Sub-basin Area Committee, and in the Non-governmental Stakeholder Group meetings. Discussions mainly covered pressures identified for the four case study townships (Table 4.2). We present in this section a summary of identified pressures and human impact. In the report, Characterization of the Bago Sub-basin, Pilot implementing the EU Water Framework Directive, Eriksen et al. (2017) presents a more thorough description of pressures identified in the Bago Sub-basin. Chemical and biological monitoring results from the Bago River are presented in Appendix B. Section 4.5 presents identified water bodies at risk of not meeting environmental aims in the Bago Sub-basin.

Citations from welcome speeches by the secretaries of the Committee are presented:

- *The head secretary of the Committee, Zaw Win Myint (Director Forest Department Bago Region), stated in his opening speech: In order to prevent over nutrition in the water, the use of chemical fertilizer should be effectively regulated by Law, Rule, and Regulations, and actions should be taken by Region level. Moreover, there are many rubber plantations around the Bago City and the use of pesticides and chemicals should also be controlled. Agricultural systems that encourage the increase in soil cover should also be considered as there are different agricultural patterns and Taung-ya practices in the watershed areas of the upper part of Bago River.*

- The Committee co-secretary, Ko Ko Oo, (Director of Irrigation and Water Utilization Management Department, Bago Region): *"Bago River Basin is endowed with abundant water resources and water utilization is diverse in the region. There are totally (36) water utilization areas including Moe Yun Gyi Ramsar Site, rivers, lakes, dams, weirs and sluice gates. Environmental pressures such as loss of agricultural lands and bank erosion were occurring especially in the downstream Bago River area".*

- The Committee co-secretary, Thay Aung (Director of DWIR)*: "The Bago Region is enriched with water resources and bounded by a large number of rivers, creeks and lakes, and due to lack of proper management on abundant water resources, the area is now under the threats of flooding, bank erosion, loss of fertile farmlands in the rainy season and scarcity of portable water in some areas".*

From the minutes of the Non-governmental stakeholder meeting:

- The Non-Governmental Stakeholder Committee Secretary and Associate Secretary, respective representatives from different organizations stated that: *it is urgently needed to maintain and conserve the entire ecosystem of the Bago River Basin area as the quality of river water is getting poorer and the natural ecosystem in this area is being deteriorating due to the anthropogenic activities from that area.*

Table 4.2. Meeting for the discussion of prioritized management issues in Bago (September 2016).

Bago township	Thanatpin township	Kawa township	Waw township
Sewage Garbage Sand mining Industrial waste River Bank Erosion and Sedimentation	Salt water intrusion Invasive shell species destroying paddy fields High concentration of phosphorus and nitrogen Groundwater pollution Riverbank Erosion and Sedimentation	Salt water intrusion Invasive shell species destroying paddy fields High concentration of phosphorus and nitrogen Riverbank Erosion and Sedimentation	Salt water intrusion Invasive shell species destroying paddy fields High concentration of phosphorus and nitrogen Riverbank Erosion and Sedimentation

4.3.1 Point source pollution pressures

Point source pollution is identified as a single identifiable source of air, land, or water pollution. Typical examples include domestic sewage and industrial wastewater discharges whereby pollution is discharged via a pipe or drain.

Few point source pollution pressures have been identified along the Bago River. Identified industries are mainly saw mills, and brick production industries in the Bago Township, but diffuse rather than points source pollution is associated with these. Furthermore, production are mainly low scale and impacts are apparently low.

4.3.2 Diffuse pollution pressures

Diffuse source pollution – refers to run-off from land-use activities, both rural and urban which are not related to well-defined points of discharge. It includes such as, run-off from farmland, sewage from scattered dwellings and urban areas. It is the sum of many, often small, pollution sources that collectively result in a significant environmental impact. A major incident of non-point source pollution into rivers and streams is related to the monsoon season as heavy precipitation acts as surface wash-off for various pollutants

Sewage and garbage from towns and settlements

The Committee members and the Non-Governmental Stakeholder Group members identified disposal of garbage and sewage directly into the Bago River as two major pressures in the Bago Sub-basin. Disposal of garbage block the drains, and sewage and waste water are harmful for usage of water for domestic purposes. Houses with toilets and tubes for discharge into Bago River can be observed when travelling by boat on the river.

As part of a meeting with the Bago Township Development Committee in 2015, it was stated that: "Water quality in the river is bad. Sewage from households and agriculture is the main problem. Sewage management is the household's responsibility, they dig pits for 'septic tanks'. When one pit is full they dig a new one." (Personal communication with the Bago Township Development Committee, 2015). The sewage system is the responsibility of the Bago Township Development Committee, but only a relatively small fraction of the Bago City sewage is collected from septic tanks. There is no treatment of sewage in the district.

The lack of proper sanitation will lead to deteriorating water quality. Pathogens such as *Escherichia coli* (hereafter *E. coli*), *Clostridium perfringens, Campylobacter* and *Salmonella* are common in human and animal fecal and are hazardous to human health. High amounts of pathogens in the water used for irrigation can damage crops and be a liability for human health as crops become unsuitable for human consumption.

Run of from agricultural areas
Key pollutants include nutrients, pesticides, sediment and fecal microbes. Fertilizers used on agricultural plains alongside the Bago River cause runoff of nitrogen and phosphorus into the river. Animal husbandry alongside the river, or close to reservoirs, are destructive as trampling by animals destroys vegetation cover increasing run off to water bodies, and their dumping is a source of fecal microbes and nutrients. The areas alongside the Bago River around the Bago City Area, and also downstream the Bago City have little vegetation cover causing runoff to the river. Runoff of nutrients and sediments are higher where vegetation cover alongside the river is fragmented or lost. Nutrients (nitrogen and phosphorus) can have significant eutrophication effects in lakes, reservoirs, and coastal areas. Nutrients will have the largest effect in the river itself at low/stable flow conditions. The amount of fertilizers (referring mainly to nitrogen and phosphorus) may cause toxic algal blooms and reduce oxygen levels in the water; both of which are harmful for aquatic organisms. The combined impact of these problems may affect economic conditions of local communities.

The usage of pesticides varies between farmers, but according to personal communication with the Bago Region Agricultural Department usage is low. Pesticides are mostly applied by wealthier farmers during the growing season of crops. Loss will be highest when pesticides are applied just before, or during, high precipitation events. Hydrophobic pesticides adsorbed to particles can remain active for long periods and can cause toxic effects.

4.3.3 Land and water use - pressures (include hydro-morphological alterations)

Hydro-morphological alterations – including abstractions of water for irrigation, human consumption, and industrial purposes; and impoundment of water by dams for a range of uses such as hydropower, irrigation; embankments, channel alignments, substrate excavation, draining.

Water abstraction and dams
Water from the Bago River is used for irrigation of paddy fields and for hydropower production (Eriksen et al. 2017). Thirteen reservoirs, where five are hydropower multipurpose plants located on Bago River and on tributaries to the Bago River. Dams and weirs create migration barriers for biota. The main challenge in managing abstraction is meeting the reasonable needs of water users, while leaving enough water in the environment to conserve river and wetland habitats and their species. According to communication with the secretaries of the Bago Sub-basin Area Committee, abstraction cause no significant negative impact on water availability. There is however according to Shrestha et al. (2017) an issue with regard to sufficient water in the dry season in the Moeyingyi reservoir. This wetland is used to supply water to the Bago–Sittaung canal during the dry season as a source of irrigation water for rice farmers[5]. Members of the Bago Non-governmental stakeholder Group argued that the water flow management regime contributes to increased flooding and that drains in poor condition contribute to flow conditions.

[5] A network of freshwater wetlands, rivers and adjacent the Bago River are major sources of water to the Moeyungyi wetland. Around 8.5 m3/s of water is diverted to the Moeyungyi wetland through the Zangtu weir at the Bago River. Water is diverted during the monsoon season to prevent flooding in Bago City. The Moeyungyi wetland is managed by the FD, whereas sluice gates are controlled by the (Irrigation and Water Utilization Management Department (Shrestha et al. 2017).

The deforestation pressure, erosion flooding and salt water intrusion
Forest cover have decreased significantly between 2010 and 2015 with reduction in 21 % for open forests and 10 % for closed forests (Forest Department, 2017).

Deforestation upstream the Bago River cause soil erosion and increased sediment transport as the binding capacity of the forest floor is substantially reduced with removal of forests. Damage to the forest floor by large trucks removing logs further increases soil erosion. Leaching of nutrients such as nitrogen and phosphorus can be activated during deforestation and contribute to eutrophication or increasing the nutrient content downstream. Eventually erosion pressures cause downstream sedimentation pressure. Downstream sedimentation cause increased flooding during the monsoon and navigation becomes problematic. Furthermore, a combined effect of sedimentation and water abstraction/ divergence cause reduced discharge rates; this may contribute to increased salt water intrusion from the sea into the lower reaches of the Bago River. The impact of erosion and salt water intrusion is particularly high in the townships of Kawa and Thanatpin.

Charcoal production by households is prevalent to provide extra incomes. There is little direct impact from charcoal production on water quality, but indirect impacts occur as cutting forest contributes to deforestation.

Sand mining and erosion
Sand mining was emphasized as an important problem in Committee meetings and in Bago Non-Governmental Stakeholder Group meetings. Pyinbongyi sand from the banks of Bago River is renowned for its high quality and there have the recent decade been mushrooming of river sand mining activities. Related problems include riverbank erosion, river bed degradation, river buffer zone encroachment, and deterioration of river water quality (see also Khan and Sugie, 2015).

Rinaldi et al. (2005) report on the following potential impact of sand mining:
a) bed degradation and consequent effects on channel and bank stability;
b) increased sediment loads, decreased water clarity and sedimentation;
c) changes in channel morphology;
d) ecological effects on bird nesting, fish migration, angling, etc.
e) modification of the riparian zone including bank erosion;
f) direct destruction from heavy equipment operation;
g) discharges from equipment and refuelling;
h) reduction in groundwater elevations;
i) impacts on coastal processes.

Electro shock and chemical fishing
Electro shock, and chemical fishing are furthermore problems in the Bago area. In the study area's four districts, 93 instances of electro fishing were reported 2016, with 6 fishermen caught (Bago Forest Department, 2017). Fishing in the spawning period is not allowed, but to what extent this regulation is violated is not known.

4.3.4 Invasive and alien species

Alien species – this pressure refers to invasive and introduced species seen as pests by local people. In the Bago Sub-basin people complained about invasive shell species.

4.4 Water bodies and water body groups at risk of not meeting environmental objectives

The project team identified in 2016 a total of 35 water bodies for assessing ecological status by monitoring of hydromorphological, chemical and biological water quality elements in the Bago River Sub-basin (Figure 4.1, Appendix B). The purpose of this division of water bodies has been to enable identification of a suitable and effective monitoring program, and identify reference conditions to benchmark ecological status classification[6]. A water body is defined as a management unit, which have definite hydrological, physical, chemical and biological characteristics, shares the same pressures, the same water use criteria and environmental status and aims.

The discussion of abatement measures need to focus on water bodies at risk of not meeting environmental aims, and water use criteria. To ease the discussion of abatement measures, we introduced the concept of water body groups. That is, we group water bodies according to; (i) *water use criteria*, (ii) *types of pressures,* and (iii) *the distance in status from reaching environmental aims.*

In total five water body groups were identified in the Bago Sub-basin; Upstream Bago City Area water bodies, Bago City Area water bodies, Downstream Bago City Area water bodies, Reservoirs and dam water bodies, and National parks and wetlands protected for biodiversity. These water bodies are assessed with reference to the risk of not meeting environmental objectives. In total five water body groups were identified in the Bago Sub-basin; Upstream Bago City Area water bodies, Bago City Area water bodies, Downstream Bago City Area water bodies, Reservoirs and dam water bodies, and National parks and wetlands protected for biodiversity. These water bodies are assessed with reference to the risk of not meeting the objective of good ecological status. It is suggested that good ecological status in the Myanmar context, refers to the five environmental objectives: no eutrophication; water bodies free of contaminants, healthy rivers, lakes and streams, sufficient water flow, and no soil erosion. Ecological quality criteria are being identified for Myanmar conditions for chemical and biological water quality elements.

[6] Reference conditions reference conditions that represent the stable state of an ecosystem in the absence of significant human disturbance (see, Bouleau and Point, 2015).

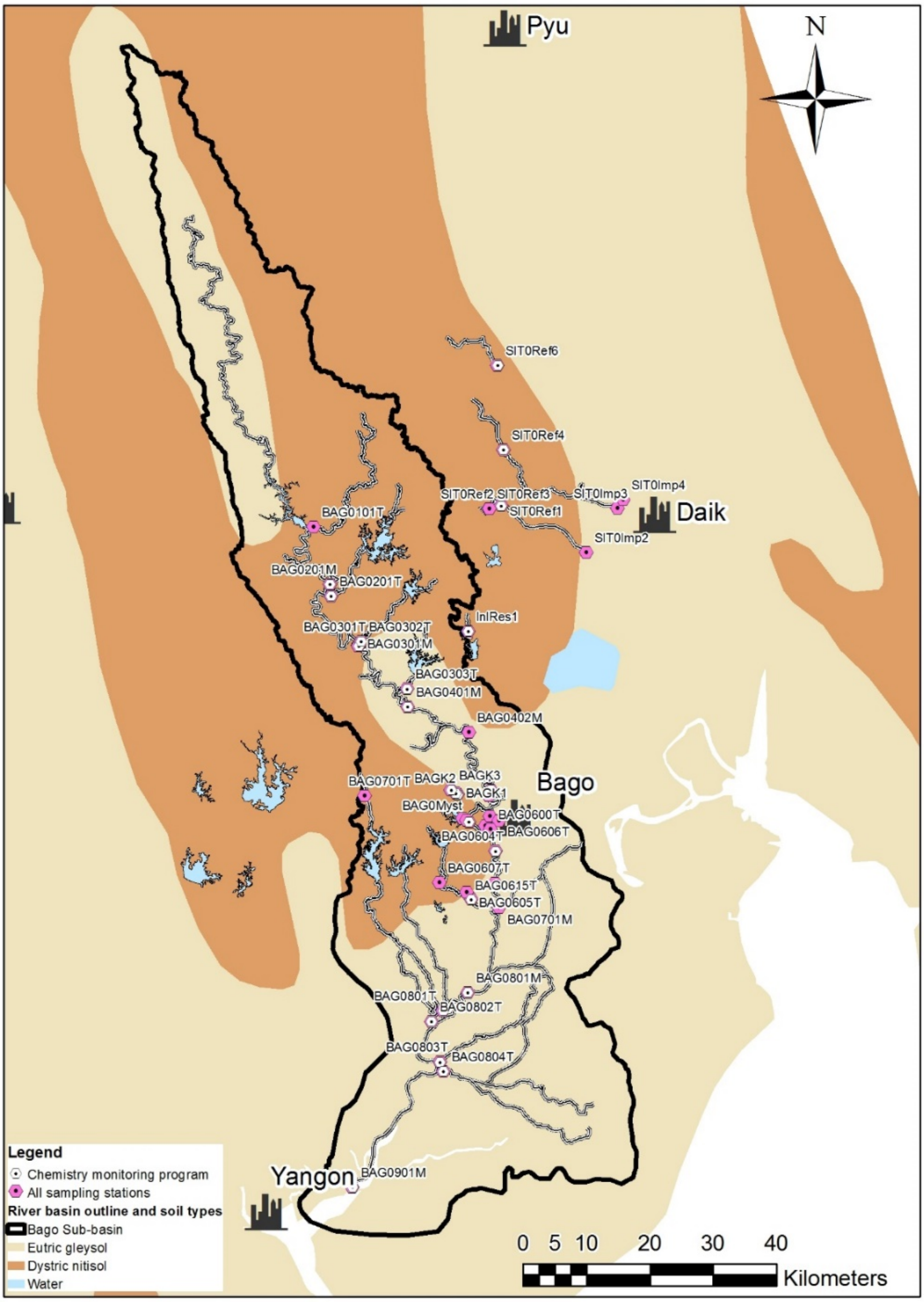

Figure 4.7. The Bago River Sub-basin Area showing water sample stations, i.e. stations are identified by station codes which are linked to water quality analysis results (Appendix B).

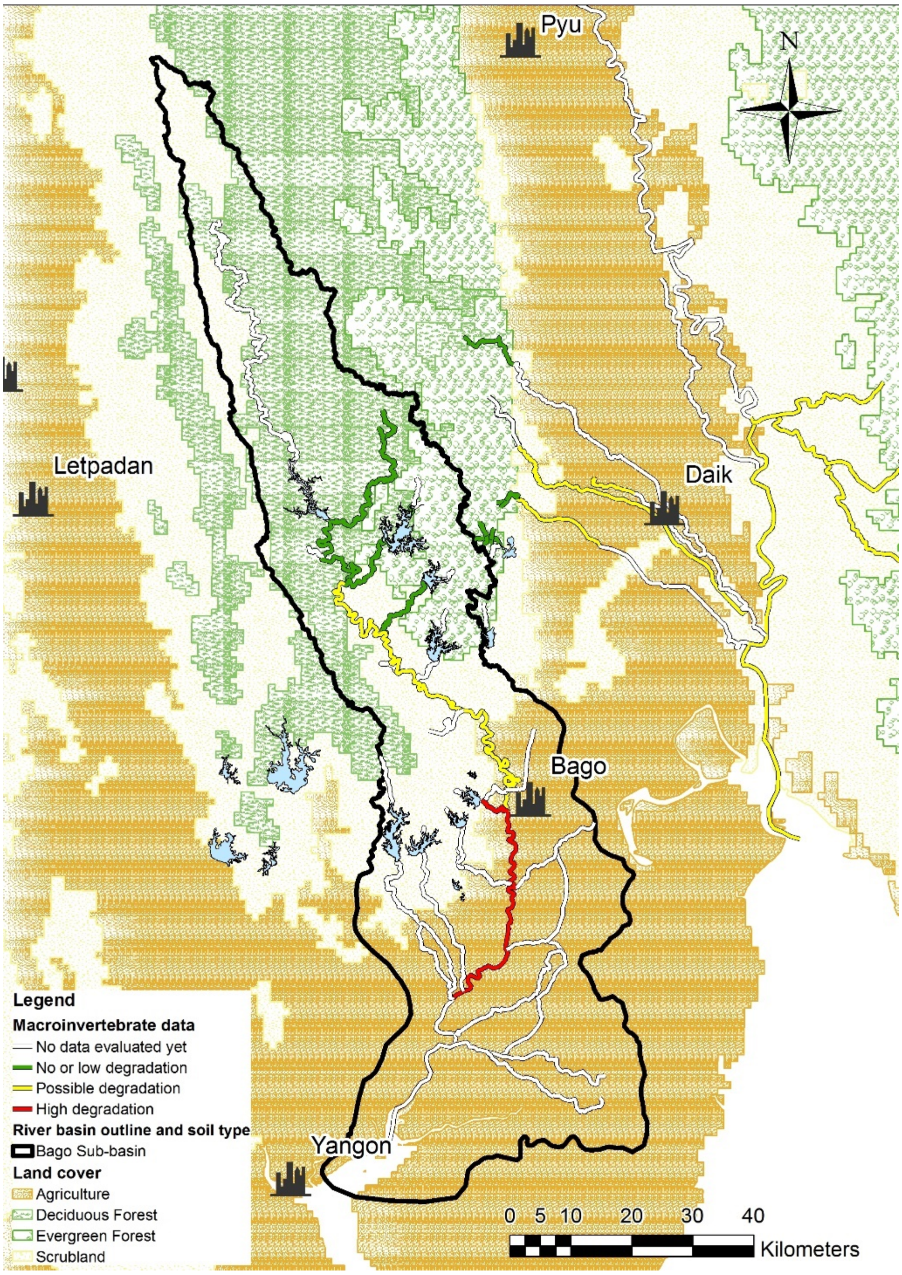

Figure 4.8. Qualitative assessment of streams of the Bago-Sittaung river basin based on macroinvertebrates. Green color of stream segment denotes no or low degradation, yellow possible degradation and red high degradation (Developed by T.E. Eriksen, 2018). White color denotes no available data. Land cover of agriculture, deciduous forest, evergreen forest and scrubland is shown based on open GIS data from the Myanmar Information Management Unit (http://www.themimu.info).

4.4.1 Upstream Bago City and tributaries to Bago River

From the initial assessment of status and use of water quality elements, i.e., the chemical, the biological and the hydromorphological elements in the Bago sub-basin, it appears that upper parts of the sub-basin system upstream of Bago city is mostly not at risk. Although a relatively large proportion of this area is influenced by human activity such as deforestation, agriculture and dams, the ecological status in this area is in general good or high condition based on the initial sampling programme. These results indicate that the pressures identified probably do not have a strong influence on environmental quality; this is likely because the upper parts of the Sub-basin, and catchments of the main tributaries, drain forested areas with little or no human impact.

Relatively large quantities of water combined with a physically varied environment result in both dilution of compounds entering the river, and self-purification that is breaking down organic matter and using nutrients. Results indicate high levels of sediment and nutrient transport in the rainy season, but this will most likely be transported through this part of the river without having a significant impact on the biota in this part. However, excess sediment deposited on the river bed can have significant negative impacts on ecological status by clogging natural substrates and reduce habitat availability. At this moment, there is not sufficient knowledge available to quantify the possible effects of high sediment loads upstream of Bago City. The "no erosions objective" is challenged in deforested areas. Moreover, the preliminary conclusion on ecological status given here should be interpreted with caution, as they are based on an initial sampling programme with relatively few data points and a limited list of response variables measured.

4.4.2 The Bago City water bodies

Water bodies within the limits of Bago City is deteriorated by various types of human activities and sewage inputs, resulting in the water bodies not reaching good ecological status. They are consequently at risk and their status should be improved by implementing several abatement measures. Runoff from untreated sewage, and input of various types of discharges in to the water bodies appear to be the main issue, but also physical modification and large quantities of litter and solid waste are observed throughout the urban waterways. In the main stream of the Bago River, both total phosphorous and nitrogen increase substantially to around 40 µg/L Tot-P and 400 µg/L Tot-N immediately downstream of city. This corresponds to a more than 3-times increase in phosphorous concentration, and a doubling for nitrogen concentration, compared with measurements taken in the main stream of the Bago River just upstream of the city limits. It is likely that, the high concentrations of phosphorous stem from waste water and sewage from settlement areas, while nitrogen stem from agricultural areas (application of fertilizers). Moreover, occurrence of E coli is recorded in water samples downstream of the city but not above, indicating the effect of untreated sewage being discharged to the river in Bago City. In the Mazin Chaung stream, that drains the Mazin reservoir, the increase in phosphorus is even more pronounced. The water leaving the reservoir is very low in Tot-P with a concentration around 7 µg/L, while the concentration is 40 µg/L just before the confluence with the main stem of Bago River after passing through the city.

4.4.3 Downstream Bago city water bodies

The initial assessment of water bodies below Bago City indicates that they are at risk and currently not fulfilling the environmental criteria of good ecological status. Concentrations of Tot-P and Tot-N are very high compared with upper parts of the Sub-basin with values of > 1000 µg/L recorded for both nutrients. It is likely that, the high concentrations of phosphorous stem from waste water and sewage from settlement areas, while nitrogen stem from agricultural areas (application of fertilizers). Most water bodies in this area have bad ecological status and are far from reaching satisfactory conditions. This can be related primarily to input of sewage from Bago city, extensive agricultural areas along the downstream parts of the river as well as other human activities. It is necessary to put abatement measures in to place that would improve water quality and ecological status.

4.4.4 Dams and reservoirs water bodies

Two reservoirs in the Bago Sub-basin have been investigated regarding water quality.

The catchment of Kandawgyi reservoir drains an area of protected public forest, a protection that has been in force since 1997. In addition, more than 50 % of catchment area is occupied by a private rubber plantation. The reservoir is an important source of drinking water for Bago City. The Myanmar Drinking water standard is the reference document related to water bodies used for drinking water (Appendix F). Water quality in the reservoir is overall good with a low concentration of Tot-P of 8 µg/L and only trace amounts of other chemical substances. The concentration of Tot-N is 390 µg/L, which indicate run-off from agricultural fields as the value is higher than what has been recorded in reference rivers in the area. More information is needed on background concentrations in this area as well as additional sampling of e.g. pesticides would be informative in a drinking water context. The station codes BA GK1, BA GK 2, BA GK 3 in Appendix B, provides information about water quality parameters from Kandawgyi.

The Mazin reservoir is used for irrigation purposes primarily, i.e. not drinking water, and the catchment is also partly covered by rubber plantations. Chemistry is very similar to that of Kandawgyi, with 7 µg/L Tot-P and 388 µg/L Tot-N. There are only trace amounts of other substances. Similar to Kandawgyi reservoir, it is not known if the relatively high nitrogen concentration is due to agricultural activities, that is application of fertilizers in these areas, but this is likely. There is no doubt however, that the higher Tot-N concentrations from these two reservoirs are part of the explanation for the elevated nitrogen concentration in the main stem of Bago River downstream of the city (4.4.2.).-The station code Bago604T in Appendix B, provides information about water quality parameters from Kandawgyi.

4.4.5 Moeyungyi Wetland Wildlife Sanctuary

This nature reserve within the Bago region was established in 1988 and became the first Ramsar site in Myanmar in 2004. The protection of Moeyungyi is important and it should be prioritized as an integrated part of the River Basin Management plans for the Bago Sub-basin Area (see draft management plan for the Moeyungyi Ramsar site, MONREC, 2017). The wetland consists of a shallow and turbid lake which could be in danger of eutrophication as well as impacts from pesticides and various toxic compounds that enters the wetland from the surrounding areas. Average Tot-P and Tot-N values, measured at 6 stations in the reservoir in November 2015, were 25 µg P/l and 318 µg N/l, respectively. These are relatively low concentrations considering the perceived risk of eutrophication. Filling of the reservoir during the rainy season has most likely diluted the nutrients in the reservoir in November as samples taken in May 2015, at the end of the dry season, showed much higher TP and TN concentrations; 185 µg P/l and 1700 µg N/l, respectively.

5 Abatement measures to reach environmental aim in Bago River Sub-basin

The purpose of this chapter is to present possible and relevant abatement measures for meeting environmental objectives in the Bago River Sub-basin as discussed in the Bago River Sub-basin Area Committee and in the Non-governmental Stakeholder Group during 2016 and 2017. Identification of possible abatement measures as part of the pilot testing the River Basin Management Approach in the Bago River Sub-basin has been a process over 1,5 years. The process included iterative discussions by sector and environmental authorities, and non-governmental stakeholders on the environmental aims and abatement measures. Discussions were supported by a common understanding of pressures and ecological status enabled by presentations prepared by FD, IWUMD and NIVA on water quality monitoring results from the Bago Sub-basin.

Section 5.1 presents measures currently implemented in the Bago District, and also measures discussed in the Bago Sub-basin Area Committee, and in the Non-governmental Stakeholder Group. To provide more information about relevant measures, reference to experiences elsewhere in Myanmar and in Asia are provided. As resources are limited, prioritization of measures is important before making final decisions. Section 5.2 present the process of prioritizing abatement measures towards for reaching a final agreement of measures to be implemented.

5.1 Environmental measures in Bago and some references to other relevant abatement measures

The Bago Sub-basin Area Committee discussed possible abatement measures in a meeting on March 3rd, and the Non-governmental Stakeholder Group possible abatement measures on June 19th 2017. To enable preparation for the meetings, minutes from the previous meeting were disseminated to members of the Committee and of the Group. This entailed a simple folder presenting the purpose of the project, update of monitoring results and main points already discussed, such as, pressures, and environmental aims and later also abatement measures (Appendix C). The folder was updated with new discussion points after every meeting. These factors have been important for a repetition of the issues to be discussed, and it has allowed for an understanding of the approach and discussion points for new attendants. A note of potential relevant abatement measures prepared by the Forest Department and NIVA (Appendix D) was disseminated to people attending meetings.

Every Committee and the Group meeting has been initiated with a ppt presentation which included a recent update of the ecological status in Bago water bodies based on monitoring of water chemistry and biology (invertebrates). The purpose has been to facilitate for a common understanding of the situation. Then, discussion groups have been asked to discuss and identify possible measures to target pressures for reaching the environmental objectives. Abatement measures have been discussed relative to *five water body group types* identified. The five water body groups which were identified based on water use criteria and the of types and levels of pressures included*:* (i) upstream Bago city water body groups (ii) Bago City area water body groups, (iii) downstream Bago City water body groups, (iv) reservoirs used for drinking water and irrigation water bodies, and (v) water bodies protected for biodiversity. Discussions of possible measures in the sub-basin in the Committee and in the Group, did not detail how, or where in the basin measures could be implemented. Some suggested “measures” have character of an aim. Discussions occurred in five groups for about 45 minutes (free seating), and each group consisted of about 5-8 people. After discussing, each group presented core points from the group discussions. The need to increase local awareness was repeatedly emphasized, and in particular by the Non-Governmental Stakeholder Group

The Bago Forest Department as the head secretary has subsequently interviewed sector authorities to collect information about ongoing abatement measures in the Sub-basin (Table 5.1). This also involved an assessment of the effectiveness of measures. Abatement measures can be can be categorized as either economic, regulation or soft measures (Nesheim and Platjouw, 2016). Measures identified in the Bago District are mostly rules and regulation type of measures (described below).

Other possible measures identified based on search or knowledge about implemented other in areas within the country or within the region are presented in this section.

Table 5.1. Current implemented and ongoing abatement measures are presented along with institutional responsibility.

Institutional responsibility	Pressure type	Measure	Township/ District	Effectiveness	Timeline	Funding
FD	Deforestation leading to erosion and sedimentation problems	Ban on logging	Bago Yoma	Relatively good, illegal logging continues to some extent	10 yrs	MONREC
		Reforestation and rehabilitation of the forests in Bago Region	Bago,Taungoo, Tharyarwaddy and Pyi Districts	Low effectiveness with regard to sedimentation as the measure is not targeted for mitigating this pressure.	10 yrs	MONREC
DWIR IWUMD	Flood	Dredging and excavation work of natural drainages and creeks within the river basin area Reconstruction and resection work for flood embankments made by local farmers and flood protection dike and embankments under the IWUMD's control	Bago, Thanatpin and Kawa townships	Enhance flood security by increasing agricultural productivity due to executing these measures such as improvement of drainages and flood protection dikes.	5 yrs	Both Union Government's budget and Regional Government's budgets
DWIR	Sedimentation problem	Excavation to attain sufficient water depth	Bago Region	Short term quite effective.	Long term	Both Union Government's budget and Regional Government's budgets
DWIR	Sand mining for construction cause erosion	10) number works/ licenses are no longer given for the Bago City area -	Bago City	Difficult to know the effect of only one year, effect not likely big.	1 yr.	No funding, DWIR gave only recommendation for sand mining
ECD	Contamination of water by industry	Point source pollution control, mostly after complaint. The measure is part of ECD's responsibility.	Bago Region	Few industrial activities, the effect is most likely low as there is also no available waste water treatment plant.	Long term	Regulation, no specific funding
Bago Township Development Committee	Waste	Systematic garbage management in Bago City area including collection from 6 garbage bins.	Bago Township	Collection of garbage is effective, but impact is low because too few collection points (garbage bins).	Long term	Bago Region government.
	Sewage	30 % within the Bago City area have septic tanks which are emptied every 2^{nd} or 5^{th} year.	Bago City area	The measure is effective, but impact on ecological status low as it only refers to 30%.	Long term	Bago Government
Fishery Department	Unsustainable fishing practices	Fishing is not allowed in the spawning period (May-July)	Bago Region	Enforcement varies.	Long term	Regulation, no funding

5.1.1 Waste disposal regulation and place for dumping garbage

Abatement measures to regulate waste disposal is the responsibility of Township Development Committees, i.e. in this study, the Bago, Waw, Thanatpin, and Kawa Township Development Committees.

Some ward administrations take responsibility for collecting waste within the ward center area. Also, some groups which have been formed to do good and for providing welfare for others, e.g. "Twel-let-myar", also contribute to waste collection in the Bago District.

All the information below has been acquired from the Bago Township Development Committee (2018), and one of the Secretaries of the Non-governmental Stakeholder Group, Dr. Hein Thant Zaw.

The following measures are being implemented:

A dumping ground for waste of about 20 acres is located at the Khe-Phaung-taw-kwin, which is near the Snake Pagoda. Local people use this place for disposal of household waste. This dumping ground does not have a garbage decomposing machine.

Sin-phyu-kwin dumping ground is a relatively new area of 95.1 acres (Figure 5.3). The dumping ground is the official site for disposal of garbage by the Bago Township Development Committee, and it has been active for two years (since 2015). Waste decomposing machines are placed in Sin-phyu-kwin (Figure 5.1). There is no landfill liner in place, and there is no sign has been placed to inform about discharge of waste, e.g. if hazardous waste can be dumped in this area.

Figure 5.1. Waste decomposing machine being checked by the Township Development Committee (*Source:* the Bago Township Development Committee).

Six garbage bins have been put up in the Bago City area, but this is not enough for all the waste produced in the city (Figure 5.3). The garbage collecting trucks empty the waste from the garbage bins every day except Sunday. They collect the waste from each ward in the Bago City once a week. The garbage is dumped at the Sin-phyu-kwin dumping ground.

A garbage campaign; “Save the Bago River” is a collaborative campaign initiated by the Township Committee and involving civil society. The campaign includes patrols every night on the two main Bago bridges, to stop people from throwing garbage into the river. In addition, civil society garbage collection campaigns are organized. On February 10th 2018, five hundred people collected garbage in the Bago City area.

The following plans for regulating waste disposal exist:

• Fences will be constructed along the market in 2018, that is on the east side of the river to reduce disposal of garbage in the river. The fence will be 1,900 feet (579m) long and it is being placed at the east side of the river (Figure 5.2). The funding come from Regional Government Budget.

• There are plans for placing more garbage bins in the Bago City Area, already placed in the Bago City, but they cannot cover for all the waste that come from the city. So, the township development committee is trying to place more bins in the city to collect more waste. Additional budget is needed.

• The Bago Township Development Committee, state that; “they could raise the awareness of the local community to dispose waste systematically, but there is not enough garbage bins in every wards to dispose waste”.

• The Bago Township Committee, is considering placing a garbage decomposing machine in Khe-phaung-taw-kwin in the future.

Figure 5.2. The fence being built along the market within the Bago City Area to reduce disposal of garbage in the river. (Source: Kyaw Min San, 2018).

Figure 5.3. The two pictures on the left side show garbage bins in the evening in Bago, the third picture from the left show the garbage truck, and the picture to the right show the Sin-phyu-kwin dumping ground. (*Source:* the Bago Township Development Committee).

Examples of measures to regulate waste disposal

The Meiktila Lake Basin Management Plan presents four measures aiming to reduce waste at village level (Kyaw Lin Htet, et al. 2017). These include; (i) constructing individual pits for storage and eventually burning of waste, (ii) establishment of a communal dumping ground, (iii) sell recyclable waste to the trucks of recycling shops, and (iv) separate organic waste from other waste and to use it to fertilize fields.

A handbook on waste management for village levels administrations in India has been produced by the National Institute of Rural Development & Panchayati Rajnird (NIRD) in India (NIRD, 2016). Five different phases or steps for waste management are suggested:
(i) *A preparation phase* **-** to decide how local organizations and community associations should cooperate, to set standards on what a clean village should entail. The main idea is that each household are given buckets of different color to sort different kinds of waste. Villages should be mapped and places where waste is dumped should be identified. The idea of turning garbage dumping spots into something more enjoyable is presented, for thereby discourage the use of the spot for waste. Swing for children, planting trees and flowers are mentioned as examples.
(ii) *The Planning phase* - to gain competence on how to treat and process the garbage collected. For example, some waste may be recyclable. It is essential to assess the initial costs of establishing a waste facility and the running costs of maintaining a waste disposal system.
(iii) The *Organizing phase and the Implementation phase* – there is a need for coordination between community members, sanitation workers and authorities to ensure a continuous running of the solid waste facility. Households and waste makers must know enough about waste and how to separate different sources of waste. A service fee collected from each household can help covering the cost of operating the waste facility.
(iv) *The monitoring and correctives -,* it is necessary to continue to educate and teach households on how to separate waste and to collect information and feedback from different involved actors to improve the operation of the facility.

5.1.2 Treatment of sewage

Abatement measures to treat or regulate sewage are the responsibility of the Bago Township Development Committee.

The following measures are being implemented:

<u>Septic tanks</u>: About 30 % of the households in the Bago City Area have septic tanks. All hotels and institutions have septic tanks. These are emptied about every 2 years or 5 years by vehicles. The content is then taken to the Bo-kar-di Khe-Phaung-taw-kwin Graveyard. The remaining have pit latrines (70%), some of which are open pits.

The following plans for regulating sewage exist:

- There are plans for a Water treatment plant at Kandawgyi lake funded by Japan International Cooperation Agency (JICA. There are however, some technology and design problems; timeline for construction of the plant is not known.

Examples of measures to treat and dispose of sewage
In the rural areas it is advised to use a decentralized approach with many small units of treatment.

a separate treatment system for wastewater and run-off water will be difficult and expensive to achieve due to the current lack of sewage system.

Decentralized systems provide a range of treatment options from simple, passive treatment with soil dispersal, commonly referred to as septic or onsite systems, to more complex and mechanized approaches such as advanced treatment units that collect and treat waste from multiple buildings and discharge to either surface waters or the soil. They are typically installed at or near the point where the wastewater is generated. Septic tanks, pit-latrines and urine diversion are some of the strategies that are gaining popularity as decentralized wastewater management systems (Parkinson and Taylor, 2003; De Gisi et al., 2014). Another alternative is the use of natural treatment methods like algae and duckweed based ponds and constructed wetlands, with harvesting of protein biomass, or the use of maturation ponds and anaerobic pre-treatment to allow for stabilization of organic matt. (Nhapi, 2004a), Centralized management of the decentralized wastewater treatment systems is essential to ensure they are inspected and maintained regularly (Nhapi, 2004b). Systems that discharge to the surface (water or soil surfaces) should require a National Pollutant Discharge permit.

5.1.3 Watershed management to control erosion and sedimentation (the deforestation pressure)

The Forest Department (FD) Bago Region is the central government authority for mitigating and reducing soil erosion related to the deforestation pressure.

The following measures are being implemented:

Ban on logging: Currently, the Bago Region government has prohibited logging for the next ten years to stop deforestation. It is recognized however, that illegal logging continues to some extent, despite controls. The Bago Region Forest Department prepares weekly and monthly reports, including information on planting of trees, forestry status, and illegal logging.

Reforestation program: To counter deforestation and degraded forests, a new reforestation and rehabilitation program in charge of the Bago Region Forest Department are carried out in Bago Yoma, upper Bago Region. Among the planned actions include planting new, and regenerate existing forest plantations with a particular focus on community forestry and planting valuable species such as teak. The program will also support existing forests with regeneration and enrichment planting. Some of the community forests in Bago Region, will be combined with agriculture (MONREC 2017).

The following plans exist to reduce erosion:

- Establishment of watershed plantations
- Forming watershed working cycles in Bago Yoma watershed areas
- Agroforestry and contour burn demonstration plot to encourage the awareness of local farmers

Examples of measures reduce to erosion

Buffer zones is a potential measure to be initiated by the Forest Department. It refers to a belt of forest, bushland or also grassland of about five meters on the sides of a side water body so as to prevent sediments, nutrients and other organic materials as runoff into the water body. Buffer zones are widely used as a measure to reduce non-point pollution, as riparian buffer zones have been found to improve water quality (Buckley et al. 2012).

The use of structural protective measures is a potential measure of the DWIR. Measures to control erosion have been reported from the Jamuna River in Bangladesh. Sarker et al. (2011) summaries and evaluates the degree that different structural protective measures have reduce river erosion. The structural measures refer to; Revetments built to preserve the existing use of the shoreline and to protect the slope as defense against erosion have been constructed from CC blocks, boulders, mattresses, open asphalt concrete and currently sand-filled geobags have replaced the CC blocks, and Groyne (a rigid hydraulic structure that interrupts water flow and limits the movement of sediments, usually made out of wood, concrete or stone). They have been constructed to divert the river away from important sections of the banks and are made of gravel, stone, rock, earth or pile structures.

5.1.4 Management to control erosion caused by sand mining

Directorate of Water Improvement of River Systems (DWIR) is responsible for the regulation of sand mining in Bago. Sand mining operations requires a license provided by the DWIR. In the past, the General Administration Department (GAD) issued sand mining permits based on comments the following departments: DWIR, IWUMD, and ECD. This issue is now the responsibility of the Bago DWIR. Clear environmental rules and regulations have been lacking.

The following measures are being implemented:

Licenses in for sand mining in the Bago City area has been stopped for one year (DWIR responsibility). Enforcement is unknown. Current instruction from the Bago Government is that sand mining in the Bago City area is prohibited (no time limitations).

Possible measures for implementation:

- The following recommendations for management of sand mining are referred to by a Sand Mining Guide from the Department of Irrigation in Malaysia (DID; 2009).

a) Permit Mining Volume Based on Measured Annual Replenishment
b) Establish an Absolute Elevation below Which No Extraction May Occur. The absolute elevation below which no mining could occur or “redline” would be surveyed on a site-specific basis.
c) Limit In-stream Extraction Methods to Bar Skimming - limited mining to the downstream end of the bar with a riparian buffer on both the channel and hillslope (or floodplain) side.
d) Maintain Flood Capacity - Flood capacity in the river should be maintained in areas where there are significant flood hazards to existing structures or infrastructure.
e) Establish a Long-term Monitoring Program - Monitoring of changes in bed elevation and channel morphology, and aquatic and riparian habitat upstream and downstream of the extraction would identify any impacts of sand and gravel extraction to biologic resources.
f) Minimize Activities That Release Fine Sediment to the River - No washing, crushing, screening, stockpiling, or plant operations should occur at or below the streams "average high water elevation," or the dominant discharge. These and similar activities have the potential to release fine sediments into the stream, providing habitat conditions harmful to local fish.
g) Retain Vegetation Buffer at Edge of Water and Against River Bank - Riparian vegetation performs several functions essential to the proper maintenance of geomorphic and biological processes in rivers. It shields river banks and bars from erosion. Additionally, riparian vegetation, including roots and downed trees, serves as cover for fish, provides food source, works as a filter against sediment inputs, and aids in nutrient cycling.

i) The in-stream mining should only be allowed during the dry season.
j) An Annual Status and Trends Report, including monitoring. Monitoring plans will provide data on profile changes and sediment transport capacity to enable the authorities to evaluate the long-term effect of the mining activities both upstream and downstream of sand extraction sites. Monitoring will provide data to evaluate the upstream and downstream effects of sand and gravel extraction activities, and long-term changes. (DID, 2009). The report should document changes in bed elevation, channel morphology, and aquatic and riparian habitat. The report should also include a record of extraction volumes permitted, and excavation location.

5.1.5 Minimize pesticide and fertilizer use – training and rules

Regulation of pesticide and fertilizer use is the responsibility of the Department of Agriculture and Livestock. The Department of Health has responsibility for drinking water quality set by the drinking water standard. The Department of Irrigation and Water Utilization Management Department has responsibility for water quality of reservoirs.

The following measures are being implemented:

Prohibition of further establishment of plantations; The regional government has recently approved a ban on further establishments of plantations within the area of the Kandawgyi watershed as the reservoir is used for drinking water (MONREC, 2017). At the plantations pesticides and fertilizers have been used. The reservoir is currently monitored for water quality bimonthly.

Awareness raising; The Department of Agriculture is educating local farmers on the use of pesticides and fertilizers.

Pesticide and fertilizer use by farmers in Bago is otherwise not regulated. Data on the use of pesticides and fertilizers is purchased directly from private companies by the individual farms, usage however may be regulated.

Examples of measures to reduce pesticide and fertilizer use
A key target for improved nutrient management and more sustainable agriculture is efficient use of N to maintain food production to reduce its impact on the environment.

Swaminathan (2002) describes an integrated farming system for food production. The seven essential constituents include, soil health care, water harvesting and management, crop and pest management, energy management, post-harvest management, choice of crop and animal components. The aim is tight nutrient cycling with synchrony between demand of crops and nutrient release within the soil while minimizing loss of nutrients through leaching, runoff, volatilization and immobilization. Nitrogen is obtained by biological fixation by legumes, P from unrefined rock phosphate and K from seaweed and various K-containing minerals. Deep-rooting plants are used to recycle nutrients from subsoil to topsoil. Instead of just one or two crops, judicious rotation of cereals, millets, oil seeds and leguminous pulses is proposed. The farm animals (cows, bullocks and milk buffaloes) provide dung and urine to enrich the soil, while crop residues and fodder form the bulk of the feed for these animals. Recycling of animal manures and composted wastes is central to organic management systems.

Fertilization with N or NPK without ensuring adequate supplies of all other limiting nutrients (S, Zn, B, etc.) has little value, but contributes to environmental degradation. A close interaction between scientists with their modern scientific inputs and the traditional farmers with their ecological prudence and practical experience of soil management is important. It may be advised that agricultural extension staff advise farmers on how to provide a proper supply of all macronutrients and micronutrients in a balanced ratio throughout their growth.

Integrated pest management (*IPM)* - is effective for controlling pests of various kinds, namely sucking pests (aphids, mealy bugs and leaf hoppers), leaf caterpillars (shoot and fruit borers) and internal feeders and stored products pests. It consists of cultivating insect resistant/tolerant crops, using trap crops that are highly preferred/susceptible so that the main crop is spared. Light traps and pheromone traps (pheromones are chemical substances secreted by adult insects (mostly female) for attracting the members of the opposite sex of its own species) to lure and trap help in reducing mating and egg laying. Biological methods involve the use of living agents (insects and micro-organisms) to manage the destructive species; parasitoids, predators, and pathogens (FAO, 2006; Roy et al. 2006).

5.1.6 Regulate electric and chemical fishing

Department of Fisheries and Livestock is responsible for regulating fishing. Fishing is allowed everywhere.

<u>In Moeyungyi wetland (Ramsar site);</u> fishing is only allowed for daily livelihoods.

<u>Fishing prohibited during the spawning period</u> (May to July) is prohibited by Fisheries Department. The use of electric and chemical fishing is not allowed, but enforcement is poor.

Examples of measures to regulate fishing
Fishing during the spawning period (May – July) is prevented, but enforcement varies.

- An important measure is to increase awareness on, why fishing during the spawning period is prohibited, and why chemical, and electric fishing is not allowed.

5.1.7 Upgrade proper drainage system

A drainage system in urban and industrial areas, refers to a facility to dispose of liquid waste. There is a drainage system in Bago, which is maintained every year. But maintenance is not sufficient. Maintenance is funded by 70% of municipality fund. (round about 70% of 5,000 million Kyats).

The Bago River follows a meandering course and within its bends are many places where sediments accumulate and forme bars, obstructing smooth water flow. Kawasaki et al. (2017) report on dredging work in 2014-2015 at eleven spots between Bago City and Tawa Village, where Bago River contexts to the Bago Sittaung Canal. Dredging and river improvement work were also done on tributaries to the Bago River; as a result of this work, the flow area increased about five times (Kawasaki et al., 2017).

5.1.8 Industrial waste

The Environmental Conservation Department (ECD) is responsible for regulating industrial waste.

The following measures are being implemented:

Monitoring: Based on complaints of point source pollution, the ECD will monitor water quality downstream the effluent. The ECD can also require information from the polluting actor about discharge and effluents.

In the case of new industries, an EIA is needed. The operation of EIAs is the responsibility of ECD. See the Environmental Impact procedures developed by the ECD, MONREC here:
http://www.aecen.org/sites/default/files/eia-procedures_en.pdf

5.2 Prioritization of abatement measures

The purpose of prioritization is to find the most cost-effective combination of measures that achieve environmental goals. The principle of cost-effectiveness was also an important principle for discussions in the Committee, and in the Group. Sources of funding, and political and social will to implement measures are decisive factors. It was emphasized that awareness raising for both government staff and for civil society are critical for prioritization of measures.

The process of prioritizing abatement measures in Bago included two main steps, the first step involved discussion in the Bago Sub-basin Area Committee on June 16th and by the Non-governmental Stakeholder Group on November 10th 2017, while the second step included bilateral discussions with sector authorities, and with Bago Region parliament members for further feedback. The purpose of this was as far as possible to suggest and involve sector authorities in realistic abatement measures.

At the Committee and the Group meetings, members were asked to discuss prioritized measures for each water body group. They were asked to consider the following criteria in their discussions:

1. Where; 2. When, Costs, (low moderate high), 3. Socially acceptable, 4. Politically acceptable, 5. In line with climate change mitigation objectives, and Identify responsible institution.

After discussing for about an hour, each group presented a summary of suggested prioritized measures for each water body group (Table 5.2). In most cases several institutions were identified as being responsible for a suggested measure. This situation requires close coordination related to implementation of measures. In the below sub-sections, suggested prioritized abatement measures are summarized and presented for each water body group. For more information on already implemented measures, see sub-section 5.1.

Table 5.2 A summary of measures as discussed in Bago River Sub-basin Area Committee and the Bago Non-governmental Stakeholder Group.

Protected Areas for biodiv.	Dams and reservoirs	Upstream Bago City	Bago City area	Downstream Bago city
Man-made issues (waste disposal)	Upgrade proper drainage system	Reforestation, rehabilitation e.g. Kan Taw Gyi watershed	Public awareness	Construction of erosion control wall
Reduce invasive species	Reduce salinity hazards and water-logged conditions	Training to local people how to use pesticides and fertilizers.	Locate alternative place for garbage	Control usage of chemical fertilizers
Awareness raising of local people, ex. control on fishing	Minimize pesticide and fertilizer use	Watershed plantation, to reduce protect soil erosion	Treatment plant for sewage	Planting trees in buffer strips
Ecosystem and biodiversity conservation especially for migratory birds	Watershed management to control erosion	Regulations, and public awareness to local people don't dump near the river and in the river	Rules & regulations (law enforcement)	Controlling environmental pollution & monitor water quality
Counter measures for natural disasters	Alertness for local people to improve willingness to participate	Sand mining based on permits & license rules, and an EIA/SIA	Treatment plant for industrial waste	Reduce number of permits for sand mining

5.2.1 Abatement measures: Water bodies upstream the Bago City area

Water bodies in the upper parts of the Sub-basin and in catchments of main tributaries are mostly within the Bago Township, but, but also Waw Township. These water bodies refer to the upper parts of the catchment, and sub-catchments of main tributaries, draining forest with little or no human impact on ecological status in upstream water bodies. Ecological status in these water bodies have mostly good and high status. Regarding the environmental objective, "No erosion" there is deforestation pressure in this area. Deforestation contributes to erosion and causes sedimentation downstream. The main important measure for reducing erosion and sedimentation is regulating for *buffer zones in the riparian zone.* Regulation for buffer zones would be the responsibility of the Forest Department (FD) (see Table 5.3 for an overview of other measures).

The Rural Development Department (RDD) has responsibility for the accessibilities of water, electricity and conducting training in rural area. Hence coordination between the FD and the RDD related to training and awareness is relevant.

<u>Reforestation measures and *buffer zones*</u> have been suggested among the prioritized abatement measures. The riparian zone or riparian area is the interface between land and a river or stream or lake, a zone which is important for the health of the water body. If riparian vegetation is still intact, it is important to implement regulations to avoid deforestation of these areas. A buffer zone of 3-5 meters is recommended. It is recommended to initiate a strategy for reforestation of deforested / or devegetated riparian buffer zones (see for more information about buffer zones; Hawes and Smith, 2005).

<u>Strategy for handling of waste and sewage</u>; Though the upstream population density is relatively sparse, it is recommended to initiate a strategy for handling of waste and sewage. Currently, this is not specifically the responsibility of any department in rural areas. Increasing the awareness and

provide education on recycling and collection measures (see sub-section, 5.1.1, and 5.1.2), with the aim of reducing solid waste disposal into the river should be considered.

Regulation of the fishing activity is the responsibility of the Fishery Department (see also Table 4.1, on overview of some water related Myanmar laws). Fishing is an important subsistence consumption for local livelihoods in the area, and it is important to regulate fishing activities for sustainability. This requires enforcement of regulation, and better coordination and collaboration between the Department of Fisheries, Department of Education, Rural Development Department, and the General Administration Department.

Table 5.3 Abatement measures in the Bago Upstream water bodies

Measure	Where	Costs (low, moderate, high	Acceptability		In line with aim of mitigating climate change	Timeline of implementation	Effectiveness of measure	Responsible institution
			Social	Political				
Reforestation	Buffer zone along the river	Moderate	Yes	Yes	Yes	No specific plans yet.	Effective to reduce erosion and sedimentation downstream.	FD, GAD, NGOs FD, DOA, Local authorities
Extension given to local people on proper pesticide and fertilizer use		Moderate	Yes	Yes	Yes		Depends on extent and alternatives.	DOA, GAD, environmental conservation team
Progress rules and regulations for solid waste disposal to the river		Low	Yes	Yes	Yes	Not yet	Effectiveness depends on enforcement, important in combination with extension.	Municipal, GAD
EIA /SIA for sand dredging	Bago TS, Waw TS	Moderate	Yes	Yes	Yes		An EIA is important, but management plans and monitoring needed.	GAD, DWIR, ECD
To control fish hunting using chemicals and electric shock	Bago Region	low	Yes	Yes	Yes		Effect depends on enforcement, currently not high.	DOF, GAD

5.2.2 Abatement measures: Water bodies in the Bago City area

Water bodies located in and nearby Bago City, and within Thanatpin, Waw, and Kawa townships centers are densely populated areas, where pressures are characterized by, lack of waste management and sewage systems. As a result, ecological status is mostly poor, and surface waters may represent a hazard in case of human consumption. Sand mining operations have also been emphasized as a pressure that need to be regulated. To summarize, good status in these water bodies for all identified environmental objectives are at risk (Chapter 3). Below we list measures as prioritized by Committee and Group members (Table 5.4).

Waste management has been emphasized as a priority activity by the Bago Sub-basin Area Committee and also Non-governmental Stakeholders. The main responsible institution for handling of waste and sewage, is the Township Development Committees. It is important to involve and created awareness of these issues also by other departments. Other relevant departments include Department of Education (DOE), Forestry Department (FD), DWIR, Irrigation and Water Utilization Management Department (IWUMD), General Administration Department (GAD), Environmental Conservation Department (ECD), and Department of Fisheries (DOF).

- Awareness raising of both the government and the civil society on waste management, and, collection of garbage to a site for waste disposal were prioritized measures. Specifically, it has been discussed with the Bago Municipal Development Committee to prioritize placing garbage bins along the Bago market to allow for collection of garbage.
- A measure to prevent people from throwing garbage into the river, is fencing alongside the market area. This measure is already being implemented (Kyaw Min San, 2018)
- There is also a plan for making selected areas alongside the river nice for recreation, cleaning up such areas and placing benches. A poster will be place for awareness raising in these selected areas.

Management of sewage; the need for a proper sewage system was highlighted in Committee and Group meetings and it was argued for using a decentralized treatment system including septic tanks (see 5.1.2).

- It is recommended that the Bago Municipal Development Committee, and the Thanatpin, Kawa, and Waw Townships Development Committees develop a strategy including a timeline for providing septic tanks to settled areas according to prioritized criteria. Important relevant criteria for prioritization are, the proximity of residential areas to the Bago River, and the proximity to water bodies.

Sand mining management plan: the Committee and the Group emphasized the following actions; (i) only license holder should be allowed to take part in sand mining activities, (ii) enforce the regulation of no mining activities in the Bago City area and increase the duration of this regulation.

- Current instruction from the Bago Government is that sand mining in the Bago City area should be prohibited as a general rule (no time limitations).
- It is furthermore recommended to develop a sand mining management plan for the Bago River and to monitor the impact of the mining of the river health.

Proper drainage system around the Bago City area: The Committee and Non-governmental Stakeholder Group in addition also argued for the need to upgrade the drainage system for the proper treatment of water around the Bago City area. This is the responsibility of Municipal Department.

Table 5.4 Abatement measures in the Bago City water bodies

Measure	Where	Costs (low, moderate, high	Acceptability		In line with aim of mitigating climate change	Timeline of implementation	Effectiveness of measure	Responsible institution
			Social	Political				
Extension and awareness to people on waste disposal and sewage	Center township areas of Bago Thanatpin, Waw, Kawa	Moderate	Yes	Yes	Yes	Long term	Depends on extent and alternatives.	MONREC, GAD; Municipal, MoHS
Site for solid waste disposal		Moderate	Yes	Yes	Yes	Long term	Effective if site for solid waste disposal includes proper protection of area and the site is away from water bodies.	GAD, municipal and land management
Sewage: use septic tank; Change the direction of the house to facing the river		Moderate	Yes	Yes	Yes	Long term	Compared to current system, septic tanks which are regularly emptied will be effective. The effectiveness also depends on where and how the content is disposed of.	GAD, municipal and land management
Controlling the water resources (sand mining); no sandmining in this area.	BagoTS, Waw TS, Kawa TS, Thantpin TS,	Low	Yes	Yes	Yes	Long term	Proper enforcement and monitoring is needed. The effect of the measure will also depend on sand mining activities upstream and downstream of this area.	DWIR

5.2.3 Abatement measures: Water bodies downstream the Bago City area

Water bodies downstream the Bago City area within the townships, Bago, Kawa and Thanatpin, have relatively high population densities. Besides settlements, the area is characterized by agricultural low lands. Population densities in these areas are relatively high and pressures include waste and sewage. The impact of fertilizers and pesticides from agricultural land may pose a risk to contamination of water. To summarize, good status in these water bodies for all identified environmental objectives are at risk. Below we list measures as prioritized by Committee and Group members (Table 5.5).

Regulation of pesticide and fertilizer use were emphasized as prioritized activities by the Bago Sub-basin Area Committee and also Non-governmental Stakeholders. Regulation and awareness are responsibilities of the Department of Agriculture. *It is recommended* to provide awareness on the impact of fertilization and pesticides, and to educated on the system of an integrated farming system for food production where essential constituents include such as, soil health care, crop and pest management, energy management, post-harvest management practices (see 5.1.5). Then, it must be emphasized that the most important measures for reducing runoff of pesticides and fertilizers to the river is regulating for a buffer zone. A buffer zone consisting of trees, bushland and also grassland, will act as a filter and reduce runoff to the river. This measure would require collaboration between DOA, DOE, FD, ECD, and GAD.

It is an objective by the ECD to reduce chemical compound and related substances which is used in the Agriculture Sector and promote using of Bio-chemical widespread.

Erosion prevention; The river sides are highly impacted by erosion in these areas causing sedimentation of the river bed. The Non-governmental Stakeholder Group suggested to construct erosion control walls. Erosion control walls should be implemented in particularly vulnerable areas. A strategy to reduce erosion risks should be developed, including a combination of different type of strategies; (i) erosion control walls in particularly vulnerable areas, buffer zones, land use restrictions on the river bank. This is the responsibility of the DWIR, but requires coordination / collaboration with the FD, IWUMD.

Waste and sewage: It is recommended to initiate a strategy for handling of waste and sewage (see, 5.2.3, and 5.2.4). Within the townships centers of Thanatpin and Kawa this is the responsibility of the Township Development Committees. Currently, this is not specific responsibility of any department in rural areas. The Rural Development Department is however, responsible for training, hence awareness activities need to be coordinated with this department

Table 5.5. Abatement measures Bago City downstream water body groups

Measure	Where	Costs (low, moderate, high	Acceptability		In line with aim of mitigating Climate change	Timeline of implementa tion	Effectiveness of measure	Responsible institution
			Social	Political				
Planting trees in buffer strips	Bago River Sub-basin, riparian zones	Moderate	Uncertain	Yes	Yes	Long term	reduce climate change impact, increase forest cover, erosion control	Planting trees in buffer strips
Construction of erosion control walls	Bago River Sub-basin	High	Yes	Uncertain	Yes	Short term	If erosion is controlled, water quality is improved	Construction of erosion control walls
Controlling pollution and monitor water quality	Bago River Sub-basin	Moderate	Yes	Yes	Yes	Long term	water quality improved	Controlling pollution and monitor water quality
To control agriculture that uses chemicals	Bago River Sub-basin; alongside the river	Low	Yes	Yes	Yes	Long term	water quality improved	To control agriculture that uses chemicals
Regulate sand mining: systematic controls of sand mining permits	Bago TS	Low	Yes	Yes	Yes	Long term	reduce soil erosion and loss of marine ecosystem	Regulate sand mining: systematic controls of sand mining permits

5.2.4 Abatement measures: Water bodies- reservoirs for drinking water and irrigation

It is important to restrict usage of land neighboring reservoirs for drinking water and irrigation water. Management of reservoirs is the responsibility of the IWUMD and the Department of Hydro Power (DHP), however several departments have responsibility regarding the protection of reservoirs for human safety (Table 5.6). The main other responsible departments refer to the GAD which are responsible for the enforcement, while the FD is responsible for reforestation measures and avoiding deforestation, and the DOA is responsible for regulation of the use of pesticides and fertilizers. *The Myanmar Drinking water (Ministry of Health) standard is a core reference document with regard to water quality in water bodies used for drinking water.*

The following land use restrictions should be applied:
- (i) No domestic animals should enter such water bodies
- (ii) No pesticides or fertilizers should be used within the catchment of the reservoir
- (iii) No settlement within an
- (iv) Ideally, a fence should surround the water body.
- (v) Buffer zones with forests should be
- (vi) Signs should be placed to inform of restrictions on land use, the effect of violation, and the cause of restrictions.

Comments to measures

Land use restrictions upstream reservoirs for irrigation or drinking water exist and implementation is the responsibility of the IWUMD. No mining operations are allowed upstream a reservoir. The Department of Mines must to get permission from the IWUMD to issue license for mining operations. Extensive land use restrictions as those listed above however, may be a long-term goal, though it is questionable whether such restrictions can be within reach within the near future. It is recommended to initiative a discussion how to increase the protection of reservoirs for human safety. Measures to increase local awareness should always be part of the restrictive measures.

Table. 5.6 Reservoirs for drinking water and irrigation water body groups

Measure	Where	Costs (low, moderate , high	Acceptability		In line with aim of mitigating climate change	Timeline of implementation	Effectiveness of measure	Responsible institution
			Social	Political				
Upgrade proper drainage systems	Bago TS Waw TS Thanatpin TS Kawa TS	Moderate	Yes	Yes	Yes	Medium term	prevent form flood and diseases	IWUMD, GAD
Reduce salinity hazards & water logging conditions	Thanatpin TS Kawa TS	Low	Yes	Yes	Yes	Medium term		IWUMD, FD, DOA, GAD
Minimize pesticides and fertilizers	Farms and rubber plantations in particular close to water bodies	Low	Yes	Yes	Yes	Medium term	If pesticides and fertilizers are not allowed in a buffer zone of the reservoirs, the measure is effective.	DOA, GAD, local farmers
Watershed management for control erosion	Watershed working cycles	Moderate	Yes	Yes	Yes	Long term	Reforestation for buffer zone – effective.	FD, GAD
Alertness to local people to improve willingness to participate	City markets and villages along the Bago River side	Low	Yes	Yes	Yes	Medium term	If participation of local people is encouraged, the measure is effective.	Regional government & local

5.2.5 Abatement measures: Water bodies protected for biodiversity

The main protected area in the Bago Sub-basin is the Moeyungyi Wetland Wildlife Sanctuary Ramsar Site. This water body is situated in Waw Township and it is the responsibility of the, Nature and Wildlife Conservation Division under Forest Department, MONREC. Other responsible departments include ECD, FD, GAD, IWUMD (Table 5.7).

A draft management plan for this wetland has been development, and prioritized abatement measures is under development (MONREC, 2017). This management plan need to be included as an attachment for this Sub-basin Management Plan. It is staff at the sanctuary which are responsible for implementing measures in cooperation with the GAD. Awareness raising in protected areas is the responsibility of the staff at the sanctuary.

The prioritized abatement measures in this plan includes:

- (i) Enforce no electro fishing,
- (ii) Regulate for waste disposal,
- (iii) Reduce water pollution;
- (iv) Promote awareness raising.

Table 5.3 presents the measures prioritized by the Committee and the Group. Overall, activities in the catchment of the lake, primarily agriculture, need to be regulated to reduce loss of nutrients and other compounds to wetland. Abatement measures should as retention ponds and riparian buffer zones should be considered to reduce impacts of land use.

Table 5.7 Prioritized abatement measures in water bodies protected for biodiversity.

Measure	Where	Costs (low, moderate, high	Socially acceptable	Politically acceptable	In line with aim of mitigating CC	Timeline of implementation	Effectiveness	Responsible institution
Conservation of forest and reforestation in watershed area	In a buffer zone of protected water bodies.	Moderate	Yes	Yes	Yes	Medium term and long term	If reforestation occurs in a buffer zone towards the lake, effectiveness is reasonable.	ECD, FD, GAD, IWUMD
Extension to local inhabitants	Bago District	Moderate	Yes	Yes	Yes	Medium term and long term	Extension is important; yet level of effectiveness is difficult to assess, long term effectiveness can be high.	ECD, FD, Police, IWUMD

5.3 Methods for prioritization of measures

We present below well-known methods for prioritization of measures. See in Appendix E, a suggested guide for identification of measures and for prioritizing among measures, translated and adapted from (Directorate group in Norway, 2012).

5.3.1 Cost efficiency

There is a need for abatement measures to be cost-efficient. One way of examining this is the concept of cost-effectiveness analysis (CEA). Balena et al. (2011) describe CEA as a *'technique for identifying the least cost option for meeting a specific physical objective/outcome'.* This technique can be used for ranking and analyzing how one or a combination of abatement measures can perform 'on the basis of their costs and effectiveness'. To conduct a CEA, it is common to first evaluate pressures and what one can do to mitigate the pressures and then to try to estimate how effective to measures would be and lastly to try estimate the cost of applying such measures. In CEA, measures are evaluated against the cost of the measure and the assumed effectiveness of the measure. A CEA differs from cost-benefit analysis (CBA) in that only the *'costs of implementing measures are monetized but the effects of measures are expressed in physical terms'* (Balena et al. 2011). In a CBA both sides are monetized, and this is used to analyze whether a measure makes economic sense and whether the benefits outweigh the costs. CEA appears to be the most commonly applied assessment tool across European countries. To estimate the cost effectiveness of an abatement measure it is important to also consider how affected target groups such as farmers are likely to respond to the measure and what additional social cost the abatement measure might involve.

5.3.2 MCA

Another commonly used approach for environmental decision-making and water management is a multi-criteria analysis (MCA). MCA is a systematic approach for analyzing and navigating the priorities of various stakeholders with different and manifold objectives. MCA is considered an effective tool for water management (Hajkowicz and Higgins, 2008), because decisions in water management are often characterized by multiple objectives held by multiple stakeholders. As such, a MCA works best when working with multiple stakeholders and when the co-benefits and negative impacts of a measure needs to be assessed. The economic cost is one of multiple criteria in a MCA.

MCA is a decision-making tool used to carry out a comparative assessment of different alternatives, on the basis of a set of evaluation criteria, taking into account the opinions of the different actors concerned. It allows experts or involved stakeholders to assign a score to each alternative, in order to quantify its performance in relation to the selected criteria. The main phases in the MCA methods are: identifying the objectives, attributes/criteria and alternatives; utility function choice; assessing the performance of alternatives related to the attributes and objectives; and determining their relative importance in the decision situation (weight allocation and final ranking) (Marttunen, 2011)

5.3.3 Collaborative governance and Win-win situations

Collaborative governance refers to a mode of governance which brings multiple stakeholders together in common forums with public agencies to engage in consensus-oriented decision making (Ansell and Gash, 2007). It is a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented and deliberative and that aims to make or implement public policy or manage public programs or assets (Emerson et al. 2011).

Core aspects of a collaborative governance regime include a; (i) cyclic process which needs to be characterized by communication, trust, commitment to shared goals, understanding, and outcomes (Huxham, 2003; Imperial, 2005). Core factors for commitment are face-to-face communication, trust building , transfer of knowledge. A "thick" communication allowed by direct dialogue is necessary for stakeholders to identify opportunities for mutual gain, (ii) there need to be mutual perspective of win-win of agreement of goals and plans for action, actors and stakeholders must develop shared understanding of what they collectively achieve together, and (iii) Trust building is a time-consuming process that requires a long-term commitment to achieving collaborative outcomes. The development of shared understanding can be seen as part of a larger collaborative learning process.

6 Concluding remarks

This report have presented the main process and the learning experiences gained as part of pilot implementing the river basin management approach in the Bago River Sub-basin Area. Together with the report "Characterization of the Bago Sub-basin, Pilot implementing the EU Water Framework Directive" (Eriksen et al. 2016), this report provides the main input to the Bago River Sub-basin Management Plan (to be published September 2018).

The Myanmar National Water Framework Directive has the objective to developing river basin management plans in Myanmar, however, there are currently no operational rules or guidelines for how such plans may be developed. The aim of this report has been to (i) present environmental objectives and abatement measures as discussed in the Bago Sub-basin Area Committee and in the Bago Non-governmental Stakeholder Group, and (ii) report on this experience in order to provide input for adapted guidelines and an operational framework for the process of identifying environmental objectives and abatement measures in Sub-basins in Myanmar. Our work has been guided by the experience of implementing the EU WFD in Europe, and by literature on relevant abatement measures in particular from other Asian countries. While a broader outlook and experience from other locations are useful, we want to emphasize the importance of considering local conditions by enabling input from sector and environmental authorities, and non-governmental stakeholders on repeated occasions. In the Bago Sub-basin, iterative meetings and encounters with the actors stated above have been important for raising awareness about environmental objectives, and abatement measures for achieving a healthy river.

The more formalized methods for prioritizing among proposed measures, such as cost effectiveness analysis (see section 5.3.1), may in principle be relevant in Myanmar. Yet, as the data required for these methods often are largely unavailable, such methods alone are often inappropriate. Our approach instead build on frameworks for collaborative governance and we have emphasized the broader socio-environmental win-win perspective (5.3.3). In prioritizing among abatement measures, important aspects of cost effectiveness, and political and social acceptability have been considered and discussed. Our approach has been to facilitate collaborative governance between sector and environmental authorities in Bago, and with regard to the multiple governance levels in Myanmar. This pilot study has therefore aimed for identifying possible prioritized measures for implementation on short term for a healthy Bago River. Some long term strategies are recommended for reaching specific environmental objectives.

We hope this report can be a starting point for continuous progressive and coordinated approach for achieving a healthy Bago River.

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Appendix A. Myanmar National Water Framework Directive

*Myanmar National Water Framework Directive by the Advisory Group (AG) of the National Water Resources Committee (NWRC) Page **1** of **4***

Introduction The National Water Resources Committee (NWRC) is a national APEX body in the water sector of Myanmar. The NWRC consists of Union Ministers, Regional Ministers, Mayors, Permanent Secretaries, Director Generals, and representatives (Chair, Secretary and Joint Secretary) of the Advisory Group Members. The members of the Advisory Group are contributing their talent, time and energy to make sure that our most important and precious water resources are properly developed, managed and shared among all citizens of Myanmar. Many consultation meetings were held across Myanmar in 2014 the whole year. The intention of those consultations was to share the MNWFD draft document, seek comments, input and advice from the Civil Society and non-state actors to further improve the draft Framework Directive. Also opportunities were given to various stakeholders to work more closely with the Advisory Group of NWRC and members of NWRC during the Myanmar National Water Law drafting process. The MNWFD was finalized in December 2014.

Key purposes
to ensure water security, water-related disaster risks reduction, good water governance, sustainable development and acceleration of the promotion of Water Security and Green Growth through Integrated Water Resources Management practices; to realize the mandate of NWRC, i.e. to conserve, protect, manage and develop water resources of Myanmar for sustainable development and reduce and manage water-related disaster risks in Myanmar; to achieve the status of clean and sufficient water for all purposes by a set deadline;
to begin the implementation of integrated water resources management (IWRM) based on proper spatial unit called basin-wide approach;
to create an approach of green practices and quality standards;
to set the water and sanitation tariffs with priority on pro-poor prices in respect of human rights while boosting the economically viable prices for development and commercial uses;
to promote proper perspective and priorities in relation to water-energy-food-ecosystem nexus and Climate Change impact;
to encourage citizens' active involvement and hands-on projects to achieve dire need for Peace and Prosperity through fair water sharing and allocation;
to formulate a continuum of water legislation in Myanmar to ensure water security and direct and indirect revenues from water-based economy.

The Water Framework Directive

The "**Water Framework Directive"** of the Republic of the Union of Myanmar aims to establish **"a framework for all walks of life towards the National Water Law and National Water Policy"**, which

*Myanmar National Water Framework Directive by the Advisory Group (AG) of the National Water Resources Committee (NWRC) Page **2** of **4*** overarches the Myanmar's water sector in the sense that it prescribes steps to reach the common goals rather than adopting the pretext by top down approach.

Goals Three main goals of Myanmar National Water Framework Directive (MNWFD) are:-
1. getting Myanmar rivers healthier, waters cleaner and more beneficial for all purposes;
2. getting the citizens involved in a peaceful way; and
3. getting Green Economy momentum quickly and achieve Green Growth shortly.

Text of the Directive
There are seven directives as listed below.

Directive (1): Good status for all ground water and surface water
The Water Framework Directive aims for *'good status, i.e. clean and sufficiently stored'* for all ground water and surface water (rivers, lakes, transitional waters, and coastal waters) in Myanmar.

Directive (2): National Water Budget (Available Water Quantity) The Water Framework Directive stipulates that National Water Budget must be estimated under the current hydrological and meteorological conditions taking into consideration of the Climate Change impacts already visible. The surface and groundwater must achieve "good quantitative status" and "good chemical status" (i.e. not polluted) by 2030. Classification of bodies, "good" or "poor" according to the current status, should be examined.

Directive (3): The ecological and chemical status (Continuous Water Quality Monitoring) The ecological and chemical status of surface waters should be assessed according to the following criteria:
Biological quality (fish, benthic invertebrates, aquatic flora);
Hydro-morphological quality such as status of river banks, river bank structures, river training works, river continuity or substrate of the river bed;
Physical-chemical quality such as temperature, oxygenation and nutrient conditions;
Chemical quality that refers to environmental quality standards for river basin specific pollutants. These standards specify maximum concentrations for specific water pollutants. If even one such concentration is exceeded, the water body will not be classed as having a "good ecological status".

Directive (4): Cooperation between the Union Government and the States and Regional Governments
The Water Framework Directive requires State and Regional Governments "to encourage the active involvement of interested parties" in the implementation of the Directive. This is generally acknowledged the requirement of frequent consultative and coordinating meetings yielded by capacity building workshops across the country. It also emphasizes the need to have clear mandate, duties and responsibilities as well as finance sharing between the Union and the State and Regional Governments.

Directive (5): Spatial management of river basins One important aspect of the Water Framework Directive is the introduction of River Basin Management approach. These basin areas have to be designated within the national boundary, not according to administrative or political boundaries, but rather according to the river basin (the spatial catchment area of the river) as a natural geographical and hydrological unit. As our main rivers cross many administrative boundaries, i.e. States and Regional Administrative Boundaries, the Local Governments have to cooperate and work together for the management of the river basin (so-called national basins) such as Ayeyarwady, Sittaung, Chindwin, etc. and international basin such as Mekong and Thanlwin. All major basins in Myanmar need River Basin Development Plans, which provide a clear indication of the way the objectives set for those river basins, are to be reached within the required timescale. They should be updated every ten years.

Directive (6): Transgressions (River Water Transfer projects) The River Water Transfer projects are very popular due to water scarcity around the world and heavily criticized as being contrary to the principles of Sustainable Water Resources Management of each River Basin. Therefore this topic should be addressed in a proper manner. Thus it has a place in the Water Framework Directive as precautionary principle/section.

Directive (7) Restructuring Process
Citizens of Myanmar expressed their concerns over water scarcity, safety and water pollution issues through media and various workshops as well as direct communication to the President’s office. This is one of the main reasons to draft this Water Framework Directive and Myanmar National Water Policy. New sectorial and/or thematic water policies will be formulated and proposed along the line after holdinga number of public consultations at the regional and community levels. In achieving three goals and seven directives, the changing role of the Government and that of citizens and civil society groups will be crucial. This is the reason that the new Myanmar Water Policy was also drafted with citizens’ involvement in order to achieve Peace and Prosperity. That also indicated that a serious restructuring process (or) water sector reform is necessary!

Key issues under Myanmar National Water Framework Directive and Myanmar Water Policy

1. Water Pollution
2. Environmental Flow
3. Water Allocation
4. Water Pricing
5. Mandate Sharing between authorities
6. Effective use of Integrated Water Resources Management
7. Water use Efficiency for economic development towards Green Economy and Green Growth
8. Phase by phase tackling of “water legislation” – water law, policies and procedures, regulations and Acts, etc.

Myanmar National Water Framework Directive by the Advisory Group (AG) of the National Water Resources Committee (NWRC) Page ***4*** *of* ***4***

9. Efficient communication mechanism by the NWRC Secretariat to up and down channels; the Union Government, States and Divisional Governments, Ministries, Line Agencies and Citizens of Myanmar – setting up an open process
10. Coordination of objectives to achieve a good status for all waters by a set deadline
11. Coordination of measures
12. The river basin management plans
13. People-centered Public Private Participation (PPPP) for secure investments
14. Water-related Data Bank and Hydro-Informatics Centre (i.e., not only limited to hydrological, meteorological, geotechnical, environmental and climate change data but also including economy, market, trade, product, innovative technologies, societal, cultural, research and investment opportunities as well as financial aid data)
15. Water-related disaster risk reduction, Integrated Flood Management System and early warning systems
16. Water for peoples, water for food, water for energy, water for industries, and water to sustain the ecosystem
17. Water projects for social inclusion and good governance
18. Water, sanitation and hygiene programmes
19. Water and Peace – meaning Good Water Governance
20. Streamlining legislation to abolish the outdated ones and to enact the new ones which are suitable for the present time. This is extremely important for the revenue creation.
21. Getting the appropriate prices for the business and for the peoples
22. More topics can be added . . . .

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Conclusion

In reality, it is a political process!

Let us share the momentum from the President led national reform process.

Appendix B. Chemical and biological monitoring results from the Bago Sub-basin

The appendix presents results from about 57 different physical and chemical parameters from 43 stations (Figure 4.7), also analyses of invertebrates as indicators for ecological status of water bodies are presented. The values are the average of all data collected for the given parameters for specific stations which have been transferred to the project database in Aquamonitor during the period 2016-2018. The ecological status criteria for some parameters are uncertain, that is, the threshold reference indicating, substantial human impact, or no substantial human impact on good ecological status; this refers to all figures which are not marked. Analysis results which clearly indicate negative impact on ecological status is marked with red, while good status has a green mark. Suspiciously high values are marked with red text. *The last table provides a qualitative summary based on these markings, as well as a qualitative assessment of macro-invertebrates.*

StationCode	StationName	COD mg/l	BOD mg/l	E coli MPN/100ml	Faecal coliform MPN/100ml	PO4-P µg/l	TOC mg/l	Total coliforms MPN/100ml	TOTN µg/l	TOTP µg/l	NO3+NO2-N µg/l	NH4-N µg/l	Turbidity FNU	Turbidity NTU	Conductivity mS/m	pH	Alkalinity mmol/l	Colour mg Pt/
BAG0201M	Bago River - 201 M	39	12	0	0	7	3,8	> 16	365	19	120,0	36	1,5	23,6	26,0	7,40	2,485	2,5
BAG0301M	Bago River - 301 M	33,5	12	0	0	34	2,8	> 16	375	55	150,0	24	9,2	52,6	13,6	7,31	1,485	6
BAG0401M	Bago River - 401 M	35,1	14	0	0	13	2,6	> 16	350	33	17,0	7	8,2	55,9	13,1	7,37	1,475	5
BAG0501M	Bago River - 501 M	32,4	10	0	0	13	3,3	> 16	248	27,5	37,5	24	7,8	24,9	12,5	7,30	1,256	8,5
BAG0601M	Bago River - 601 M	42,5	10	2,55	2,55	42	4,0	> 16	403	97,5	66,5	27	58,0	75,4	11,8	7,36	1,721	10
BAG0701M	Bago River - 701 M					780	13,2		1050	1000	240,0	200	1600,0		14,8	7,84	1,400	16
BAG0801M	Bago River - 801 M	47,5	14	0	0	1000	20,7		1800	1300	820,0	240		606,7	191,9	7,32	1,765	7
BAG0901M	Bago River - 901 M	70,2	35	0	0	320	7,8	> 16	1160	450	700,0	110	870,0	871,7	706,6	7,49	2,205	4
BAG0101T	Bago River - 101 T					5	4,7		325	27	13,0	30	2,4		26,7	8,12	2,780	13
BAG0201T	Bago River - 201 T	32,1	12	0	0	4	3,5	> 16	400	14	160,0	40	2,1	22,8	8,1	7,26	0,933	34
BAG0301T	Bago River - 301 T					12	2,5		400	30	170,0	25	15,0		6,0	7,27	0,792	14
BAG0602T	Mazin chaung St2	51,5	19	0	0	20	3,1	> 16	368	44	35,3	62	20,2	249,9	3,4	6,68	0,425	5
BAG0603T	Mazin chaung St1	40,5	7	0	0	10	3,4	> 16	350	37	21,0	55	150,0	37,2	2,3	6,74	0,338	11
BAG0502M	Bago River - 502 M					98	3,7		445	130	89,0	22	150,0		7,2	7,42	0,652	21
BAG0503M	Bago River - 503 M					49	3		445	190	84,0	27	140,0		6,7	7,43	0,609	13
BAG0504M	Bago River - 504 M					37	3,1		400	130	83,0	19	74,0		6,6	7,44	0,583	16
BAG0602M	Bago River - 602M					79	2,8		405	170	89,0	33	83,0		6,6	7,36	0,572	25
BAG0605T	Zalathaw chaung	52,5	18	0	0	7	1,8	> 16	290	20	75,0	29	9,1	48,9	2,4	6,54	0,390	8
BAG0604T	Mazin outlet					1	2,5		388	7	176,5	51	0,8		1,9	6,83	0,193	3,5
BAG0606T	Bago City stream					990	9,6		5300	1100	130,0	390	13,0		26,7	7,31	1,530	24
SITORef1	Sittaung Reference 1	28,2	10	0	0	40	3,8	> 16	220	88	30,0	< 20	> 100	82,1	17,3	7,09	1,790	11
SITORef4	Sittaung Reference 4	25,3	9	0	0	230	3,4	> 16	1010	430	91,0	61	> 100	19,0	24,5	7,27	2,315	12
SITORef6	Sittaung River - Ref-6	8,3	5	0	0	< 4	2,7	> 16	270	15	83,0	< 20	2,2	22,4	12,7	7,20	1,390	12
BAG0701T	Bago River - 701 T					< 4	7,9		200	21	20,0	< 20	6,9		2,4		0,330	< 2
BAG0302T	Bago River - 302 T	20,6	9	0	0	8	3,5	> 16	335	22	130,0	< 20	7,8	22,4	6,1	7,21	0,862	11
InlRes1	Inlet Reservoir 1	14	5	0	0	< 4	1	> 16	99	5	20,0	< 20	6,5	25,9	3,7	6,72	0,500	2
BAG0801T	Bago River - 801 T	49,6	17	0	0			> 16						744,7	191,2	7,15	1,700	
BAG0802T	Bago River - 802 T	59,1	20	0	0			> 16						667,5	32,7	6,87	1,750	
BAG0803T	Bago River - 803 T	36,2	12	0	0									642,0	226,4	7,25	1,900	
BAG0804T	Bago River - 804 T	35,7	11	0	0									190,3	287,5	7,27	1,960	
BAG0600T	Mazin chaung St3					40	4,2		570	57	200,0	160	3,3		2,4		0,249	10
BAG0Myst	Mystic River					< 4	4,2		300	9	20,0	47	1,7		2,0		0,219	3
SITOImp2	Sittaung impacted 2					< 4	4,4		355	10	5,0	< 20	5,7				< 0,09	7
BAG0303T	Bago River - 303 T	22,9	9			< 4	4,7		375	12	70,0	110	5,7	21,7	4,6	7,23	0,697	16
BAG0615T	Zalathaw chaung 2					< 4	3,5		625	25	65,0	60	6,8		3,2		0,303	14
BAG0607T	607T					< 4	3		190	15	10,0	< 20	3,0		2,4		0,255	14
SITOImp3	Sittaung Impacted 3					7	9		285	29	20,0	< 20	2,7		11,4		1,080	13
SITOImp4	Sittaung Impacted 4					< 4	2,8		190	19	8,0	< 20	2,7		10,7		0,996	18
SITORef2	Sittaung Reference 2					10	1,5		125	41	10,0	< 20	18,0		9,7		0,819	5
SITORef3	Sittaung Reference 3					10	4,6		103	20	20,0	< 20	1,1		9,2		0,873	15
BAG0402M	Bago River - 402 M					5	2,8		235	20	30,0	30	1,5		6,4		0,648	4
BAGK1	Bago River - K1					4	2,1		390	8	20	43	0,5	3,2	1,7	6,45	0,600	14
BAGK2	Bago River - K2													2,6	1,7	6,35	0,600	
BAGK3	Bago River - K3													1,4	1,6	6,35	0,600	

StationCode	StationName	Ag µg/L	Al µg/l	Arsenic µg/l	As µg/l	As-filt µg/l	B µg/l	Ba µg/l	Be µg/l	Ca mg/l	Cd µg/l	Cd-filt µg/l	Cl mg/L	Co µg/L	Cr µg/l	Cr-filt µg/l	Cu µg/L	Cu-filt µg/l	Fe µg/l	Fe ppm
BAG0201M	Bago River - 201 M	< 0,002	40,1	2,00	1,03	1,45	22,9	4,27	< 0,006	16,3	0,000	< 0,003	4,7	0,11	0,364	1,19	11,03	0,93	95,4	0,034
BAG0301M	Bago River - 301 M			0,32						10,3	0,000		3,1		0,111		18,33			0,138
BAG0401M	Bago River - 401 M			0,29						10,0	0,000		2,6		0,189		17,40			0,172
BAG0501M	Bago River - 501 M			2,25		0,62				11,4	0,006	< 0,003	4,4		0,642	0,7	10,05	0,75		0,152
BAG0601M	Bago River - 601 M	< 0,002	782	4,46	0,41		8,5	11,1	0,108	8,1	0,006		4,2	2,06	1,410		14,47		1550	0,166
BAG0701M	Bago River - 701 M	0,009	3800		3,09		22,1	30,4	0,822		0,110		3,0	13,10	9,520		23,20		9280	
BAG0801M	Bago River - 801 M	0,033	7530	0,38	4,59		189	63,2	1,74	29,9	0,100		492,5	25,70	9,888		28,56		18000	2,760
BAG0901M	Bago River - 901 M	0,025	2970	4,04	4,52		661	45,1	0,518	61,9	0,039		2055,6	6,60	4,813		18,91		6470	2,206
BAG0101T	Bago River - 101 T	< 0,002	57,4		1,29		23,1	5,26	0,007				3,0	0,32	0,230		0,78		168	
BAG0201T	Bago River - 201 T	< 0,002	35,3	1,60	1,1		6	4,69	< 0,006	5,4	0,000		4,3	0,22	0,175		9,74		1680	0,252
BAG0301T	Bago River - 301 T	< 0,002	113		0,66		6,6	21,7	0,02	3,9			4,1	0,66	0,280		0,47		1290	0,760
BAG0602T	Mazin chaung St2	< 0,002	80,1	0,27	0,4	0,44	6,85	8,98	0,015	1,4	0,000	< 0,003	4,0	0,31	0,796	0,53	7,68	0,22	634	0,254
BAG0603T	Mazin chaung St1	< 0,002	301	2,57	0,47		6,1	7,6	0,017	0,9	0,006		3,1	0,40	0,566		8,11		566	0,078
BAG0502M	Bago River - 502 M	< 0,002	1770		0,48		9,1	16,7	0,191		0,011		0,8	4,76	5,270		4,25		3800	
BAG0503M	Bago River - 503 M	< 0,002	1250		0,48		8,6	12,9	0,135		0,008		0,9	3,03	3,310		3,06		2400	
BAG0504M	Bago River - 504 M	< 0,002	984		0,46		8,5	10,9	0,103		0,010		0,9	2,22	2,590		2,41		1900	
BAG0602M	Bago River - 602M	< 0,002	858		0,47		8,3	9,79	0,087		0,007		1,1	1,94	2,320		2,37		1710	
BAG0605T	Zalathaw chaung	< 0,002	87,3	0,27	0,33		4,5	8,95	0,02	1,3	0,000		4,1	0,38	0,686		19,37		478	0,206
BAG0604T	Mazin outlet	< 0,002	2,1		0,35	0,37	3,7	14	< 0,006	0,4		0,007	1,1	0,08	0,034	0,48	0,09	0,29	250	
BAG0606T	Bago City stream	0,005	122		1,61		16,4	15,2	0,01		0,014		210,0	0,64	0,540		2,40		752	
SITORef1	Sittaung Reference 1			2,01		1,09				6,1	0,000	< 0,003	6,2		1,758	0,47	16,48	0,36		0,178
SITORef4	Sittaung Reference 4			0,36		1,65				9,9	0,000	0,004	7,0		1,162	1,04	13,17	0,85		0,072
SITORef6	Sittaung River - Ref-6			0,26		1				6,2	0,000	< 0,003	5,4		0,666	0,45	13,33	0,14		0,424
BAG0701T	Bago River - 701 T					0,3						< 0,003				0,56		0,34		
BAG0302T	Bago River - 302 T			2,45		0,57				2,3	0,000	< 0,003	6,2		1,725	1,07	30,08	0,20		0,460
InlRes1	Inlet Reservoir 1			1,00						1,0	0,000		5,8		1,837		9,56			0,124
BAG0801T	Bago River - 801 T			0,26						12,2	0,000		598,7		0,732		18,96			13,675
BAG0802T	Bago River - 802 T			0,28						5,6	0,000		73,3		0,431		10,55			11,125
BAG0803T	Bago River - 803 T			0,38						18,3	0,000		756,9		0,496		13,65			1,730
BAG0803T	Bago River - 803 T			0,38						18,3	0,000		756,9		0,496		13,65			1,730
BAG0804T	Bago River - 804 T			0,35						20,4	0,000		948,5		0,472		18,94			0,136
BAG0600T	Mazin chaung St3					0,48						< 0,003				3,05		0,24		
BAGOMyst	Mystic River					0,38						< 0,003				0,66		0,12		
SITOImp2	Sittaung impacted 2					0,97						< 0,003				0,51		0,71		
BAG0303T	Bago River - 303 T			5,00		0,54				2,0	0,000	< 0,003	3,8		0,103	0,27	27,46	0,13		0,267
BAG0615T	Zalathaw chaung 2					0,55						0,004				1,17		0,72		
BAG0607T	607T					0,46						< 0,003				0,53		0,41		
SITOImp3	Sittaung Impacted 3					1,16						< 0,003				0,38		0,70		
SITOImp4	Sittaung Impacted 4					1,07						< 0,003				0,62		0,39		
SITORef2	Sittaung Reference 2					0,83						0,010				0,82		0,46		
SITORef3	Sittaung Reference 3					0,67						< 0,003				0,52		0,21		
BAG0402M	Bago River - 402 M					0,72						< 0,003				0,51		0,26		
BAGK1	Bago River - K1			0,04		0,32				1,6	0	0,033	4,96		0,558	0,39	38,26	0,05		0,1
BAGK2	Bago River - K2			0,02						1,6	0		4,96		0,494		38,71			0,1
BAGK3	Bago River - K3			0,02						1,6	0		7,09		0,479		53,25			0,1

StationCode	StationName	Li µg/l	Manganese µg/l	Mercury µg/l	Mg mg/L	Mn µg/l	Mo µg/l	Na mg/L	Ni µg/L	Ni-filt µg/l	Pb µg/L	Pb-filt µg/l	K mg/L	Sb µg/l	Se µg/l	Si mg/l	SiO2 mg/l	Sn µg/L	SO4 mg/L	Sodium mg/l
BAG0201M	Bago River - 201 M	0,28	0,07	0,001	16,59	48,3	0,06	9	0,43	1,35	0,06	0,15	3,49	0,023	< 0,05	6,5	17,25	< 0,05	11	24,1
BAG0301M	Bago River - 301 M		0,11	0,001	8,15			5,96	0,16		0,02		2,87				20,8		4,99	13,6
BAG0401M	Bago River - 401 M		0,19	5,159	7,87			7,24	0,20		0,03		2,86				15		7,56	12,8
BAG0501M	Bago River - 501 M		0,12	0,003	6,64			8,04	0,02	0,82	0,01	0,084	2,64				13,55		8,79	13,2
BAG0601M	Bago River - 601 M	1,25	0,21	0,003	6,54	149	< 0,02	5,405	2,71		1,41		2,81	0,026	< 0,05		18,8	< 0,05	4,9	15,3
BAG0701M	Bago River - 701 M	7,33			9,00	1330	< 0,02	9,2	29,90		30,10		2,91	0,085	< 0,05	> 10	87,3	< 0,05	5,28	
BAG0801M	Bago River - 801 M	20,4	0,07	0,000	37,93	2290	0,27	400	29,10		26,32		20,34	0,16	0,13	> 10	126	< 0,05	90	127,9
BAG0901M	Bago River - 901 M	31,4	0,23	0,003	130,11	647	1,01	1700	8,64		8,56		52,92	0,25	0,13	> 10	44,3	< 0,05	400	364,5
BAG0101T	Bago River - 101 T	0,88			14,00	85,7	0,092	16	1,31		0,23		4,07	0,073	< 0,05	9,9	21	< 0,05	3,3	
BAG0201T	Bago River - 201 T	0,39	0,08	0,902	4,12	80,5	< 0,02	2,93	0,61		0,07		3,00	< 0,01	< 0,05	5,32	16,9	< 0,05	0,59	10,9
BAG0301T	Bago River - 301 T	0,58			3,07	121	< 0,02	3,39	1,06		0,50		3,27	0,016	< 0,05	6,75	19,7	< 0,05	0,31	10,3
BAG0602T	Mazin chaung St2	0,585	0,04	0,006	1,03	34,35	< 0,02	2,245	0,43	0,76	0,61	0,127	2,01	0,047	< 0,05	4,98	10,5	< 0,05	0,50	4,5
BAG0603T	Mazin chaung St1	0,52	0,07	0,003	0,76	36,5	< 0,02	1,73	0,50		0,74		1,67	0,018	< 0,05	5,14	12,8	< 0,05	0,38	6,2
BAG0502M	Bago River - 502 M	2,17			3,91	291	< 0,02	3,74	12,60		4,53		1,19	0,025	< 0,05		27,5	< 0,05	3,45	
BAG0503M	Bago River - 503 M	1,71			3,56	200	< 0,02	3,48	8,32		3,32		1,18	0,027	< 0,05		28,7	< 0,05	3,12	
BAG0504M	Bago River - 504 M	1,34			3,52	147	< 0,02	3,48	6,32		2,68		1,18	0,019	< 0,05		21,9	< 0,05	3,07	
BAG0602M	Bago River - 602M	1,24			3,42	124	< 0,02	3,53	5,66		2,53		1,22	0,026	< 0,05		21,5	< 0,05	2,98	
BAG0605T	Zalathaw chaung	0,54	0,17	0,001	0,91	41,8	< 0,02	1,9	1,10		0,22		1,95	0,012	< 0,05		9,5	< 0,05	0,33	6,0
BAG0604T	Mazin outlet	0,51			0,53	30,9	< 0,02	1,57	0,34	0,66	0,07	0,062	1,04	0,021	< 0,05		9,75	< 0,05	0,31	
BAG0606T	Bago City stream	1,84			49,00	98,3	0,47	37	2,35		2,29		89,00	0,26	0,11		17,3	< 0,05	70	
SITORef1	Sittaung Reference 1		0,02	0,004	6,83				0,06	0,86	0,02	0,049	6,40				42			23,2
SITORef4	Sittaung Reference 4		0,04	0,002	11,03				0,04	2,07	0,02	0,506	4,40				66			22,3
SITORef6	Sittaung River - Ref-6		0,02	0,002	7,03				0,04	0,60	0,01	0,047	3,94				12,6			11,6
BAG0701T	Bago River - 701 T									1,29		0,131					15,5			
BAG0302T	Bago River - 302 T		0,08	0,002	4,10				0,25	1,02	0,02	0,088	4,12				15,4			11,2
InlRes1	Inlet Reservoir 1		0,03	0,006	1,62				0,05		0,01		4,52				32			7,8
BAG0801T	Bago River - 801 T		0,14	0,004	43,07				0,07		0,04		26,38							167,0
BAG0802T	Bago River - 802 T		0,05	0,003	10,74				0,06		0,02		10,60							46,4
BAG0803T	Bago River - 803 T		0,05	0,002	47,09				0,06		0,02		30,03							205,3
BAG0804T	Bago River - 804 T		0,06	0,002	59,89				0,37		0,02		36,48							309,2
BAG0600T	Mazin chaung St3									2,25		0,093					11,4			
BAGOMyst	Mystic River									0,78		0,027					10,6			
SITOImp2	Sittaung impacted 2									1,05		0,108					9,65			
BAG0303T	Bago River - 303 T		0,04	0,001	2,93				0,18	0,70	0,03	0,026	3,70				13,4			8,6
BAG0615T	Zalathaw chaung 2									1,72		0,193					10,5			
BAG0607T	607T									1,13		0,146					9,16			
SITOImp3	Sittaung Impacted 3									0,91		0,08					11,4			
SITOImp4	Sittaung Impacted 4									0,65		0,16					13,4			
SITORef2	Sittaung Reference 2									1,04		0,137					43			
SITORef3	Sittaung Reference 3									1,01		0,101								
BAG0402M	Bago River - 402 M									0,89		0,047					13,6			
BAGK1	Bago River - K1			0,003	0,98	0,02		5	0,03	0,46	0,02	0,025	2,70				13,4		0,48	
BAGK2	Bago River - K2			0,001	0,98	0,02		5	0,05		0,02		2,60						0,48	
BAGK3	Bago River - K3			0,009	0,98	0,07		5,5	0,02		0,02		2,70						0,48	

StationCode	StationName	Sr	SS	Sulphate	Ta	Ti	Tl	U	V	V-filt	Zn	Zn-filt
		µg/l	g/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/L	µg/l	µg/l	µg/l
BAG0201M	Bago River - 201 M	108	0,216	18,35		0,76	< 0,01	0,065	0,580	1,05	0,87	2,4
BAG0301M	Bago River - 301 M		0,250	9,51							0,22	
BAG0401M	Bago River - 401 M		0,294	0,48							0,00	
BAG0501M	Bago River - 501 M		0,274	7,59						0,393	0,00	0,99
BAG0601M	Bago River - 601 M	35,2	0,381	7,59	< 0,007	3,5		0,078	3,130		2,67	
BAG0701M	Bago River - 701 M	86,6				7,6	0,019	0,858	17,800		34,20	
BAG0801M	Bago River - 801 M	346	2,212	64,36		11,3	0,061	1,650	33,100		36,73	
BAG0901M	Bago River - 901 M	1250	2,079	17,48		11,9	0,059	1,400	12,900		17,69	
BAG0101T	Bago River - 101 T	133				0,76	0,015	0,262	1,680		0,52	
BAG0201T	Bago River - 201 T	40,8	0,124	0,48		0,64	< 0,01	0,006	0,240		2,07	
BAG0301T	Bago River - 301 T	51,3	0,073	0,48		1,9	< 0,01	0,022	0,697		0,76	
BAG0602T	Mazin chaung St2	10,25	0,371	3,27	< 0,007	0,63	< 0,01	0,022	0,520	0,157	1,80	1,3
BAG0603T	Mazin chaung St1	8,8	0,249	0,48		1,7	< 0,01	0,061	0,693		1,19	
BAG0502M	Bago River - 502 M	42	0,316		< 0,007	5,7		0,134	6,720		11,00	
BAG0503M	Bago River - 503 M	36,8	0,208		< 0,007	5,8		0,097	4,620		6,80	
BAG0504M	Bago River - 504 M	35,5	0,195		< 0,007	3,6		0,076	3,560		5,40	
BAG0602M	Bago River - 602M	34,4	0,242		< 0,007	3,8		0,071	3,170		4,90	
BAG0605T	Zalathaw chaung	7,73	0,219	0,48	< 0,007	0,63		0,019	0,381		1,24	
BAG0604T	Mazin outlet	10,5	0,003		< 0,007	0,18		0,002	0,022	0,073	0,19	2,1
BAG0606T	Bago City stream	98	0,047		< 0,007	2,1		0,037	2,470		19,00	
SIT0Ref1	Sittaung Reference 1		0,314	0,48						1,14	2,73	0,58
SIT0Ref4	Sittaung Reference 4		0,220	16,43						2,76	2,44	0,9
SIT0Ref6	Sittaung River - Ref-6		0,248	0,48						0,228	3,72	1,8
BAG0701T	Bago River - 701 T									0,183		1,8
BAG0302T	Bago River - 302 T		0,218	0,48						0,147	8,86	1,5
InlRes1	Inlet Reservoir 1		0,312	0,48							0,40	
BAG0801T	Bago River - 801 T		1,740	38,42							12,76	
BAG0802T	Bago River - 802 T		4,063	0,48							0,23	
BAG0803T	Bago River - 803 T		1,338	43,85							0,00	
BAG0804T	Bago River - 804 T		1,092	39,00							0,00	
BAG0600T	Mazin chaung St3									0,176		1,5
BAG0Myst	Mystic River									0,059		1,1
SIT0Imp2	Sittaung impacted 2									0,766		2,4
BAG0303T	Bago River - 303 T		0,320	0,48						0,037	2,51	1,9
BAG0615T	Zalathaw chaung 2									0,223		2,3
BAG0607T	607T									0,148		1,2
SIT0Imp3	Sittaung Impacted 3									0,566		0,85
SIT0Imp4	Sittaung Impacted 4									0,712		0,79
SIT0Ref2	Sittaung Reference 2									0,492		1,9
SIT0Ref3	Sittaung Reference 3									0,288		0,83
BAG0402M	Bago River - 402 M									0,205		6,9
BAGK1	Bago River - K1		0,08							0,041	0,00	1,5
BAGK2	Bago River - K2		0,06								0,41	
BAGK3	Bago River - K3		0,05								1,30	

StationCode	StationName	Qualitative evaluation based on macroinvertebrates	Evaluation based on water chemistry samples	Comment
BAG0201M	Bago River - 201 M	No or low degradation	No or low degradation detected	
BAG0301M	Bago River - 301 M	Not yet evaluated	Possible degradation	
BAG0401M	Bago River - 401 M	No or low degradation	No or low degradation detected	
BAG0501M	Bago River - 501 M	Possible degradation	No or low degradation detected	
BAG0601M	Bago River - 601 M	Degradation	High nutrient/organic pollution	
BAG0701M	Bago River - 701 M	Not evaluated - marine influence	High nutrient/organic pollution	
BAG0801M	Bago River - 801 M	Not evaluated - marine influence	High nutrient/organic pollution	High concentration of suspended sediment:
BAG0901M	Bago River - 901 M	Not evaluated - marine influence	High nutrient/organic pollution	High concentration of suspended sediment:
BAG0101T	Bago River - 101 T	No or low degradation	No or low degradation detected	
BAG0201T	Bago River - 201 T	No or low degradation	No or low degradation	
BAG0301T	Bago River - 301 T	Possible degradation	Possible degradation	
BAG0602T	Mazin chaung St2	Degradation	High nutrient/organic pollution	
BAG0603T	Mazin chaung St1	Degradation	High nutrient/organic pollution	
BAG0502M	Bago River - 502 M	No sampling	High nutrient/organic pollution	
BAG0503M	Bago River - 503 M	No sampling	High nutrient/organic pollution	
BAG0504M	Bago River - 504 M	No sampling	High nutrient/organic pollution	
BAG0602M	Bago River - 602M	No sampling	High nutrient/organic pollution	
BAG0605T	Zalathaw chaung	Not yet evaluated	Possible degradation	
BAG0604T	Mazin outlet	Not yet evaluated	No or low degradation detected	
BAG0606T	Bago City stream	Degradation	High nutrient/organic pollution	
SITORef1	Sittaung Reference 1	Not yet evaluated	Possible degradation	
SITORef4	Sittaung Reference 4	Not yet evaluated	High nutrient/organic pollution	
SITORef6	Sittaung River - Ref-6	No or low perturbation	No or low degradation detected	
BAG0701T	Bago River - 701 T	Not yet evaluated	High nutrient/organic pollution	
BAG0302T	Bago River - 302 T	No or low degradation	No or low degradation detected	
InlRes1	Inlet Reservoir 1	Not yet evaluated	No or low degradation detected	
BAG0801T	Bago River - 801 T	No sampling	Possible degradation	High concentration of suspended sediment:
BAG0802T	Bago River - 802 T	No sampling	Possible degradation	High concentration of suspended sediment:
BAG0803T	Bago River - 803 T	No sampling	Possible degradation	High concentration of suspended sediment:
BAG0804T	Bago River - 804 T	No sampling	Possible degradation	High concentration of suspended sediment:
BAG0600T	Mazin chaung St3	Degradation	High nutrient/organic pollution	
BAGOMyst	Mystic River	Possible degradation	Possible degradation	
SITOImp2	Sittaung impacted 2	Degradation	No or low degradation detected	
BAG0303T	Bago River - 303 T	Not yet evaluated	Possible degradation	
BAG0615T	Zalathaw chaung 2	Not yet evaluated	Possible degradation	
BAG0607T	607T	Not yet evaluated	Possible degradation	
SITOImp3	Sittaung Impacted 3	Possible degradation	Possible degradation	
SITOImp4	Sittaung Impacted 4	Possible degradation	Possible degradation	
SITORef2	Sittaung Reference 2	No or low degradation	No or low degradation detected	
SITORef3	Sittaung Reference 3	No or low degradation	No or low degradation detected	
BAG0402M	Bago River - 402 M	Possible degradation	Possible degradation	
BAGK1	Bago River - K1	No data	No or low degradation detected	
BAGK2	Bago River - K2	No data	No or low degradation detected	
BAGK3	Bago River - K3	No data	No or low degradation detected	

Appendix C. Minutes as prepared in a folder for Committee and Group meetings

Integrated Water Resources Management Institutional building and training

The long term goal is well-functioning Integrated Water Resources Management for inland waters in Myanmar.

The project which is a collaboration between Forest Department/ MONREC, IWUMD / MOALI and DWIR /MOTC and the Norwegian Institute for Water Research (NIVA) pilot implements the *River Basin Management approach in the Bago Sub-Basin.*

The River Basin Management approach

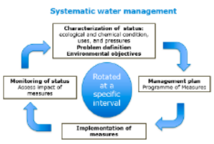
An important argument for integrated water management within the boundaries of the catchment is that all uses and discharges are linked through the hydrological cycle. Hence the component parts of a water system need to be understood in relationships with each other.

The principle of the river basin management approach is emphasized as an important objective for Myanmar in both the *National Water Framework Directive (NWFD)* and in the *National Water Policy (NWP).*

The project involves development and capacity building of practical water management tasks in the Bago Sub-basin. These tasks consist of: identification and characterization of water bodies, including chemical and ecological status and monitoring, pressure analysis, risk assessment, economic analysis of water use; Classification, Environmental goals, Program of measures to reach the goals, and the development of a River Basin Management Plan for the Bago Sub-basin Area.

The River Basin Management Plan

An important aim for sustainable development of a river basin is a River Basin Management Plan (RBMP). A RBMP will be developed as a coordinated effort by sector and environmental authorities being members of the River Basin Area Committee. A non-governmental stakeholder group referring to NGOs and civil society will meet to discuss and to provide input to the Sub-basin Area Committee.



Characterization of pressures in Bago

Main water users and uses

The Bago Region has a total of about 4.8 million inhabitants with 22 % living in urban areas (Department of Population 2015). The majority live in the lower parts of the catchment. The main use of water is irrigation of agricultural areas. In the upper part of the Bago River basin, a total of ten large dams and reservoirs are present, the main usage is for irrigation and drinking water, and one is also used as a reservoir for hydropower production.

The second largest water use is domestic use and includes in the different municipalities sanitation and drinking water. Drinking water is usually extracted from drinking water reservoirs, and shallow wells. Rainwater is also collected for domestic purposes. There are relatively little industrial activities in the Bago Region, apart from agriculture.

Protected Areas and land use restrictions in Bago Sub-basin Area

*Moeyungyi Wildlife Sanctuary (*RAMSAR sight since 2004) and *Zarmani-Inn* reservoir are wetlands in Bago protected for management of biodiversity and ecosystems.

Shwekyin and Kantawgyi are protected public forests. The watershed area of Kantawgyi is protected to enhance water flows into the Kantawgyi Lake, to sustain water supply for drinking water, irrigation and to reduce rate of sedimentation.
There are restrictions on land use upstream dams and reservoirs used for irrigation. Reservoirs are protected by prohibiting mining industries on first and second tributary upstream reservoir area. The following 17 dams and reservoirs can be found in the Bago Region: Zaung Tu, Zalat Htaw, War Ka Toke, Shwe Pyi(3), Shwe Laung, Salu, Pyinpon, Mazin, Alaing Ni, La Gun Pyin, Kodu Kwe, Kawliya, Bawni, Ye New, Baing Dar, Kyun Chaung, and Shwe Kyin.

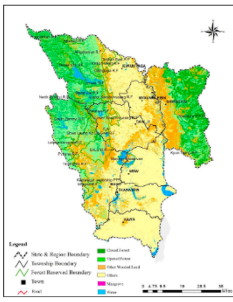


Figure 1. Forest Cover in Bago District (GIS and RS section, Planning and Statistics Division, Forest Department)

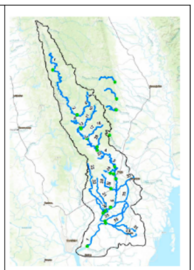


Figure 2. Water body division of the Bago basin (numbers) and locations for biological and chemical monitoring (green circles)

Pressures

GIS data for upstream Bago River basin has shown substantial clear cuts during the last 15 years, the large clear cuts have been concentrated to central and northern parts of the Bago River basin (Figure 1). Mercury, micro pollutants and high sediment loads are important parameters that become mobilized with deforestation and follow the river downstream to where water may be used for irrigation and domestic use.

The main pressure from urban areas is sewage from human feces due to the lack of proper sewage treatment. Pathogens such as E-coli, Clostridium perfringens, Campylobacter and Salmonella common in human and animal fecal are hazardous to human health. Waste disposal is another problem in urban areas as the river is used for disposal of waste. The waste affects the environment and human health.

Large amount of fertilizers used in the agricultural plains will increase concentrations of phosphorus and nitrogen in the river by runoff. This may lead to eutrophication, toxic algal blooms and reduced oxygen levels.

Sea level rise, climate change and future drought enhance salt water intrusion into freshwater areas of Bago.

Water quality characterization in Bago

Ecological status classification for lakes and rivers are initiated by the use of available data and expert judgement.

Biological indicators directly show relevant responses to environmental pressures. Such indicators integrate their responses over time and space, potentially lowering sampling effort and cost.

Drinking water: surface waters which are used as drinking water sources should be subject to additional monitoring.

Habitat and species protection areas: Monitoring should be carried out to assess the magnitude and impact of all relevant significant pressures on such bodies and, where necessary, to assess changes in the status of such bodies.

The Bago River monitoring programme

35 water bodies (Figure 2) have been selected for monitoring based on similar water body type (catchment area, altitude, geology and region) and exposure to similar pressure types (factories, agriculture, towns, and dams). The water body is the management unit in which environmental objectives will be linked.

To investigate ecological status in the selected water bodies (Figure 3), chemical and biological parameters are monitored: **Macroinvertebrates (biology) and chemistry**; **metals** - mercury (Hg), copper (Cu), nickel (Ni), lead (Pb), chromium (Cr), zinc (Zn), Manganese (Mn), Cadmium (Cd), Iron (Fe) and arsenic (As); **physio-chemical** – pH, turbidity, suspended solids (SS), alkalinity, calcium (Ca), potassium (K), chloride (Cl), magnesium (Mg), sodium (Na) and sulfate (So), nitrogen (TN), nitrate (NO3), phosphate (PO4-P), phosphorous (TP) and ammonia (NH4).

Water samples are collected every month by FD and IWUMD staff, and samples are analysed at the Forest Research Institute laboratory (NPT), at the IWUMD (Yangon) and at NIVA (Norway).

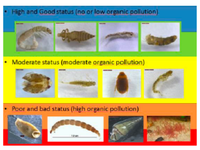


Figure 3. Macroinvertebrates are excellent indicators of organic pollution

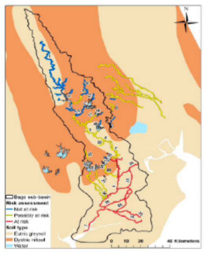
Results from characterization work

Biological water quality elements

Preliminary results show that macroinvertebrates respond to pollution in the Bago River much the same way as elsewhere in the world. Therefore, we believe it will be a suitable biological indicator also in Myanmar. More research and data are needed in order to define class boundaries. So far we can separate between low and high levels of pollution (Figure 4).

Figure 4. The composition of macroinvertebrates from unpolluted (top left), moderate (top right) and high pollution (bottom) streams sites in the Bago River sub-basin. Only a few and tolerant species survives high pollution.

The investigations so far indicate no metal pollution in the Bago River basin. Concentrations of nutrients and suspended particles (brownish water colour) in the water were on the contrary elevated in some areas, and indicates a worsening of the status especially from Bago city and downstream. High levels of particles in the water makes the water turbid and may contain pesticides, nutrients, pathogens (bacteria, viruses and parasites), and other pollutants. Pathogens give infectious diseases to human and animals, and inorganic particles may cause a buildup of sediments. Nutrients can cause toxic water (algal blooms) and depletion levels of oxygen in the water that cause fish deaths. Therefore, turbid water is often related to unhealthy water quality, and run-offs of nutrients and other suspended particles should be prevented. A preliminary classification of the Bago River sub-basin is shown in Figure 5.



Preliminary classification

The first classification of ecological status for all surface waters should be based on available data and expert judgement. The aim of this classification is to group water bodies into one of the three categories not "**at risk**", "**possibly at risk**" or "**not at risk**". **At risk** means that there is significant alteration in the ecological quality, while **possibly at risk** means moderate alternations or that there is not sufficient information to decide, and **not at risk** - no or slight alteration. The preliminary classification therefore helps to identify areas where monitoring should be focused and abatement measures most probably are required.

Figure 5. Preliminary classification of the Bago River sub-basin into one of the three categories **"not at risk"**, **"possibly at risk"** or **"at risk"** based on available data and expert judgements.

Meeting for the discussion of Environmental objectives in Bago

Bago Sub-basin Area Committee meeting November 2016, and Bago Non-Governmental Stakeholder Group meeting February 2017.

The Committee and the Group discuss relevant environmental objectives in the Bago Sub-basin. The discussion focused on relevant objectives on national, regional and local level. The objectives are as according to the EU Water Framework Directive, categorized with reference to a, chemical water quality element, a biological water quality element, and a hydro morphological quality element.

A sustainable development goal refers "safeguarding living oceans, rivers and lakes for the benefit, safety and enjoyment of present and future generations.

The environmental objectives shall contribute to the sustainable development goal:

Contaminants shall not affect human affect human health or biological diversity in terrestrial and aquatic environments

Eutrophication shall not have a negative impact on biodiversity, human health, or deterioration of water quality in ocean, rivers and lakes

→ Chemical water quality element

Biodiversity and their variety of habitats in lakes, rivers, and transitional must be ecologically sustainable.

→ Biological water quality element

Reduce erosion to protect soils adjacent rivers, streams and lakes and to reduce transportation of pollution.

Consistent and sufficient water flow to secure ecosystem services for biodiversity and human security in a living and thriving river system.

→ Hydro-morphological water quality element

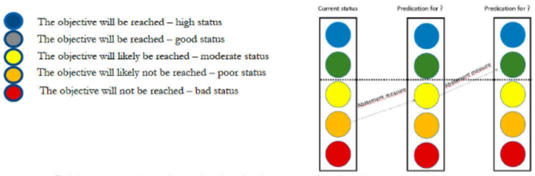


Figure 6. A traffic light system may be used to track and predict the progress of reaching the environmental objectives.

Coordination Arenas for the development of River Basin Management Plan

Coordination of actors on River Basin Area and Sub-Basin Area levels for the discussion of practical water management tasks and development of a River Basin Management Plan are needed.

A River Basin Area Committee embraces all relevant sector and environmental authorities within the administrative units of the Bago Sub-basin Area. Attendance at the Committee meetings: Regional ministers, one from Natural Resources, Forestry, and Environmental Conservation and one from Agriculture and Livestock, parliamentary members, government officials from (11) departments and Township Development Committees in Bago Region. At the Committee meeting on March the 3rd, Mr. Kyaw Min San (Bago Regional Minister of MONREC) was elected as chair person, and one secretary Director Mr. Zaw Win Myint from Bago FD and two co-secretaries, Director Mr. Htay Aung from Bago, DWIR Deputy Director Mr. Ko Ko Oo from Bago IWUMD, were elected with the agreement of all participants.

The Non-governmental Stakeholder Group – embraces people from NGOs, CBOs, civil society members, and other private actors. On March 2nd, the following secretaries were elected for the Non-governmental Stakeholder Group; Chairman of Twet Let Myar CSO, Member of USDP/Union Solidarity Development Party Bago District, and EC Member of National League for Democracy/NLD Bago District.

The Committee and the Non-Governmental Stakeholder group will meet separately and regularly in 2016- 2018 to discuss: prioritized management issues, environmental objectives, the programme of measures, to develop the River Basin Management Plan.

Meeting for the discussion of prioritized management issues in Bago (September 2016)

The members of the Committee discussed and proposed a number of pressures as prioritized management issues for the Bago Sub-Basin Area (see Table 1).

Table 1. Pressures as identified by the Bago Sub-basin Area Committee and the Non-governmental Stakeholder Group Meetings

Bago township	Thanatpin ts	Kawa ts	Waw ts
Sewage Garbage Sand mining Industrial waste River Bank Erosion and Sedimentation	Salt water intrusion Invasive shell species destroying the paddy fields High concentration of phosphorus and nitrogen Ground water pollution River Bank Erosion and Sedimentation	Salt water intrusion Invasive shell species destroying the paddy fields High concentration of phosphorus and nitrogen River Bank Erosion and Sedimentation	Salt water intrusion Invasive shell species destroying the paddy fields High concentration of phosphorus and nitrogen River Bank Erosion and Sedimentation

Meeting to discuss abatement measures for reaching environmental objectives in Bago

Bago Sub-basin Area Committee meeting March 3rd 2017, and Bago Non-Governmental Stakeholder Group meeting June 19th 2017.

The Committee meeting on March 3rd discussed in groups and then groups presented:

1. Relevant abatement measures for each of five water body types to reach the environmental aims;
2. The groups were asked to be specific and indicate institution (and what level) to be responsible for implementing the measures

Protected water bodies for biodiversity | **Dams for irrigation and drinking water** | **Upstream Bago water body types** | **Bago city water body types,** | **Downstream Bago city water body types**

The members of the Committee were divided into five groups, each group were to discuss abatement measures for one of the specific water body type (specified above). Table 2 presents the different abatement measures suggested by the different groups. The next step involves prioritizing among suggested abatement measures.

Table 2. Abatement measures as suggested by the Bago Sub-basin Area Committee Meeting

Protected Areas for biodiversity	Dams and reservoirs	Upstream Bago City	Bago City area	Downstream Bago city
Man-made issues (waste disposal)	Upgrade proper draingage System	Reforestation, rehabilitation e.g. Kan Taw Gyi watershed	Public awareness	Construction of erosion control Wall
Reduce invasive species	Reduce salinity hazards and water-logged conditions	Training to local people how to use pesticides and fertilizers.	Locate alternative place for garbage	Controlling using chemical fertilizers
Awareness raising of local people, ex. control on fishing	Minimize pesticide and fertilizer use	Watershed plantation, to reduce protect soil erosion	Treatment plant for sewage	Planting trees in buffer strips
Ecosystem and biodiversity conservation especially for migratory birds	Watershed management to control Erosion	Regulations, and public awareness to local people don't dump near the river and in the river	Rules & Regulations (law enforcement)	Controlling environmental Pollution & monitor water quality
Counter measures for natural disasters	Alertness for local people to improve willingness to participate	Sand mining based on permits & license rules, and an EIA/SIA	Treatment plant for industrial waste	Reduce number of permits for sand mining

Contact information: Watershed Management Division, Forest Department, Ministry of Natural Resources and Environmental Conservation (MONREC). Email: watershedfdmoecaf@gmail.com, https://www.facebook.com/Integratde-Water-Rescources-Management-IWRM-448331942221896/

Funding agency: The Norwegian Ministry of Foreign Affairs / The Royal Norwegian Embassy in Myanmar

NORWEGIAN EMBASSY

Appendix D. Abatement measures for improved water quality in Bago River

Abatement Measures for Improvement of Water Quality in Bago River as suggested by Forest Department

A. Pressure: Erosion and sedimentation downstream; Suggested abatement measures

- To implement reforestation and conservation of forests in upland/watershed areas
- To reduce conventional plantation establishment by cleaning and cutting the existing vegetation in critical watershed areas and other development activities that interrupt natural vegetation, soil and waterways
- Not to allow private plantation forestry in the watershed area of Bago rivers
- To prohibit sand mining in Bago River
- To promote practicing of sloping land agricultural techniques (SALT) in the existing hillside agricultural activities.

B. Pressure: High concentration of phosphorus and nitrogen; Suggested abatement measures

- To introduce organic farming systems

For more suggestions for abatement measures see examples below.

C. Industrial waste, other types of waste and contaminants from waste; Suggested abatement measures:

- To extend water quality testing results to local communities, introduce them with less-costly methods and locally available practices, regularly report to local authorities about the polluted conditions and encourage regional government to tackle issues occurred.
- To promote environmental education in all levels especially like from the grass root community to decision maker (e.g Parliamentary members).
- To coordinate among all relevant departments, led by especially Municipal and Development committee to address the issues of water pollution in Bago River
- To formulate legal frameworks, rules and regulation for waste management by Bago Regional Government
- To consider special campaign of collecting garbage and cleaning river banks of Bago River that should be regularly organized by Bago Regional Government with the participation of all levels of students from Primary schools to University, Volunteers, Environmental Conservation Activists.
- To pay attention of investment on monitoring not to dispose the waste and industrial pollutants to Bago River by relevant authorities, to improve environmental education on waste water management systems for all industries, and to encourage them to follow-up EIA and SIA procedures.
- To ensure law enforcement by taking real action on the activities on disposing garbage and sewage to Bago Rivers.
- To encourage reducing utilization of chemical fertilizers and more utilization of fertilizers and pesticides that less affect the environment and raise awareness activities by relevant authorities.
- To submit monthly report of the water quality data and update situations to the regional government body, and then take less-cost effective measures to address any emerging polluted issues.
- Prohibit establishment of rubber and other estate crop plantations that use a lot of pesticides and weedicides.

Other examples of possible abatement measures

Erosion: Local materials and knowledge can be used to construct low-cost structural measures such as bamboo "fence" to help prevent erosion of riverbanks and the loss of agricultural and residential land.

Other types of erosion controls, such as jute netting, silt fences, and check dams.
Reclaim or apply protective covering on disturbed soils as quickly as possible.
Restore the banks of water bodies to their natural condition.
Clean and maintain catch basins, drainage ditches, and culverts regularly.

Overview of type of measures implemented in Europe

Key to KTMs

KTM	Title
1	Construction or upgrades of wastewater treatment plants beyond the requirements of the Directive on Urban Waste Water Treatment
2	Reduce nutrient pollution in agriculture beyond the requirements of the Nitrates Directive
3	Reduce pesticides pollution in agriculture
4	Remediation of contaminated sites (historical pollution including sediments, groundwater, soil
5	Improving longitudinal continuity (e.g. establishing fish passes, demolishing old dams)
6	Improving hydromorphological conditions of water bodies other than longitudinal continuity
7	Improvements in flow regime and/or establishment of minimum ecological flow
8	Water efficiency measures for irrigation (technical measures)
9	Progress in water pricing policy measures for the implementation of the recovery of cost of water services from households
10	Progress in water pricing policy measures for the implementation of the recovery of cost of water services from industry
11	Progress in water pricing policy measures for the implementation of the recovery of cost of water services from agriculture
12	Advisory services for agriculture
13	Drinking water protection measures (e.g. establishment of safeguard zones, buffer zones etc.)
14	Research, improvement of knowledge base reducing uncertainty
15	Measures for the phasing-out of emissions, discharges and losses of priority hazardous substances or for the reduction of emissions, discharges and losses of priority substances
16	Upgrades or improvements of industrial wastewater treatment plants (including farms) beyond the requirements of the Integrated Pollution Prevention and Control (IPPC) Directive

Examples of abatement measures against agricultural run-off in Norway.

The measures most usually applied in Norway are focusing on reduced losses of phosporus to streams and lakes. Measures against nitrogen and pesticides are also important.

Measures against point sources

Point sources may include leakages from silos, manure storage, waste piles, barns, equipment washing facilities, farm buildings, etc. Point source pollution needs to be assessed in an environmental plan that each farmer need to prepare for the farm. Failure to prepare such plans can lead to reduced subsidies. Furthermore, pollution from point sources are regulated by several different laws, which are referred to in a guideline.

Fertilizer planning

Fertilizer planning involves systematic quantification of the need for plant nutrients for the individual agricultural crop at each field of a farm. The fertilizer requirement is calculated based on a number of factors, primarily from the soil nutrient status and the crop's production potential for each location. Nutrient cycling is an important component of Conservation Agriculture, in which minimum soil disturbance, intercropping, crop rotations and a permanent soil cover minimize the need for chemical fertilizers (FAO 2000). Usage of only non-persistent, immobile herbicides.

Conservation tillage - involves minimum tillage before seeding, e.g. harrowing or direct seeding. Conservation tillage will reduce the loss of soil and nutrients especially in steep fields.

Vegetated buffer zones:
A vegetated buffer zone between the water body and farmland can act as an effective filter for soil particles, nutrients and particle-bound pesticides in surface runoff from agricultural land. Vegetation zones can also reinforce the stream and river banks and protect against landslides and excavation by the stream water.

Sedimentation ponds, constructed wetlands
Sedimentation ponds are constructed wetlands that retain soil particles, nutrients and pesticides from diffuse sources such as agricultural land, roads and urban areas. The ponds can also improve biodiversity and add an aesthetic quality to the cultural landscape.

Grass-covered waterways
On erosion-prone soils where surface water is collected in natural depressions, erosion can be prevented by establishing grass-covered (vegetation) waterways / riverbanks.

About strategies, incentives:

Economic instruments have the advantages of providing incentives to polluters to modify their behaviour in support of pollution control and of providing revenue to finance pollution control activities. In addition, they are better suited to combating nonpoint sources of pollution. The setting of prices and charges are crucial to the success of economic instruments. If charges are too low, polluters may opt to pollute and to pay, whereas if charges are too high they may inhibit economic development. Compared with economic instruments, the advantages of

Regulatory instruments: the regulatory approach to water pollution control is that it offers a reasonable degree of predictability about the reduction of pollution, i.e. it offers control to authorities over what environmental goals can be achieved and when they can be achieved. Against this background it seems appropriate, therefore, for most countries to apply a mixture of regulatory and economic instruments for controlling water pollution.

Appendix E. A guide for identification of measures

Guide for identification of measures
The purpose of this section is to provide a simple guide on how the work of identifying abatement measures for implementation can be structured so as to increase facilitation and effectiveness of coordination for decision making (see also section 6.2 which.

1. *Responsibility*: The Sub-basin Area Committee which consists of sector and environmental authorities is the responsible institution for developing the Sub-basin Management Plan, and therefor also for identifying abatement measures for implementation. It is recommended that the Committee gives the responsibility to an institution within the Committee for organizing the work of collecting, compiling, writing up ongoing abatement measures.
2. *Listing on going measures*: The Sub-basin Area Committee includes competence and knowledge of already implemented environmental measures. The work of compiling an overview of already implemented measures may start by organizing so that Committee members from each sector, provides a list of measures being implemented to the responsible institution. The list should include evaluation of measures. Each sector authority should then use the opportunity to select and measures for future discussion towards the prioritized measures.
3. *Typical sector authorities* are; MOTC, DWIR, MOEP (energi), MOALI (agriculture) Dep. Of If certain departments of relevance are not members of the Committee, then these needs to be approached for this purpose. is crucial that relevant sector authorities are actively involved. All relevant sector authorities should be aware of the obligation to help and collaborate in this work.
4. *Scale:* It may be considered to identify implemented measures on township level.
5. *The assessment of ongoing measures:* The overview of implemented measures should include, an assessment of the effectiveness of measures, and possibilities to upscale implementation. It needs to identify sector responsibility, costs, and means of financing. This is an important basis for prioritization of measures. Measures should be identified according to means of implementation, if they are economic, regulation, or soft measures. It is when discussion / identifying measures, also important to include preventive and protective measures.
6. *Consultation*: The Non-governmental Stakeholder Groups should have the possibility to discuss and provide feedback to the list of already implemented measures, and their evaluation. This Group may also have good suggestions for future measures.

Prioritizing measures

1. *Responsibility:* The mandate, the timeline for the work, and the institutions responsible for organizing the work of developing a Programme of Measures (PoM) report need to be identified. A PoM report is an important document which the Sub-basin Management Plan is based on. The PoM should specify: water bodies of risk of not meeting environmental aims, identified pressures, and prioritization of abatement measures. It can be relevant to establish topic area working groups, such as for agriculture.

2. *An assessment of effectiveness of suggested measures*: 1. It is for an assessment of effectiveness[7] proposed to introduce a relative scale of 1-3 for effect for all measures, where 1 is small power, 2 is medium power and 3 is large effect. Although uncertainty may vary between different types of measures, it will be possible to carry out such a "semi-quantitative" assessment of measures. The extent of the measure needs to be considered, when indicating effectiveness. For example, an agricultural measure only implemented in a few acres cannot get the full score for effect; 2. Assessment of distance from current state to environmental targets should be described; 3. Specify an expected delay in the effect of measures (there may be natural climatic variations that mask the effect or there may be buffer mechanisms in soil, landscapes and water) should be indicated; 4. Indicate seasonal variations in efficiency; 4. Specify distance from source of pollution to recipient.

3. *Assessment of socio-economic costs*: The main rule is that all socio-economic costs must be calculated in monetary terms. Where it is not possible / appropriate to provide a cost estimate, the cost should be described qualitatively. The purpose is to see how to achieve a certain environmental improvement with the lowest possible costs for society. Some measures have high investment costs and relatively moderate annual operating and maintenance costs, while other measures are reversed. A judgmental assessment must always be made of whether the implementation of the measures will be reasonable socio-economic.

4. *Combination of measures:* Time order when implementing measures is important for the effect of individual measures (when any measures are taken, it will affect the possible effect of measures that have not yet been implemented). Some measures have effects that are not primarily related to the improvement of ecological conditions. Examples of other positive effects that can be considered are related to aesthetics, flood damping, adaptation and recreation. This needs to be described.

5. *A local action analysis*: shall clarify and describe circumstances that may be relevant to assessing the benefit (benefits) society has in implementing the priority measures. From the local action analyzes, it should be stated whether it is locally considered that the priority measures have "greater utility than society's costs", or if the prioritized measures have "greater costs than benefits for society". In cases where it is suspected that the costs ("disadvantages") of society will be greater than the benefit, closer socioeconomic assessments of the measures of the water authority must be carried out.

6. *Cooperation and consultation with civil society:* This should be facilitated for through the help of Non-governmental Stakeholder Group, but relevant interest groups may be approached for additional feedback. It may be advisable to clarify the scope of participation in the reference group by drawing up a mandate.
7. It is recommended that the PoM report is made publicly available. Final draft report should be made available for a hearing process for NGSG. The results of a possible consultation may be presented in a separate chapter of the report.

[7] It is difficult to directly quantify the effects of measures related to effects other than eutrophication (because it often has difficulty quantifying the impact in absolute sizes, nor does it know the dose response conditions).

Appendix F. Myanmar drinking water standard

Proposed Drinking Water Quality Standards (Myanmar), By- Expert Group; National Water Resources Committee May-2014

Table I-Bacteriological Quality (Microbiological Quality)

Sr.No	Parameter	Maximum Permissible Limit		Remark
	Type of Water Source	E.Coil/ Faecial Coliforms (No/100ml)	Total Coliforms (No/100 ml)	
1	Treated Pipe Water	0	0	
2	Untreated Pipe Water	0	10*	(*) Total Coliforms should not be successively
3	Treated water in Distribution System	0	0	
4	Unpiped Water	0	10	
5	Bottled Drinking Water	0	0	
6	Emergency Water Supply	0	3	

Remark: E-Coli = Escherichia Coli / Thermotolerant coliform
Coliform organism = coliform bacteria

Table II-Physical Quality

Sr.	Parameter	Unit	Maximum Permissible Limit
1	TCU (True Color Unit)	Pt.co scale	15
2	Taste and Odour	-	Acceptable/ No objectionable taste and odour
3	Turbidity (NTU-Nephelometric Turbidity Unit)	NTU	5

Remark: TCU = True Color Unit
NTU = Nephelometric Turbidity Unit

Table III-(A) Chemical Quality of Health Significance (Inorganic Substance)

Sr.	Parameter	Unit	Maximum Permissible Limit
1	Antimony	mg/L	0.02
2	Arsenic	mg/L	0.05
3	Barium	mg/L	0.7
4	Boron	mg/L	2.4
5	Cadmium	mg/L	0.003
6	Chromium	mg/L	0.05
7	Copper	mg/L	2.0
8	Cyanide	mg/L	0.07
9	Fluoride	mg/L	1.5
10	Lead	mg/L	0.01
11	Manganese	mg/L	0.4
12	Mercury (total)	mg/L	0.001
13	Nickel	mg/L	0.07
14	Nitrate (as NO_3)	mg/L	50
15	Nitrite (as NO_2)	mg/L	3
16	Selenium	mg/L	0.04
17	Uranium	mg/L	0.03

Table III-(B) Chemical Quality not of Health Significance but not raise complaints by Consumers (Inorganic Substance)

Sr.	Parameter	Unit	Maximum Permissible Limit
1	Aluminium	mg/L	0.2
2	Ammonia (Nitrogen)	mg/L	1.5
3	Calcium	mg/L	200
4	Chloride	mg/L	250
5	Total Hardness (as $CaCO_3$)	mg/L	500
6	Hydrogen Sulphide	mg/L	0.05
7	Iron	mg/L	1.0
8	Magnesium	mg/L	150
9	pH	mg/L	6.5-8.5
10	Sodium	mg/L	200
11	Sulphate	mg/L	250
12	Total Dissolved Solid	mg/L	1000
13	Zinc	mg/l	3
14	Electrical Conductivity	µs/cm	1500

Remark: µs/cm = Micro Siemens per centimetre

Table IV- Radioactive Material Quality

Sr.	Parameter	Unit	Myanmar(2014) Expert Group NWRC
1	Gross alpha activity	ßq/l	0.5
2	Gross beta activity	ßq/l	0.5

Table V- Pesticides

Sr.	Parameter	Unit	Maximum Permissible Limit
1	Alachor	(ppm) mg/L	0.02
2	Aldicarb	(ppm) mg/L	0.01
3	Aldrin&Dieldrin	(ppm) mg/L	0.00003
4	Atrazine	(ppm) mg/L	0.1
5	Acephate	(ppm) mg/L	0.01
6	Carbofuran	(ppm) mg/L	0.007
7	Chlorpyrifos	(ppm) mg/L	0.03
8	DDT	(ppm) mg/L	0.01
9	2,4 -Dichloropropane	(ppm) mg/L	0.03
10	Dimethoate	(ppm) mg/L	0.006
11	Endrin	(ppm) mg/L	0.0006
12	Endosulfan	(ppm) mg/L	0.03
13	Imidacloprid	(ppm) mg/L	0.01
14	Lindane	(ppm) mg/L	0.002

NIVA: Norges ledende kompetansesenter på vannmiljø

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