




Strategic Environmental Assessment of the Hydropower Sector in Myanmar – Final Report

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ABBREVIATIONS

ADB	Asian Development Bank
AIRBMP	Ayeyarwady Integrated River Basin Management Project
AOI	area of influence
BAU	business-as-usual
BEWG	Burma Environment Working Group
BOT	Build, Operate, and Transfer
CIA	cumulative impact assessment
CSOs	civil society organizations
DWIR	Directorate of Water Resources and Improvement of River
EAO	ethnic armed organizations
ECC	Environmental Compliance Certificate
ECD	Environmental Conservation Department
EFlow	Environmental flow
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EITI-MSG	Extractive Industries Transparency Initiative Multi-Stakeholder Group
ENAC	Ethnic Nationalities Affairs Council
ESIA	Environmental and Social Impact Assessment
GIS	geographic information system
GoM	Government of Myanmar
GWh	gigawatt hour
HDWG	Hydropower Developers' Working Group
HIC	Hydro-Informatics Center
HPP	hydropower plant project
ICEM	International Centre for Environmental Management
IEE	Initial Environmental Examination
IFC	International Finance Corporation
JICA	Japan International Cooperation Agency
JV	Joint Venture
JVA	Joint Venture Agreements
JV/BOT	Joint Venture/Build, Operate and Transfer
KBA	Key Biodiversity Area
KIO	Kachin Independence Organization
KNPP	Karenni National Progressive Party
KNU	Karen National Union
kWh	kilowatt hour
kV	kilovolt
Lao PDR	Lao People's Democratic Republic
LNG	Liquefied Natural Gas
LPG	Liquid Petroleum Gas
masl	meter above sea level
MATA	Myanmar Alliance for Transparency and Accountability
MoA	Memorandum of Agreement
MOALI	Ministry of Agriculture, Livestock, and Irrigation
MOECAF	Ministry of Environmental Conservation and Forestry
MOEE	Ministry of Electricity and Energy
MOEP	Ministry of Electric Power
MONREC	Ministry of Natural Resources and Environmental Conservation
MoU	Memorandum of Understanding
MRC	Mekong River Commission
Mtoe	metric ton of oil equivalent

MW	megawatt
NCA	Nationwide Ceasefire Agreement
NGO	nongovernmental organization
NTFP	non-timber forest product
NTP	Notice to Proceed
PES	payment for ecosystem services
PPA	Power Purchase Agreement
RSAT	Rapid Sustainability Assessment Tool
SDF	sustainable development framework
SEA	Strategic Environmental Assessment
SOBA	State of Basin Assessment
TWh	terawatt hour
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural Organization
WWF	World Wildlife Fund

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TERMINOLOGY

Business-as-usual (BAU): project development under the current process of project-by-project approval, with no consideration of or planning to avoid cumulative impacts on basins and sub-basins.

Catchment: a generic term used to indicate a natural drainage area, ranging from a project drainage area or a discrete drainage area within a sub-basin or basin.

Chaung, Hka or Nam: river or stream in Myanmar; when a river name includes either of these words, the word "river" in English is omitted (for example, Baluchaung, Nam Li, and Mali Hka are complete river names).

Coastal basin: a group of coastal watersheds that drains directly into the sea.

Degree of regulation of a reservoir: the ratio of reservoir live storage to mean annual runoff expressed as a percentage.

Identified project: a hydropower project identified at State or Region level but not notified to the MOEE.

Mainstem river: the main trunk river within a basin that connects sub-basin drainage areas with the sea, generally defined as a Strahler Order of 4 or greater.

Proposed project: a hydropower project proposed by the MOEE or by a private developer that has been notified to the MOEE.

Regulated area: the catchment area lying upstream of a dam that regulates river or stream flow, effectively cut off from mainstem/main tributary connectivity.

River basin: a large surface hydrology drainage area that discharges into the sea and consists of a mainstem river or main basin tributary and sub-basins or watersheds.

Sub-basin: the drainage area of a basin tributary, usually directly connected to the basin mainstem river/main basin tributary.

Watershed: a discrete drainage area within a sub-basin; in coastal sub-basins, many watersheds drain directly into the sea.

1 INTRODUCTION

Myanmar, the largest country in mainland Southeast Asia, has one of the least developed economies in the region[1] despite its abundant natural resources and relatively low population density. The power system in Myanmar is illustrative of the country's underdevelopment, with 35% of households connected to grid electricity[2].

The Government of Myanmar (GoM) recognizes that access to electricity is an important key to improving livelihoods and achieving broad economic development, particularly in rural areas where 70% of Myanmar's poor reside. It aims to rapidly increase power generation and electrification across the country by 2030 to provide affordable and reliable energy. The government also sees the prospect of increasing foreign exchange earnings through hydropower exports. Key sector targets include: (i) increasing national generation capacity by 500-1,000 megawatts (MW) per year to reach 16,665 MW of installed capacity by 2030; (ii) increasing the electrification rate to 75% of the population by 2021/2022 and to 100% by 2030; and (iii) increasing energy exports to raise foreign exchange earnings.

To meet these targets, the government is considering a mix of energy-generation options, including gas, coal, hydropower, and other renewables. The country is rich in water resources, containing large river basins and high annual rainfall in different regions. Therefore, hydropower is seen by many as an important potential contributor to the provision of affordable electricity. Almost the entire Ayeyarwady River basin (90.4%, covering 372,905 km^2) lies within Myanmar, together with 47.9% of the Thanlwin basin (covering 127,493 km^2) and a small area of the Mekong basin (2.7%, covering 21,947 km^2). In addition, the Sittaung River basin and the Rakhine and Tanintharyi coastal basins are other notable freshwater resources (Figure 1-1).

These substantial hydrological resources maintain essential river-basin processes, functions, and values, including a range of important ecosystem services that would be lost or degraded by inappropriate hydropower development. Significant values include river hydrological, geomorphic, and ecological processes and functions that provide important livelihood resources to millions of people. Hydropower development must therefore be sustainable and balanced against natural resource maintenance to ensure that the benefits of hydropower are not achieved at the expense of essential ecosystem functions and existing livelihoods.

The Thanlwin is among a limited number of free-flowing major rivers worldwide (that is, undammed or unregulated). The mainstem of the Ayeyarwady is also unregulated, although many of its major tributaries have been developed for hydropower in China and Myanmar. Despite the size and importance of these two rivers, relatively little is known about their hydrology, sediment movement, and aquatic ecosystems.

Hydropower development is at an early stage in Myanmar: 29 hydropower projects (HPPs) with more than 10 MW capacity are in operation, totaling 3,298 MW installed capacity. An additional six HPPs with total installed capacity of 1,564 MW are under construction, with the largest being the 1,050 MW Shweli 3 HPP[3] in the Ayeyarwady basin. The sector will likely expand rapidly as the GoM has received proposals for another 51 hydropower projects of at least 10 MW capacity, totalling 42,968 MW. An additional 18 HPP sites (totaling 994 MW) have been identified at state and local levels for potential hydropower development.

The sector is moving away from government-dominated project ownership toward private enterprise-driven development and larger projects. Of the 51 proposed projects, nearly all are planned by private

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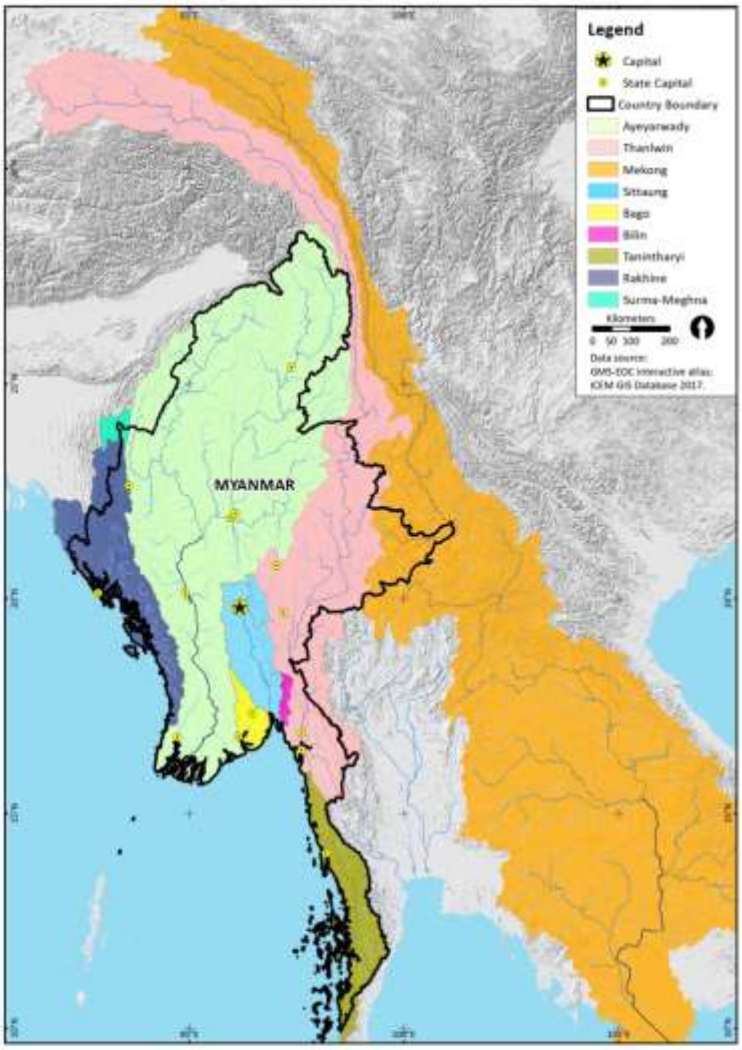
[1] United Nations Development Program (UNDP), 2013. *Accelerating Energy Access for All in Myanmar*. UNDP, Yangon, Myanmar.

[2] World Bank, 2014. *Ending Poverty and Boosting Shared Prosperity in a Time of Transition*. Yangon, Myanmar.

[3] The MOEE started construction of this project in 2011, but it has been put on hold until the private sector takes over. Progress as of January 2017 was 11%. France's EDF signed a memorandum of understanding (MoU) in December 2015 to develop the project.

companies or Chinese state-owned enterprises. Thirteen proposed projects have greater than 1,000 MW capacity, making up 82% of total proposed capacity.

Figure 1-1: Myanmar Basins



The exact level and extent of hydropower impacts on the hydrology, geomorphology, ecology, and socio-economic conditions in Myanmar's river systems are largely unknown due to a lack of reliable baseline and post-development information, but impacts at a sub-basin scale are becoming evident. The addition of an estimated 44,000 MW of medium-to-large-scale HPPs under business-as-usual (BAU) development would affect most major rivers, resulting in the fragmentation of mainstem and major tributary rivers with substantial changes to river processes and functions as well as the loss of unique environmental and social values. Stakeholders have recognized these adverse impacts and vocally opposed to some large-scale projects, causing the government to suspend three major HPPs[4] on environmental and social grounds.

[4] The proposed Myitsone HPP (6,000 MW) on the Ayeyarwady River, the proposed Tamanthi HPP (1,200 MW) on the Chindwin River, and the proposed Tanintharyi HPP (600 MW) on the Tanintharyi River were suspended by the GoM after environmental groups and civil society called on the government to halt hydropower projects on these major rivers, citing potential negative environmental and social impacts. A Presidential Order was issued on 12 August 2016 to form a commission to review the Myitsone HPP and other projects planned in the upper Ayeyarwady River.

Given the relatively low level of development so far, Myanmar has the unique opportunity to develop hydropower in an integrated and sustainable manner before significant impacts occur to river systems. Hydropower could potentially generate substantial renewable energy to drive the economy and improve livelihoods, but it should be balanced with the maintenance of river basin processes and functions, the livelihoods and economic sectors they support, as well as the retention of ecologically and culturally unique sites and values for current and future generations.

No national- or basin-level policies or plans exist to guide sustainable hydropower development based on integrated water, land, ecosystem, and socio-economic objectives. This has caused the sector to be developed on an opportunistic, individual-project basis focusing mainly on economic return and engineering feasibility. Project-centered planning approach locks in the project siting at the pre-feasibility stage with little to no consideration of the cumulative impacts of multiple projects within a sub-basin or basin, or on a mainstem river. This planning method has already resulted in the majority of larger rivers being modified by hydropower projects in other countries within the region; few major tributaries remain intact and free-flowing.

The GoM recognizes the need to overcome the increasing challenges of hydropower planning in developing a sustainable hydropower sector in Myanmar. With support from the International Finance Corporation (IFC) and the Australian government, the GoM – through a partnership between the MOEE[5] and MONREC – conducted this Strategic Environmental Assessment (SEA) of the hydropower sector as the first step in basin-wide hydropower planning. The SEA brings environmental and social considerations into early hydropower planning to ensure that project siting, design, and management are based on achieving basin sustainability.

[5] Formerly known as the Ministry of Electric Power (MOEP). In this report, the MOEP is referred to under its new name, the MOEE.

2 SEA PURPOSE, VISION, AND PRINCIPLES

2.1 SEA Purpose

The primary purpose of the SEA is to provide a "sustainable development framework" (SDF) for hydropower in each of Myanmar's major river basins to ensure both basin health and hydropower generation. The framework aims to improve project siting at the earliest stage of the development process by considering basin processes and values, and significant potential impacts on these features. This foundation planning tool seeks to achieve a balance between hydropower development and the protection of important river basin processes and values, contributing to the healthy functioning of these river systems over the next century and beyond.

By producing this early-planning framework, hydropower development can move toward sustainability as early as possible, aligning future project planning and approval with this goal. SEA preparation has started to shift stakeholder focus from project-based concerns toward long-term basin health, highlighting basin values that would be unduly degraded by inappropriate projects in terms of location, scale, design, and/or number.

The SDF does not seek to provide a definitive, one-off plan for hydropower development over the medium to long term because: (i) the baseline information available at this time is limited in all key areas; (ii) the energy market in Myanmar is changing with an ongoing debate over the proposed share of hydropower in the energy mix depending on regional demand and the cost of alternatives; and (iii) complex trade-offs need to be made between protection of the environment and hydropower development in different areas. Instead, the SDF provides a "first-edition" planning framework and a clear roadmap of recommended actions (i.e. policies, plans, studies, data gathering, and organizational arrangements) to implement and improve hydropower and related river-basin planning. In doing so, integrated basin-wide hydropower planning is brought to the front end of project siting and decision making to develop a sustainable sector. This is essential in dealing with the number and scale of proposed projects in Myanmar at present instead of allowing BAU development to continue to degrade natural resources due to unrecognized and increasing cumulative impacts.

The SDF is supported by:

- a national geographic information system (GIS) database of existing, proposed, and identified hydropower projects over 10 MW capacity;
- sub-basin evaluation of the main environmental, social, and conflict baseline conditions and trends with the potential to be impacted by or affect hydropower development;
- an overview assessment of significant BAU hydropower development impacts on basins; and
- a description of the main SDF outcomes in each basin.

2.2 SEA Vision and Objectives

The SEA vision for hydropower development in Myanmar is:

Sustainable hydropower development based on integrated water, land, and ecosystem planning, balancing a range of natural-resource uses and priorities to achieve economic development, environmental sustainability, and social equity.

This vision translates to maintaining healthy river basins by developing hydropower within the sustainable limit or "carrying capacity" of each basin. It recognizes that hydropower generation and environmental and social protection can co-exist when planned in an integrated and balanced manner.

The vision is supported by six sustainable hydropower objectives:

- **Maintain natural river-basin processes and functions that regulate and maintain river health and ecosystem services**

  The maintenance of key physical and ecological river processes (river flows, water quality, geomorphology, aquatic ecology, and terrestrial ecology) is essential to preserving river-system health and ecosystem services (i.e. regulating functions and provisioning services). Maintaining river functioning requires the retention of river connectivity and the natural-flow regime in the mainstem river and major tributaries in terms of quantity, frequency, duration, seasonal variability, and rate-of-change. These hydrologic features – combined with good water quality – maintain sediment flows, nutrient cycling, aquatic and riparian habitats, fish movement, and ecological cues (e.g. upstream migration, breeding).

- **Retain unique and important biophysical and cultural sites and values as well as representative environmental values**

  Protecting unique and irreplaceable natural and cultural heritage is essential for resource conservation and the use and enjoyment of current and future generations. These heritage features provide economic, ecological, cultural, religious, and recreational services; they include critical habitat and species of conservation significance, important religious and cultural sites, and unique natural features (e.g. the "Thousand Islands" landform). Where the value and protection of an important feature is intrinsically linked to the maintenance of upstream and/or downstream conditions (e.g. a sizable river flow required to maintain (i) wetland health or (ii) upstream fish migration), broader development restrictions are needed to conserve this feature. The protection of representative biodiversity or ecosystems within each basin is in line with Myanmar's goal of permanently preserving representative biodiversity nationwide and its commitment to the Convention on Biological Diversity, which was established to conserve biological diversity and sustain the use of these resources.

- **Avoid unacceptable social, livelihood, and economic impacts**

  Projects where the type and magnitude of social impacts (both direct and indirect) outweigh the hydropower benefits, or are of a scale and/or costs that make them unmanageable, should be avoided.

- **Share development benefits with affected people, communities, and regions**

  Medium-to-large-scale hydropower developments in the region often yield diffuse benefits, mostly accruing at the national level and in the larger regional development centers. Yet, the social costs are mainly borne by local communities and isolated areas that are less able to draw from normal government services and support. In many instances, projects usually provide affected people with one-off compensatory packages that do not support sustainable livelihoods. Benefit-sharing with affected people and communities with an aim to provide a net regional gain can assist in improving livelihoods and living standards over the long term.

- **Generate adequate, reliable and affordable hydropower energy for domestic consumption and export**

  Medium-to-large-scale HPPs can help Myanmar meet its domestic energy demand and provide an important source of export income. Optimizing power generation while sustaining healthy river basins can be achieved by developing lower value sub-basins in preference to high value sub-basins. Further developing sub-basins with substantially modified river conditions from existing projects will likely impose fewer cumulative environmental and social impacts compared to initiating projects in undeveloped sub-basins.

- **Recognize and manage conflict risks for more informed decision making**

  Robust safeguards should be put in place to identify and manage conflict risks affecting hydropower development and vice versa. While many underlying causes of conflict are deep-seated and remain unresolved over extended periods, conflict is dynamic and affects different locations from year to year. Detailed conflict assessments specific to proposed hydropower developments need to be conducted, along with risk mitigation in subsequent stages of these developments, to help safeguard the value and sustainability of the investment in the long run.

2.3 Scope

The SEA aims to provide macro-level planning guidance. As such, it is focused on priority environmental and socio-economic values and issues that need to be considered to minimize or avoid long-term and broad-scale adverse impacts when initially siting projects.

The SEA covers the whole of Myanmar, divided into eight major river and coastal basins that are analyzed separately: the Ayeyarwady, Thanlwin, Mekong, Sittaung, Bago, and Bilin river basins, and the Tanintharyi and Rakhine coastal basins. Each basin has been divided into sub-basins to enable an adequate level of analysis and appropriate planning of these large natural-drainage units.

The SEA considers projects of at least 10 MW[6] installed capacity, thereby capturing all medium (10-100 MW) and large (>100 MW) projects. A 10 MW project was selected as the minimum size for inclusion in the analysis because projects equal to and above this capacity are more likely to create notable adverse impacts as they are usually located on larger rivers, have higher dams and larger reservoirs, and create greater flow changes and cut river connectivity. While some projects with less than 10 MW capacity may have a greater environmental or social impact than larger projects, small projects were excluded to focus on the most significant cumulative basin impacts.

The temporal boundary of the SEA is the 30-year rapid development phase of the hydropower sector (2018-2048) when up to 44,000 MW of capacity is expected to be installed under BAU development. The SEA focuses on improving planning over this development horizon but recognizes that the impacts of medium-to-large-scale hydropower projects occur over the lifetime of these major capital investments, which generally exceeds 100 years.

2.4 Hydropower Sustainability Planning Principles

The main sustainable development planning principles applied to achieve hydropower sustainability were:

Whole-of-basin planning: A river basin is a dynamic interconnected hydrological system responsive to hydrologic, geological, biological, and man-induced changes. Conditions and activities in one part of the basin potentially affect or are affected by those in another part. Whole-of-basin planning accounts for these interrelationships to avoid unforeseen and progressive basin degradation. This system-level planning is essentially an "ecosystem approach"[7] at a hydrological scale, focusing on system health by recognizing and accounting for whole-of-basin features and potential significant cumulative system impacts from individual projects and activities.

The complexity of the basin is understood by recognizing two natural units that contribute to the overall ecological functioning and health of river systems:

- **Mainstem river** – the main trunk river of a basin connecting sub-basin drainage areas with the sea, providing unimpeded system connectivity for river flows, sediment, and aquatic ecosystems as well as maintaining these essential basin processes and functions.
- **Sub-basin drainage areas** – areas that either drain into the mainstem river, the main basin tributary or directly into the sea, providing the primary land/water interface where physical, chemical, and biological processes influence the ecological functioning of the basin.

[6] The upper limit of the United Nations Industrial Development Organization's definition of small hydropower.
[7] A central tenet of the Convention on Biological Diversity (1993) defined as "*a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way*."

Balanced natural resource utilization: A balance is required between the development of hydropower and the reservation of natural resources to maintain river system health. This balance can be achieved by making "landscape"-level trade-offs, permitting hydropower development in lower value areas at an appropriate scale, design, and number while protecting high value areas to maintain system processes, functions, and unique values.

Natural resource capacity-based development: Hydropower should be developed within the "carrying capacity" of the natural system without unduly degrading natural values or creating significant impacts on the communities who use these resources. This requires a good understanding of natural processes and values as well as the effects of hydropower development on these features to select areas suitable for development.

Retention of intact rivers/sub-basins: It is critical to retain intact rivers/sub-basins so that they continue to provide their full natural functions and values to offset the degradation of other rivers/sub-basins from hydropower development. Reservation of an entire unregulated sub-basin, where larger scale hydropower is excluded, helps maintain seasonal flows, water quality, geomorphology, and aquatic habitat, thereby contributing to the overall health of basin processes.

2.5 Information Limitations

The SEA has been prepared with limited available data in several key areas, including river hydrology and geomorphology, riverine ecosystems and aquatic species, and socio-economic conditions. The best available data and information has been used, but in the absence of detailed information, proxy indicators or expert opinion was used to assess some features.

The SDF needs to be periodically revised as key information becomes available. In the short- to medium-term, data should be obtained from: studies and data collection identified in the SEA as being essential for hydropower planning; the monitoring of operational hydropower projects by the GoM and private developers; feasibility studies and impact assessments undertaken by hydropower developers; and other studies that are underway or about to commence – for example, the Ayeyarwady Integrated River Basin Management Project (AIRBMP).

3 APPROACH AND METHODOLOGY

3.1 Approach

The SEA was prepared over 18 months through an open process that canvassed diverse of different stakeholders and specialists. The team obtained the best available information on hydropower projects, natural resources, and socio-economic conditions from a range of sources to achieve a broad understanding of the right direction for sustainable hydropower development over the next three decades and beyond.

This initial planning is based on the fundamental tenet that providing first-edition planning guidance as early as possible (i) moves the sector toward hydropower sustainability before more projects are approved, (ii) helps in gaining broad support on the need for sustainable hydropower development in the energy mix, and (iii) identifies main information gaps and planning requirements, enabling key actions to commence as early as possible to facilitate detailed planning in the short-to-medium term.

A consultative and transparent approach was adopted to garner the broadest views possible and to evaluate baseline conditions and trends, although this has limitations as described earlier. This approach has:

i) enhanced the understanding of and dialogue between decision-makers and other stakeholders about the range of environmental and socio-economic values and priorities that need to be considered to achieve sustainable hydropower development;
ii) defined a SDF for hydropower development in Myanmar that considered scientific and stakeholder values relating to the sustainable use and protection of natural resources and ecosystems, and long-term economic development; and
iii) provided a set of key actions (policies, plans, and studies) to implement and periodically update the SDF.

3.2 The MONREC and MOEE Partnership

The SEA was implemented in partnership with the Environmental Conservation Department (ECD) of MONREC and the Department of Electric Power Planning of the MOEE. The departments and ministries provided advice and assistance during the SEA's preparation that involved:

- participating in senior advisory committee meetings to review the SEA's direction and progress;
- providing two technical advisors from each ministry to participate in all stakeholder engagement activities;
- providing key technical data for the compilation of the hydropower project database;
- reviewing existing environmental and power-related regulations and Environmental Impact Assessments (EIA); and
- coordinating the input of other ministries and departments involved in hydropower planning and river basin management into the SEA.

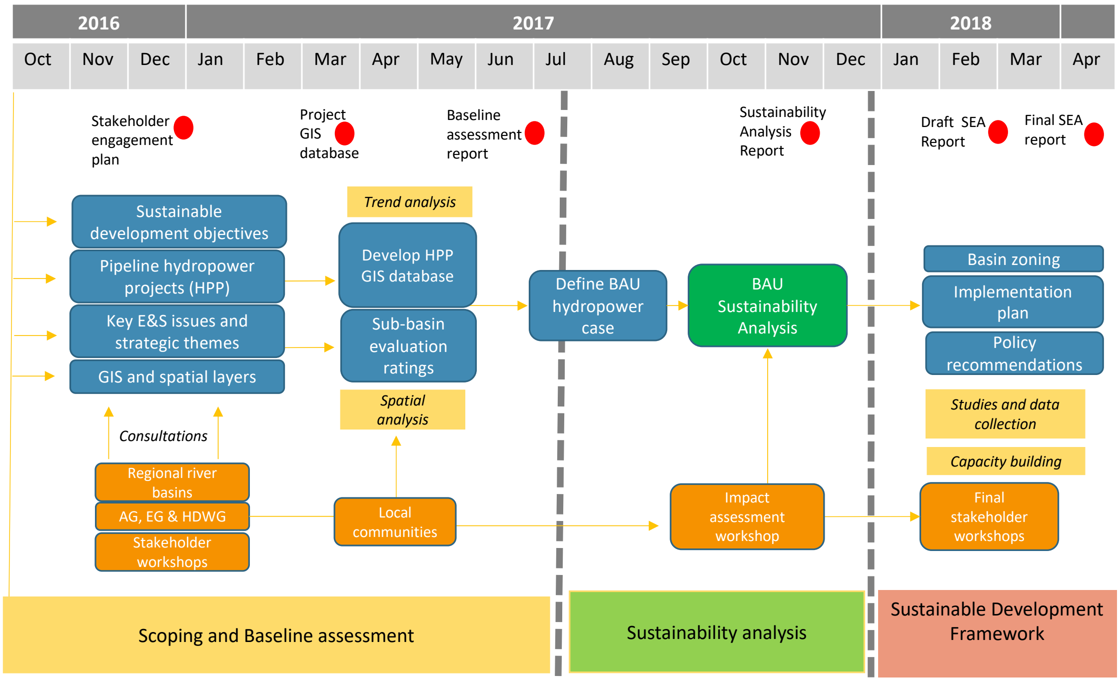
3.3 Methodology

The SEA's preparation (Figure 3-1) involved:

- issue scoping;
- formulation of an Advisory Group and Expert Groups;
- hydropower project GIS database preparation;
- sub-basin environmental and socio-economic baseline evaluation;
- hydropower BAU sustainability analysis;
- SDF development;

- SDF implementation recommendations; and
- discussions and consultation with a full range of stakeholders throughout the process.

Figure 3-1: SEA Methodology and Outputs



3.3.1 *Issue Scoping*

Issue scoping involved a series of stakeholder engagement activities with government, civil society organizations (CSOs), and hydropower companies, including multi-stakeholder workshops, regional river basin consultations, information sessions, direct discussions, and AG and technical EG meetings. These consultations canvassed the views of experts and stakeholders to identify key environmental and socio-economic issues and concerns for the sustainable development, protection, and management of river basins. The issues raised were consolidated into seven strategic themes for analysis:

- hydropower development;
- geomorphology and sediment movement;
- aquatic ecosystems and fisheries;
- terrestrial biodiversity and protected areas;
- social and livelihoods;
- economics and river basin development; and
- conflict.

3.3.2 *Hydropower Project Database Development*

A national GIS database of existing and proposed hydropower projects over 10 MW capacity was developed to take stock of the status of hydropower development in each basin and sub-basin. The database provides the location of each project and a summary of key project information as available, including:

- **Ownership and development status**: developer, type of investment, stage of development, and year the project is scheduled to be commissioned;
- **Baseline conditions**: catchment area, rainfall, mean annual flow; and

- **Project technical data**: installed capacity (MW), type of project (e.g. run-of-river, storage, multi-purpose), dam type and height, reservoir surface area and storage volume, average water retention time, powerhouse location, annual generation (GWh/year), and use of power (domestic/export %).

3.3.3 Baseline Assessment and Sub-Basin Evaluation

Information and spatial data were compiled to evaluate existing baseline conditions and related trends in each of the eight river basins. Seven separate aspects were analyzed and compiled into a set of Baseline Reports:

1. Hydropower
2. Geomorphology and sediment transport
3. Terrestrial biodiversity
4. Fisheries, aquatic ecology, and river health
5. Economic development and land use
6. Social and livelihoods
7. Peace and conflict

Environmental and social scores were assigned to each of five strategic themes for each sub-basin: 1. Geomorphology and sediment 2. Aquatic ecology and fisheries 3. Terrestrial biodiversity 4. Social and livelihoods 5. Conflict. Key biophysical and socio-economic values relating to those features likely to be significantly impacted by hydropower development were evaluated based on published information, spatial data, expert opinion, and stakeholder consultation. The five themes for each sub-basin were rated between 1 and 5 based on a set of defined criteria, providing a relative value of that theme, with 1 indicating a Low value and 5 a Very High value. A summary of baseline values was prepared for each sub-basin describing each theme's baseline features and presenting the ratings. The baseline ratings for each sub-basin were overlaid on national maps to show the distribution of biophysical, socio-economic, and conflict values across the country.

3.3.4 Hydropower Business-as-Usual Sustainability Analysis

An overview assessment of the potential cumulative impacts of assumed BAU hydropower projects was undertaken to identify significant adverse impacts on basin and sub-basin processes and functions. This analysis assumed that BAU development consisted of all currently proposed and identified HPPs. Conducting this initial assessment identified major impacts and in doing so provided justification and direction for sustainable hydropower development over the next 30 years.

3.3.5 Sustainable Development Framework

The SDF was prepared to balance hydropower development with the retention and protection of important environmental and social functions and values. It provides a whole-of-basin planning framework for river resources, based on sub-basin analysis and ratings of identified values, aiming to provide guidance that will be applicable for more than a century. Critical mainstem rivers have been identified for reservation to maintain connectivity. Sub-basins are zoned based on the baseline evaluation, with higher value areas recommended for reservation and lower value sub-basins identified as potentially suitable for hydropower development. This first-edition framework should be revised regularly as more information is obtained.

3.3.6 SDF Implementation Plan

A program of key actions was prepared to implement and periodically update the SDF, including recommendations on policies and procedures for government implementation of the SDF; obtaining critical baseline data to fill gaps and improve planning at basin and target sub-basin levels; additional coordinated basin-wide planning; enhancing institutional capacity; and a program for periodic SDF revisions.

3.3.7 Stakeholder Engagement

Stakeholder engagement was undertaken throughout the SEA process to help decision-makers better understand the range of stakeholder values and interests that need to be considered in formulating the SDF and in improving dialogue between the public and private sectors.

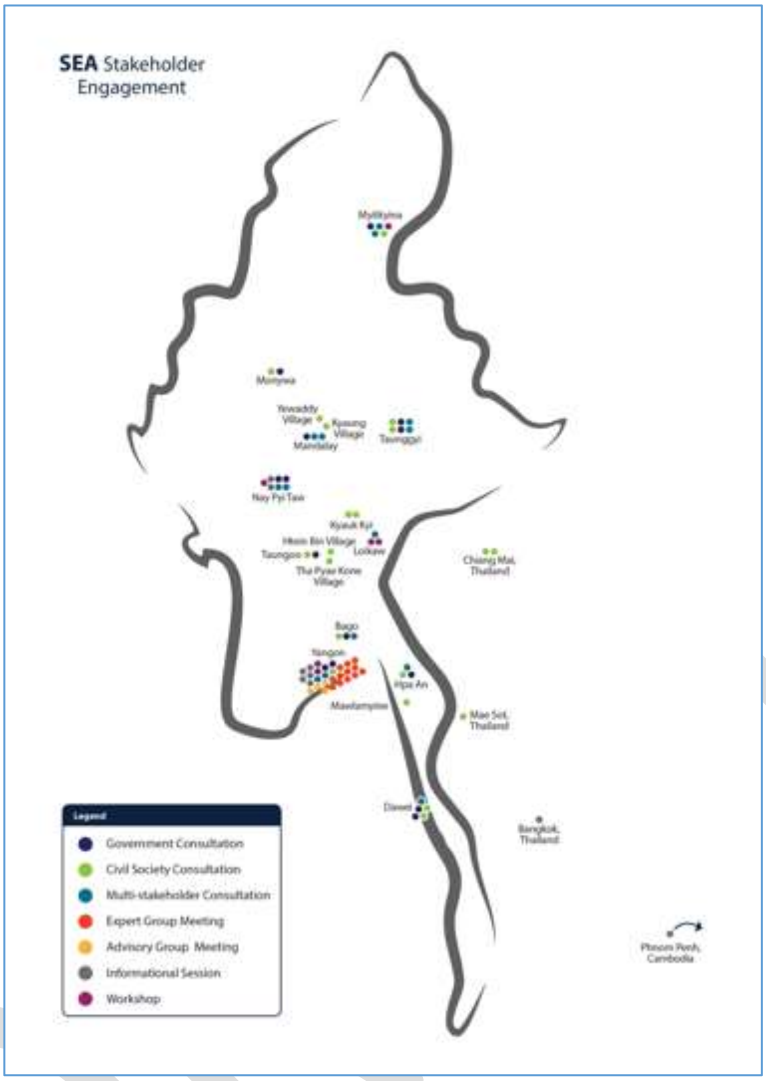
A *Stakeholder Engagement Plan* was developed outlining the consultation and communication activities when preparing the SEA, and identifying key stakeholder groups in hydropower development and river basin management. They included Union and state/regional governments, national and local CSOs, ethnic armed organizations (EAOs), political parties, local communities, the private sector, development partners, international and local NGOs, universities, multilateral development agencies, and banks.

More than 55 stakeholder engagement events were held across Myanmar to capture views from as many states/regions where hydropower is planned as possible (Figure 3-2), including:

- **Regional river-basin consultations**: workshops with CSOs and state/regional governments to identify key environmental and social issues and opportunities at the basin level during issue scoping and to review and provide feedback on the draft SDF recommendations;
- **Multi-stakeholder workshops**: open to all stakeholders including representatives from Union and sub-national governments, international and local NGOs, universities, and the private sector during all phases of the SEA;
- **Consultation with local communities:** key informant interviews and focus-group discussions with villages affected by the Upper Paung Laung, Lower Yeywa, Bawgata, Shwe Gyin, and Baluchaung 1, 2 and 3 HPPs to validate actual village-level environmental and social impacts;
- **Consultation with EAOs and political parties:** the conflict and peace assessment included additional consultations with EAOs, political parties, and CSOs in Mytikyina, Taunggyi, and Kyauk in Myanmar as well as Mae Sot and Chiang Mai in Thailand;
- **Discussions with the Hydropower Developers' Working Group** (HDWG)**:** presentations and discussions with the HDWG in Yangon. The group consists of hydropower companies and consultant firms working in the hydropower sector; and
- **Information sessions**: presentations and discussions at a range of conferences and workshops starting from the development of the SEA Terms of Reference to reach broader audiences and garner more inputs into the process.

Informal discussions were held with numerous individuals and organizations to share information and receive inputs throughout the process.

Figure 3-2: SEA Stakeholder Engagement Activities



Consultations also involved the establishment of an SEA Advisory Group and six Expert Groups. The Advisory Group provided overarching guidance and technical input into the SEA. It was chaired by IFC and consisted of 15 members from local and international NGOs, government, the private sector, development partners, and multilateral agencies. The group met five times when preparing the SEA, reviewing work and providing advice on its direction and key information sources. The Expert Groups were established to explore significant technical issues in detail, consisting of specialists from government, NGOs, academic institutions, ex-government officers, and independent researchers. Regular meetings were conducted during the SEA process to explore key issues and review material. The Expert Groups were:

1. Hydropower and energy;
2. River hydrology and geomorphology;
3. Aquatic ecology/fisheries;
4. Terrestrial ecology, protected areas, and forestry;
5. Social, livelihoods, indigenous peoples, conflict areas, cultural issues; and

6. Economics, river and basin non-hydropower use and development (including navigation, irrigation, agriculture, and mining).

Two project reports that provide additional information on stakeholder engagement at the river basin and local level are:

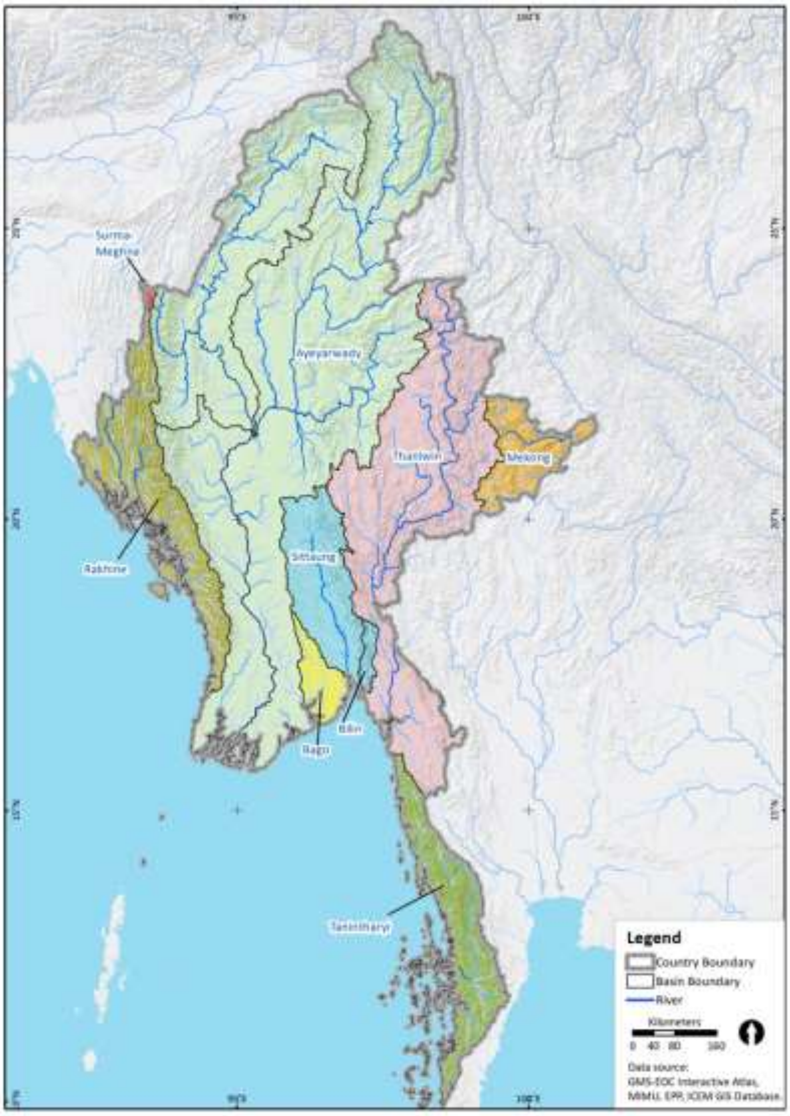
1. *Regional River Basin Consultations – Key Findings*; and
2. *Case Study on Consultation with Local Communities Affected by Upper Paung Laung and Yeywa*.

4 BASINS AND SUB-BASINS

4.1 Basin and Sub-Basin Delineation

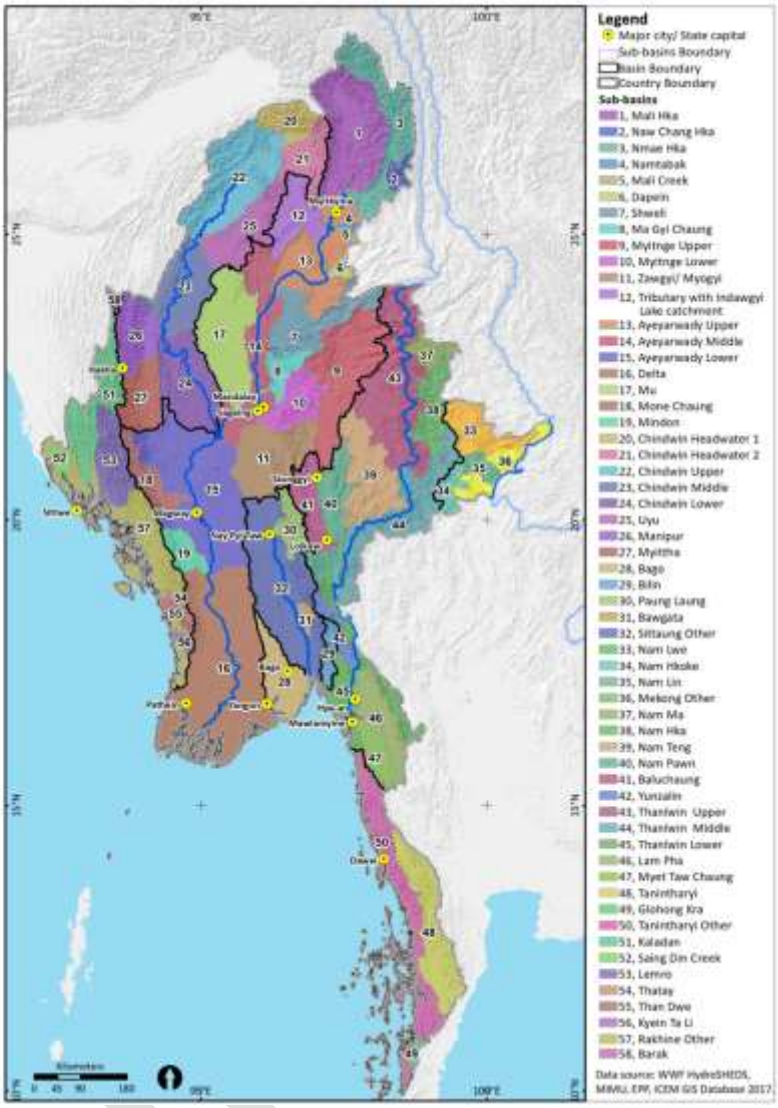
Based on surface water hydrology, six basins were defined either extending from the sea up to the headwaters of the natural drainage area wholly contained within Myanmar, or from/to the international border where the basin extends beyond Myanmar: Ayeyarwady, Thanlwin, Mekong, Sittaung, Bilin, and Bago (Figure 4-1). In addition, small coastal watersheds with similar features were combined into two coastal basins for ease of analysis and future management: Tanintharyi and Rakhine.

Figure 4-1: Myanmar River and Coastal Basins



The four large river basins (Ayeyarwady, Thanlwin, Mekong, and Sittaung) and the two coastal basins are divided into sub-basins as each is too large and complex to analyze and manage as a single unit (Figure 4-1). The Bago and Bilin basins, being only 3,056 km^2 and 10,261 km^2 in area respectively, are relatively small and hence each is treated as a single management unit.

Figure 4-2: Myanmar Sub-Basins



Sub-basins were selected as the primary spatial unit for analysis within each basin. These discrete natural drainage units are directly affected by hydropower development impacts on river flows, water quality, geomorphology, aquatic habitat, and biodiversity. This level of geographic focus aligns with the main intended use of the SDF for early project screening and the key sustainable development principle of preserving intact sub-basins/rivers while potentially developing others.

Sub-basins were defined based on the surface water hydrology boundary. This definition enables basin complexity to be analyzed and managed considering local conditions and management concerns, and allowing trade-offs to be made between areas with similar conditions. Fifty-eight sub-basins were identified using HydroSHED[8] levels, with most sub-basins (43) selected using HydroSHED level 6 boundaries. Some were divided into Level 7, 8 or 9 drainage areas to define sub-basins, especially where large hydropower projects or cascades exist or are planned, and some of these drainage areas were combined to create sub-basins of a suitable area for strategic analysis. In some cases, numerous small watersheds were combined and treated as a single sub-basin, such as the low-order streams flowing directly into the upper or middle Ayeyarwady.

[8] Hydrological data and maps based on Shuttle Elevation Derivatives at multiple scales.

Fifty-two sub-basins drain directly into the basin mainstem river, major tributaries or the sea, while each of the remaining six sub-basins drains into a downstream sub-basin before discharging into a basin mainstem or major tributary. Accordingly, sub-basin hydrological conditions (flow, sediment, and habitat connectivity and regulation) in each of the 52 directly connected sub-basins are not affected by other sub-basins. Therefore, management options are not limited by downstream sub-basin conditions.

The six sub-basins that discharge into another sub-basin were delineated as being separate from the downstream sub-basin due to their large size or distinct features (e.g. significant existing HPPs). These sub-basins are: Ngaw Chaung Hka discharging into the N'mai Hka; Myitnge Upper discharging into the Myitnge Lower; Myittha discharging into the Manipur; Baluchaung discharging into the Nam Pawn; and Paung Laung and Bawgata, both discharging into the Sittaung Other. Accordingly, the connectivity of these six sub-basins with the free-flowing mainstem or the sea is dependent on what occurs within the downstream sub-basin. Sub-basin details by basin are summarized and illustrated in Appendix 1.

As more detailed information becomes available, disaggregation of some sub-basins down to watershed level is likely to occur, thus completing a multi-scale approach to hydropower planning.[9] Such a sub-division has a higher chance of happening in large sub-basins with a distinct range of conditions allowing or requiring refined zoning or different management (hydropower development and reservation).

4.2 Basin Descriptions

The three major transboundary basins in Myanmar (Ayeyarwady, Thanlwin, and Mekong) cover a combined 79.0% of the country. The smaller Sittaung, Bago, and Bilin river basins are wholly contained within Myanmar, covering a combined 7.4% of the country, while the Tanintharyi and Rakhine coastal basins cover a further 15.2%. The Surma-Meghna basin, which is mostly located in India and Bangladesh, has a small area of headwater in Myanmar (792 km^2). The total basin area, river length, and states/regions crossed by the eight major drainage basins are summarized in Table 4-1.

Table 4-1: Major River and Coastal Basins in Myanmar

Basin	Total Basin Area (km^2)	Basin Area within Myanmar (%)	Basin Area in Other Countries (%)	Land Area of Myanmar (%)	Total Main River Length (km)	State/Region
Ayeyarwady	412,500	90.4 (372,905 km^2)	China – 5.4 India – 4.2	55.5	2,170	Ayeyarwady, Bago, Chin, Kachin, Magway, Mandalay, Nay Pyi Taw, Rakhine, Sagaing, Shan, Yangon
Thanlwin	283,335	45 (127,493 km^2)	China – 47 Thailand – 7	19.0	2,400	Mon, Bago, Kachin, Kayah, Kayin, Mandalay, Shan
Mekong	824,000	2.7 (21,947 km^2)	China – 21 Lao PDR– 24 Thailand – 23 Cambodia – 20 Vietnam – 8	3.3	3,469	Shan

[9] Pegram, C., Li, Y., Le, T., Quesne, R. Speed, J. Li, and Shen, F. 2013. *River Basin Planning: Principles, Procedures and Approaches for Strategic Basin Planning*. Paris, United Nations Educational Scientific and Cultural Organization (UNESCO).

Sittaung	34,913	100	-	5.2	450	Mon, Bago, Kayah, Kayin, Magway, Mandalay, Nay Pyi Taw, Shan
Bago	10,261	100	-	1.5	220	Mon, Bago, Yangon
Bilin	3,056	100	-	0.5	160	Bago, Kayin, Mon
Tanintharyi	44,876	100	-	6.7	400	Mon, Kayin, Tanintharyi
Rakhine	71,700	77 (55,387 km^2)	Bangladesh & India - 23	8.2	280	Ayeyarwady, Bago, Chin, Magway, Rakhine

Source: a. Basin areas from GIS HydroSHEDS/HYBAS LAKES data apart from the Thanlwin.
Note: Barak sub-basin (792 km^2) lies in the Surma-Meghna basin, outside Myanmar's eight main basins.

4.2.1 Ayeyarwady Basin

The transboundary Ayeyarwady basin has a total drainage area of 412,500 km^2, of which 90.4% (372,905 km^2) lies within Myanmar, around 5.4% (22,195 km^2) is in the People's Republic of China (mostly Yunnan), and 4.2% (17,400 km^2) is situated in India (Manipur and Nagaland). The basin covers around 55.5% of Myanmar's land area, with the major tributaries (in order of size) being the Chindwin (97,157 km^2), Myitnge, Mali, N'mai, Mu, Shweli, and Dapein rivers. The Ayeyarwady basin consists of 27 sub-basins. Of these, four sub-basins have multiple existing/under construction projects (Mone Chaung, Myitnge Lower, Shweli, and Zawgyi/Myogyi) and a further six sub-basins each has an existing HPP (Dapein, Ma Gyi Chaung, Mali, Mu, Myittha, and N'mai Hka).

The 2,170-km-long Ayeyarwady River, commencing at the confluence of the Mali and N'mai rivers and flowing into the Gulf of Martaban via the delta, is commonly referred to as having three regions: (i) Chindwin River; (ii) Upper Ayeyarwady; and (iii) Lower Ayeyarwady. The headwaters of the basin flow from mountains and hills along the Myanmar-China border region where elevations exceed 5,000 meters above sea level (masl). River flows are highly seasonal, with 90% of yearly discharge occurring during the monsoon season from May to October.

The Ayeyarwady basin is the largest and most economically significant river basin in Myanmar. Around 34.3 million people (66% of Myanmar's population) live in the basin (2013), with around 1.9 million people residing in the basin in Yunnan and 2.8 million people in India, mainly in Manipur. Population density across the basin varies from just 18 people/km^2 in Kachin State to 60 people/km^2 in the Mandalay region, and more than 180 people/km^2 in the Ayeyarwady Delta region, with the highest population densities concentrated around major cities of Mandalay, Nay Pyi Taw, and Yangon. Almost half (45%) of the basin population in Myanmar live in the central dry zone regions (Mandalay, Sagaing, and Magway), which make up 40% of the basin area. The basin, from north to south, crosses the states/regions of Kachin, Sagaing, Shan, Chin, Mandalay, Magway, Nay Pyi Taw, Bago, Ayeyarwady, Rakhine, and Yangon.

4.2.2 Thanlwin Basin

The transboundary Nu-Thanlwin basin covers 283,500 km^2, of which the upper 48% (136,126 km^2) lies within China, 45% is in Myanmar (127,493 km^2) and 7% (19,881 km^2) is in Thailand. The Nu-Thanlwin River – known as the Nujiang in China, the Thanlwin in Myanmar, and the Salween in Thailand – is the second-longest river in Southeast Asia after the Mekong, flowing 2,400 km from 4,000 masl on the Tibetan plateau eastward then south through Yunnan in China; it enters Myanmar in the northeast before flowing south into the Gulf of Martaban. The basin, narrow and mountainous, discharges an estimated average of 4,978 m^3/s, with 89% of flows occurring during the monsoon season and 11% during the dry season. The base river flow comes from glaciers in the upper reaches.

The basin covers 19.0% of Myanmar's total land area, with major tributaries in Myanmar being the Nam Pang, Nam Pilu/Nam Pawn, and the Moei River that flows north out of Thailand. A 130-km river reach forms a section of the Myanmar-Thailand border. Eleven sub-basins were defined in the Thanlwin basin within Myanmar.

An estimated 10.5 million people live in the basin: 3.8 million in China, 6.1 million in Myanmar, and 0.6 million in Thailand (www.worldpop.org). Population density is highest in Mon State (more than 300 people per km^2) and western Yunnan (up to 100 people per km^2), and lowest in Tibet (5 people per km^2). Major cities are Taunggyi, Loikaw, Hpa-an, and Mawlamyine. The basin, from north to south, crosses the states/regions of Shan North, Shan East, Shan South, Mandalay, Kayah, Kayin, Bago, and Mon.

4.2.3 Mekong Basin

Around 2.7% of the Mekong basin is in the eastern part of the Shan State of Myanmar, covering about 3.3% (21,947 km^2) of the country.[10] With headwaters on the Tibetan Plateau, the Mekong River flows southeast through China, meeting the tripoint of China, Myanmar, and Lao PDR People's Democratic Republic (Lao PDR). It forms the Myanmar/Lao PDR border for around 240 km before becoming the Lao PDR-Thailand border, then entering Lao PDR. Tributaries of the Mekong basin in Myanmar feed into the Mekong River along these borders, contributing 558 m^3/s of water to the annual average river discharge rate of 13,000 m^3/s, accounting for about 3.7% of total annual average flow. Like the neighboring Thanlwin basin, most runoff occurs during the monsoon season (mid-May till mid-November). The Mekong Basin has been divided into four sub-basins.

An estimated 0.7 million people live in the basin, with an average population density of 34 people per km^2. Major towns in the basin are Mong Yang, Mongkhet, Mongla, Kengtung, Mongyawng, Mongkhol, Monghast, and Tachileik.

4.2.4 Sittaung Basin

The Sittaung basin covers around 34,913 km^2 or 5.2% of Myanmar's total land area. The basin drains from the northeast of Yamethin on the edge of the Shan Plateau, flowing 450 km south before discharging into the Gulf of Martaban. The Sittaung River lies between the forested Bago Mountains to the west and the steep Shan Plateau to the east. The basin has a large variation in annual rainfall, ranging from 889 mm in the north to between 2,540 mm and 3,810 mm in the south. The mean annual river discharge into the Gulf of Martaban is around 1,540 m^3/s. The river is navigable for 40 km year-round and for 90 km during three months of the monsoon.[11] The Sittaung basin is divided into three sub-basins, with 23 main tributaries flowing into the Sittaung River.

Around 5.8 million people or 10% of Myanmar's total population live in the basin, being relatively densely populated due to mild slopes between the mountains and the Sittaung River. Basin water resources have been substantially developed, containing a total of 7,325 ha m^3 surface water reservoirs, with 42% servicing irrigation and 58% a combination of irrigation and hydropower. The basin, from north to south, crosses the states/regions of Mandalay, Shan, Nay Pyi Taw, Magway, Kayah, Kayin, Bago, and Mon. Major cities in the basin are Nay Pyi Taw and Bago, with towns including Tatkon, Pyinmana, Lewe, Yedashe, Thandaunggyi, Taungoo, Htantabin, Oktwin, Phyu, Kyaukkyi, Kyauktaga, Nyaunglebin, Daik-U, Shwegyin, Waw, and Kyaikt.

4.2.5 Bago Basin

The Bago basin consists of the main Bago River catchment, known as the Yangon River further downstream where it joins the Myitmaka River. It drains from the Pegu Range hills as well as the smaller Myit Mo Hka catchment to the west and several small watersheds to the east drain directly into the sea. The basin covers 10,261 km^2 or 1.5% of Myanmar's total land area, and the Bago River is about 200 km long. Annual rainfall is around 2,980 mm in the basin.

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[10] https://www.fao.org/nr/water/aquastat/basins/mekong/mekong-CP_eng.pdf
[11] https://sites.google.com/site/bagosittaungriverbasinanalysis/system-discription/a-phy/i-location-dimensions

Around 4.6 million people reside in the basin, with 78% living in rural areas and 22% living in urban areas. Bago City is the largest settlement with a population of 284,000 (2012). In Bago District, the population density is 124/km^2 compared to the national average of 76/km^2. The basin, from north to south, crosses the states/regions of Bago, Yangon, and Mon.

4.2.6 Bilin Basin

The Bilin basin covers merely 3,056 km^2 or 0.5% of the total land area of Myanmar and is therefore treated as a single sub-basin. The Bilin River flows from Papun Township, Kayin State, 210 km southward into the Gulf of Martaban. The average rainfall is 3,188 mm and average basin outflow into the Gulf is 179 m^3/s.

Population density in the basin is 70 people per km^2. Bilin town is the major settlement in the basin. The basin, from north to south, crosses the states/regions of Bago, Kayin, and Mon.

4.2.7 Tanintharyi Basin

The Tanintharyi coastal basin lies in the far south of Myanmar, comprising the coastal strip between the Myanmar-Thai border and Andaman Sea. The basin covers 44,876 km^2 or 6.7% of Myanmar's total land area. The basin consists of three sub-basins, with the largest being Tanintharyi Other.

The main river in the basin, the Tanintharyi, flows off the Tenasserim Range from an altitude of 2,074 m, through Tanintharyi Region and into the sea at Myeik (Mergui). The entire basin (17,673 km^2) lies within the Tanintharyi Region covering 41% of this area. The basin boundary forms the national border with Thailand for around 450 km. Population density in the basin is 41 people per km^2. The major cities/towns are Dawei and Myeik.

4.2.8 Rakhine Basin

The Rakhine coastal basin is in the southwestern corner of Myanmar, flanked by the Rakhine (Arakan) mountain range to the east and the Bay of Bengal and Bangladesh to the west, and extending northward to the Indian border. The basin covers 55,409 km^2 or 8.2% of Myanmar's total land area. The distance from the mountains to the sea is relatively short, with many small rivers draining the range and the basin discharging into the Bay of Bengal. The Rakhine mountains experience some of the highest rainfall in the country, exceeding 5,000 mm per annum in Thandwe.

The basin has been divided into eight sub-basins. The headwaters of the largest river in the basin, the Lemro, lie in Chin State (Mindat District), with the middle and floodplain areas located in Rakhine State (Sittwe District). Population density in the basin is 40 people per km^2. Major settlements in the basin are the towns of Sittwe, Kyaukpyu, Thandwe, Gwa, and Maungdaw.

5 ENERGY AND HYDROPOWER DEVELOPMENT

This section covers energy security in Myanmar, its history of hydropower development, existing power supply and the GoM's plans to meet demand, the hydropower development process, and current and proposed hydropower capacity.

5.1 Energy Security

Myanmar exports mainly gas from offshore fields through pipelines to Thailand and China under long-term supply agreements that effectively preclude the domestic use of these resources. In addition, the country exports power generated by several hydropower plants to China. In 2014, energy exports accounted for around 34%, or 6.3 metric ton of oil (Mtoe) equivalent, of total domestic energy production (18.5 Mtoe). Exports have now increased to 11.7 Mtoe, or around 44% of domestic energy production, according to the International Energy Agency's statistics.

At the same time, Myanmar is increasing its energy imports, particularly oil products, because of limited domestic oil supply and refining capacity. This will lead to a growing reliance on fossil-fuel imports for power generation. The sector faces several scenarios: Some proposals focus on the import and development of liquid petroleum gas (LPG)-fired power generation, while others highlight the development of coal-fired thermal plants or a combination of the two.

There are possibilities for greater exploration and development of domestic fossil-fuel resources, particularly in under-explored sedimentary basins in the west of the country. There is also potential for developing domestic renewable energy resources, including solar and wind. But in the short to medium term until 2030, further domestic fossil-fuel development or significant utility-scale renewables are unlikely to feature in power-development plans.

5.1.1 Hydropower in the Generation Mix

Hydropower is an important part of the generation mix, accounting for around 70% in 2014. It will likely become even more important in the short term as some sizeable generation projects have been commissioned and in case Myanmar decides to "buy-back" hydro-generated electricity currently exported to Yunnan. In the longer term, despite an expected increase in the total installed capacity of hydropower, its relative importance in the energy mix will probably decline as the country adopts other forms of generation such as coal, gas, and renewables.

Current power-demand projections indicate the need for adding around 440 MW generation capacity per year until 2030. The Japan International Cooperation Agency's (JICA) power-demand projections are 5,165 MW by 2020 and 14,834 MW by 2030[12]. If no additional hydropower (other than that already installed or under construction) were added to the generation mix, power demand would need to be addressed through alternative means such as:

- reduction in transmission and distribution losses;
- energy-efficiency savings;
- demand-side management; and
- alternative generation technologies.

There is scope to reduce high-level technical and non-technical losses (currently at around 20% of production), while demand-side management measures could be introduced (such as time-of-day pricing) to reduce peak demand. Energy-efficiency savings could also reduce system peaks, although it is unclear how the potential extent of these savings compares to current demand projections. Given Myanmar's very low level of electricity consumption and prospects for demand growth, sector-efficiency improvements and demand-side measures would only meet a relatively modest part of the rising demand, and at best delay additional generation-capacity needs.

[12] MOEE and JICA, 2018. *Updating the National Electricity Master Plan PowerPoint Presentation.* Nay Pyi Taw Workshop.

Even if additional capacity needs were delayed, alternative generation technologies would be needed if hydropower development was foregone. This could include coal, gas, other renewables, and increased imports. Potential for additional domestic coal production is limited; therefore, any extra coal-fired thermal plants would depend on imported coal from Indonesia or Australia. Similarly, gas-fired plants would be dependent on imported gas in the medium term, most likely using LPG imported from the Gulf states. Both gas and coal have the advantage of having plant construction close to load sources, but both are substantial emitters of greenhouse gases and are likely to be more expensive than hydropower. Utility-scale solar and wind are also a possibility. Solar is likely to be cheaper than coal and gas in areas with good solar resources. However, the integration of utility-scale solar may prove challenging due to its intermittent availability and hence may require hydropower-storage projects to balance this variability in supply. Electricity imports from Lao PDR and China's Yunnan Province are possible but requires the construction of transmission lines and international agreements. This option is likely more expensive than domestic hydropower and may pose security concerns.

Recent power-supply announcements include four new liquefied natural gas (LNG) plants and the importation of 100 MW from Lao PDR. The MOEE is considering other alternatives, including:

- repurchasing electricity exports, especially given power surpluses in Yunnan[13];
- additional LNG or new domestic gas supplies;
- imported coal;
- international connection, i.e. importing from neighboring countries; and
- other (non-hydropower) forms of renewable energy.

If hydropower development was foregone, some combination of these different generation sources could be used. Although this could make power supply more expensive, such a diversification might increase energy security if stable supply chains were secured.

5.1.2 Energy Security in the Power Sector

Hydropower development can likely reduce the risks associated with supply disruptions of imported fossil fuel or increasing fuel prices, although these potential risks appear to be small for coal. However, a hydropower-heavy generation mix may mean supply is more susceptible to hydrological risks related to low levels of rainfall. For example, from the 1990s until now, power supply in Vietnam's hydropower-dependent power system has been subject to extensive load shedding due to low reservoir-water levels during dry seasons. Other hydropower-heavy systems such as Brazil have had similar experiences. Changing patterns of precipitation associated with climate change may exacerbate these risks. Varying rainfall levels or fluctuations in the onset of the seasons associated with climate change may make management of hydrological variability and associated risks through plant operation more difficult.

5.2 History of Hydropower Development

Electricity was introduced to Myanmar in the late 1800s, with the first hydropower plant (460 kW) built on the Yeni River, Mogok, in 1898. During the 1950s, Japanese engineers surveyed the country to identify hydropower-development opportunities; their studies and more recent ones estimate that Myanmar has more than 100,000 MW of capacity potential.

The country's first large-scale hydropower project was the 84 MW run-of-river Baluchaung II power plant in the Thanlwin basin at Lawpita Falls on the Baluchaung, completed in 1960. The second phase of this project was completed in 1974, adding 84 MW. In the 1980s, an additional 25 MW capacity was built in other parts of the country, followed by three projects totaling 102 MW in the 1990s, 11 projects totaling 2,194 MW during 2000-2010, and 12 projects totaling 982 MW during 2011-2015.

[13] Under present agreements with foreign hydropower developers, hydropower plants will provide Myanmar with an agreed amount of free electricity. In addition, Myanmar will have the option of purchasing some of the electricity earmarked for exports (in 2030, up to about 2,400 MW or about 26% of installed capacity) at an agreed tariff.

Since the mid-1970s, hydropower has been the main source of electricity in Myanmar, but the industry is still in its relative infancy as its potential installed capacity is far greater than current levels. Twenty-nine hydropower projects with more than 10 MW are operational, totaling 3,398 MW, versus an estimated 45,632 MW of potential countrywide capacity (the Ministry of Electric Power, 2015). In addition, 32 mini-hydropower plants (between 0.1 and 5.0 MW capacity each) totaling 33.3 MW have been installed in irrigation dams and as separate off-grid rural electrification projects.

Hydropower development is moving from government-driven projects toward private sector-dominated ones. In the past, the majority of hydropower projects were exclusively developed by the GoM, either by the MOEE or the Ministry of Agriculture, Livestock and Irrigation (MOALI). This changed when the first private sector hydropower projects larger than 30 MW were developed under a Foreign Joint Venture/Local Build Operate and Transfer (JV/BOT) arrangement, with Shweli 1 and Dapein 1 HPPs completed in 2009 and 2011, respectively. Project development is now dominated by the private sector, with seven domestic and foreign private sector hydropower projects in operation and 22 owned by the MOEE/MOALI. Two of the six hydropower projects under construction are private sector projects.

Until 2011, projects were allocated to private companies based on bilateral negotiations between developers and the GoM. The system relied on the companies proposing projects directly to the GoM. The location and type of project either came from previous hydropower studies or the developer. Many hydropower projects being considered by foreign companies, especially the larger ones, are being planned for export to the developer's country, namely China and Thailand.

5.3 Power Demand and Supply

Myanmar has the lowest grid-connected electrification rate per capita in Southeast Asia at 38% (2016), having risen from only 16% in 1995. The country's electricity consumption at 300 kilowatt hours (kWh) per capita (2016-17) is ranked as one of the lowest in the world, substantially lower than the 2014 world average of 3,128 kWh.[14] In Asia, only Nepal has a lower consumption rate. Urban areas have the highest electrification coverage, with Yangon City the highest at 78%, while rural areas are poorly electrified, averaging less than 20%. In Kayin state and Tanintharyi region, the electrification rate remained under 10%.

Following democratic elections in 2011, the economy has shown robust growth. From 2000-01 to 2009-10, annual demand for electricity grew at about 4.8% per year, from 3,268 gigawatt hours (GWh) to 5,000 GWh. Since then demand has accelerated, growing by an average of 17.6% per year between 2009-10 and 2013-14 to 11,252 GWh, compared to annual GDP growth of 7.2% (2011 to 2014). In FY2016-17, demand reached 15,355 GWh. Between 2009-14, hydropower generation closely followed the total consumption curve. As the economy continues to grow and poverty reduction accelerates, demand for electricity is expected to rise by 9.6% annually to 49,924 GWh in 2030.[15]

In the first half of 2017, the total installed capacity was 5,389 MW, of which 3,255 MW (60.4%) was from hydropower, 1,920 MW (35.6%) from gas, 120 MW (2.2%) from coal, and 94.3 MW (1.75%) from diesel.[16,17] The MOEE owns about 60% of the total installed capacity, with the rest owned by the private sector as either independent power producers or in JV with the MOEE. Private participation in the power sector has grown from 6.2% of annual generation in FY2008-09 to 48.4% in FY2016-17. Power projects under construction or about to begin construction consist of 1,564 MW of hydropower capacity, 649 MW of gas-fired power, and 470 MW of solar power.

Due to its distinct wet and dry seasonal pattern, Myanmar experiences significant fluctuations in the supply of, and demand for, electricity. The existing base-load generation mix dominated by hydropower

[14] http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC
[15] ADB, 2015. *Report and Recommendations of the President to the Board of Directors: Proposed Loan to the Republic of the Union on Myanmar: Power Transmission Improvement Project*. October 2015.
[16] MOEE and JICA, 2017. *Power Development Opportunities in Myanmar*. Myanmar Investment Forum. June 6-7, 2017.
[17] There is a slight difference between the MOEE's data in the presentation of June 6-7, 2017, and the HP Database, which includes some State/Regional projects and has used data provided by developers.

reaches peak capacity toward the end of the wet season and tails off during the dry season, resulting in shortages. Available capacity is about 50% of installed capacity due to poor maintenance. Two hydropower plants totaling 53 MW (Baluchaung 1 and Sedawgyi) and a gas-fired (GT) power plant (57 MW Thaketa) are being rehabilitated, and seven older hydropower plants[18] totaling 528 MW are scheduled for rehabilitation.

Since 2000 there has been a large gap between demand and generation due to a combination of available capacity in the dry season as well as transmission and distribution losses. In 2013-14, losses were substantial at 20% of generation, or about 2,400 GWh in absolute terms. Hydropower electricity generation grew from about 2,000 GWh in 2000-01 to 9,360 GWh in 2015-16. The growth in other sources of electricity has remained constant, with gas in the range of 1,173 GWh to 3,320 GWh per year and coal-fired generation below 1,000 GWh up to 2013-14. After that, with the commissioning of eight gas-fired power plants totaling 25 MW, generation rose to 6,200 GWh in 2015-16. Meanwhile, generation from coal-fired power plants halved and diesel generation ceased in 2015-16.

Myanmar's transmission system comprises a network of 230 kilovolt (kV), 132 kV, and 66 kV transmission lines and substations with insufficient capacity to transmit power to where it is needed. These lines mainly transmit power from the central parts of Myanmar, where the hydropower plants are located, to the load centers of Yangon and Mandalay. Two high-voltage transmission links are used to export power from Myanmar to China: a 120-km long, 500-kV AC transmission line from Dapein 1 HPP (240 MW) and a double circuit 120-km long, 220-kV transmission line from Shweli 1 HPP (600 MW), both to Dehong in Yunnan Province.

Substantial expansion of the transmission and distribution network is required for Myanmar to meet power supply goals. International development banks are supporting the grid expansion: the Asian Development Bank (ADB) is financing the 230-kV power transmission ring in Yangon, the World Bank is financing medium and low-voltage grid extension, and the governments of Japan, Korea, and Serbia are supporting the development of a 454-km long, 500-kV transmission line from the hydropower-rich north (Meiktila and Mandalay) to the south (Yangon).

5.4 Government Energy Planning and Supply Goals

The GoM aims to rapidly increase power generation and electrification across the country by 2030 to support sustainable economic development and reduce poverty. The government is transforming the energy and power sector from an inefficient, state-controlled monopoly to a competitive, market-driven system. This involves introducing market-based reforms, facilitating public-private partnerships as well as private energy and power projects, and improving inefficient assets.

Key targets include increasing national generation capacity by 500-1,000 MW per year to reach an installed capacity of 16,665 MW by 2030, and boosting the electrification rate from 38% of the population to 75% by 2021/2022, and then to 100% by 2030. The GoM is preparing an update to the National Electricity Masterplan with assistance from the JICA. This plan includes a strategy for new electric power generation plants to be constructed by 2030 based on an energy mix of 53% (13,194 MW) hydropower, 15% (3,836 MW) domestic gas, 11% (2,621 MW) coal, 11% (2,866 MW) LNG, and 10% (2,420 MW) other renewable sources (other than hydropower)[19]. This generation mix aims to reduce the country's reliance on hydropower, thereby improving supply reliability during the summer months.

5.5 Hydropower Development Process

[18] Zaungtu (commissioned in 2000), Zawgyi II (2011), Ye Nwe (2007), Kinda (1990), Mone Chaung (2004), Thapenzeik (2002), and Kabaung (2008)
[19] MOEE and JICA, 2018. The Project for Capacity Development of Power Sector Development Planning. Presentation on the Optional Studies of Generation Mix.

Until 2011, private sector development of hydropower relied on companies proposing projects directly to the GoM. Since then, either the government or a private developer could identify and develop a potential project with the initial siting undertaken by either the MOEE or the developer.

For hydropower projects larger than 30 MW[20], the GoM enters into a contractual arrangement with the developer and the contract type is determined by the source of project funding:

- Sole investment – financed by the GoM through either the MOEE or MOALI;
- Local Build Operate and Transfer (BOT) – developed by a Myanmar private sector company; and
- Foreign Joint Venture (JV/BOT) – developed by a foreign company in a joint venture with a local company and the MOEE on a BOT basis.

The project development has four main consecutive steps ending in the following progressive agreements granting the developer the right to move the project to the next stage:

1. Memorandum of Understanding (MoU)[21];
2. Memorandum of Agreement (MoA);
3. Joint Venture Agreement (JVA); and
4. Project Development Permit.

Seeking an MoU for the right to investigate and develop a hydropower project involves a prospective developer preparing an expression of interest for a project on the MOEE's master list (developed since the 1950s). The developer can either update an existing study or undertake a basic desktop study before submitting the proposal to the MOEE, which negotiates with the developer the scope and duration of the study and fieldwork at the project site. The MOEE then prepares a draft MoU incorporating a termination and duration clause, which is sent to relevant ministries for advice. If no objections are received, the MOEE and the developer sign the MoU with an 18-month validity. Next, the developer determines the financial viability of the project and prepares a feasibility study and an EIA, which are reviewed and approved by the MOEE and MONREC, respectively. If the EIA is acceptable, MONREC issues an Environmental Compliance Certificate (ECC).[22] The MOEE and the developer then enter into preliminary negotiations on the power purchase agreement (PPA[23]) and agree on a draft PPA. The MOEE and the developer next sign a MoA, followed by the developer negotiating a draft JVA with the MOEE and other development partners. After the MOEE and the developer sign a JVA, the developer seeks all necessary permits from government agencies, including approval from the Myanmar Investment Commission, agreement on the final PPA following results from procurement, and Financial Close.[24]

HPPs with an installed capacity of up to 30 MW and not connected to the national power grid can be developed by a state/regional government (as per the Constitution, 4a of Schedule 2 – refer to Session 188):

> *Medium and small-scale electric power production and distribution that have the right to be managed by the Region or State not having any link with national power grid,*

[20] Regional and state governments can approve projects up to 30 MW capacity if not connected to the grid.
[21] The GoM is issuing a Notice to Proceed (NTP) in lieu of an MoU for LNGs projects and is expected to also provide NTPs for some hydropower projects in future.
[22] To date, no ECCs have been issued by MONREC, with no-objection letters issued instead.
[23] The Hydropower Developers Working Group (HDWG), with support from IFC, has drafted a model CA/PPA template for hydropower projects.
[24] Currently, the procurement process for HPPs is under review.

except large- scale electric power production and distribution having the right to be managed by the Union.

Small-scale electric power projects are defined as up to 10 MW capacity in the Electricity Law 2014, while mid-sized projects are defined as larger than 10 MW and lower than or equal to 30 MW. Regardless of capacity, every HPP is governed by the national EIA procedures.

5.6 Environmental Assessment

The 35 existing and under-construction medium-to-large-scale HPPs were planned on a project-by-project basis, often with only rudimentary EIAs prepared. The quality of project EIAs is generally not up to international standard, with no cumulative impact or basin-wide assessment or planning; it is usually prepared after the feasibility study has been submitted to the MOEE and serves more as a record of impacts. It does not contribute to project siting and design improvement to avoid and reduce negative impacts. This process is out of line with international industry practice, which prepares the project design and the EIA concurrently with close collaboration between the respective teams.

The ECD within MONREC is responsible for reviewing EIAs and issuing ECCs, but it lacks the capacity and resources to review the numerous submissions. The GoM has only been conducting limited monitoring to ensure that projects are implemented in accordance with the agreed environmental management plans and standards.

5.7 Operational, Under-Construction, and Proposed Hydropower Projects

Operational and Under-Construction Projects

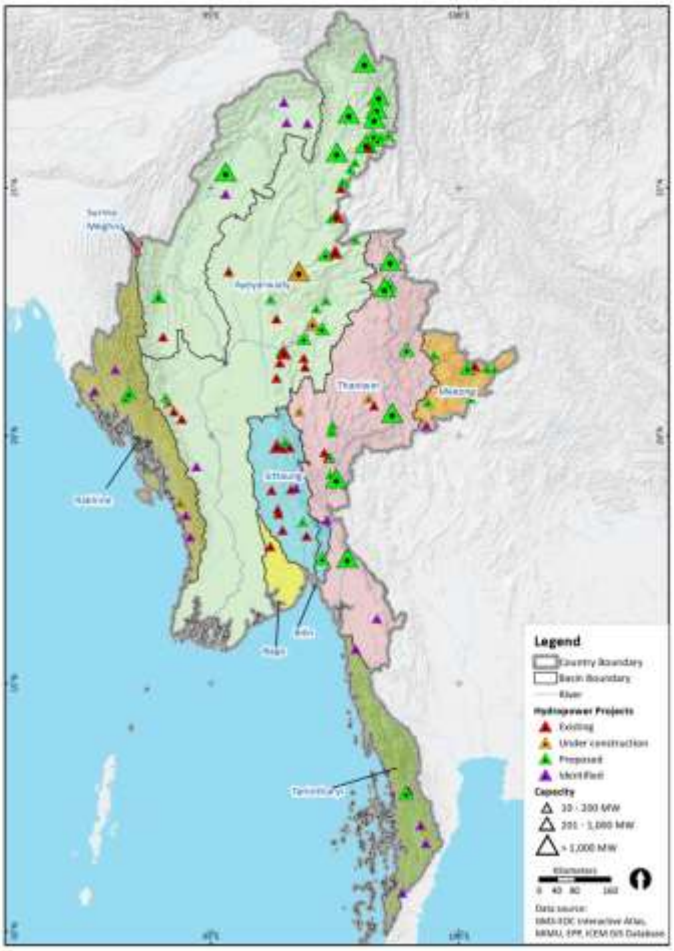
There are 29 operational hydropower plants with 10 MW capacity or greater in Myanmar, totaling 3,298 MW installed capacity (Table 5-1). Six additional projects are under construction with total installed capacity of 1,564 MW. Basin distribution of existing projects is dominated by the Ayeyarwady, with 13 operational (2,060 MW) and three under construction (1,372 MW[25]). The Sittaung basin, with an area of only 34,900 km^2 (5.2% of the country) is the most developed basin in terms of capacity per km^2, with nine projects in operation totaling 810 MW, or 24.6% of Myanmar's operational hydropower. The Thanlwin basin follows with four projects in operation (302 MW) and two under construction (81 MW[26]). There are only two operational projects of 10 MW and above in other basins, totaling 86 MW[27], and only one project is under construction in these areas, Thahtay HPP (110 MW) in Rakhine basin.

Table 5-1: Status of Hydropower Projects by Basin

Project Status	Number of Projects	Ayeyarwady (MW)	Thanlwin (MW)	Sittaung (MW)	Other (MW)	Total (MW)
Built	29	2,100	302	810	86	**3,298**
Under Construction	6	1,372	81	-	111	**1,564**
Proposed/Identified	69	24,604	16,110	410	2,724	**43,848**
Total	**104**	**28,076**	**16,493**	**1,220**	**2,921**	**48,710**

[25] Buywa HPP (47 MW), Yeywa HPP (280 MW), and Shweli 3 HPP (1,050 MW).
[26] Keng Taung Upper HPP (51 MW) and Baluchaung Upper (30 MW).
[27] Zangtu HPP (20 MW) in Bago basin and Mongwa HPP (66 MW) in Mekong basin.

Figure 5-1: Status of Hydropower Development in Myanmar



Proposed and Identified Projects

Proposed and identified HPPs of 10 MW capacity or greater in Myanmar total 43,849 MW (Tables 5-2 and 5-3), consisting of 22,760 MW on mainstem rivers (51.9%) and 21,089 MW in sub-basins (48.1%). Over 60% of all proposed projects by capacity are on the Thanlwin mainstem (34%) and in the N'mai Hka sub-basin (26%). Most are large projects, with 13 of them above 1,000 MW each, comprising 81% of total proposed capacity (Table 5-2).

Table 5-2: Proposed Hydropower Projects by Installed Capacity (MW)

Project Capacity (MW)	Number of Projects	Total Capacity (MW)	% of Total Proposed MW
>2,000	6	25,100	58.6
1,000-2,000	7	10,060	23.4
500-1,000	5	3,020	7.0
100-500	24	4,223	9.9
10-100	9	451	1.1
Total	**51**	**42,854**	**100**

Fifty-one proposed projects with a combined total capacity of 42,854 MW have been notified to the MOEE and are in various stages of pre-construction development. These projects are all proposed by the private sector. A further 18 projects have been identified at state and regional level with total capacity of 995 MW (Table 5-3), bringing all proposed and identified project capacity to 43,849 MW.

Eight projects, ranging between 600-7,000 MW capacity each, are proposed on identified mainstems or the main basin tributary. Five of them have been proposed on the Thanlwin River totaling 14,960 MW (66% of all proposed mainstem projects). The remaining three – Myitsone (6,000 MW) on the Ayeyarwady River, Tamanthi (1,200 MW) on the Chindwin River, and Tanintharyi (600 MW) on the Tanintharyi River – have, however, been suspended.

The main sub-basin proposed for hydropower development in Myanmar is the N'mai Hka, with seven proposed projects totaling 11,395 MW (54% of all proposed sub-basin projects). The Mali Hka (1,900 MW) and Ngaw Chang Hka (1,200 MW) are the next largest sub-basins in terms of total proposed MW.

The 18 identified hydropower projects at state/regional level, for which no feasibility studies have been prepared, have a combined total capacity of 995 MW (Table 5-3). The average installed capacity of these projects is far lower than proposed projects, with the majority being less than 100 MW.

Table 5-3: Identified Hydropower Projects by Capacity

Capacity (MW)	Number of Projects	Total Capacity (MW)
100-200	4	600
10-100	14	395
Total	**18**	**995**

Identified projects per square area of basin are concentrated in the Rakhine and Tanintharyi basins, where energy supply is the lowest in the country.

6 SIGNIFICANT ENVIRONMENTAL AND SOCIAL ISSUES

The SEA focuses on significant environmental and socio-economic issues directly related to major HPPs to reduce negative impacts during project siting and design.

6.1 Major Potential Hydropower Environmental and Social Issues

Hydropower development can create environmental and social impacts at basin, sub-basin, and site levels. The major potential impacts of medium-to-large-scale hydropower are summarized in Table 6-1.

Table 6-1: Major Potential Environmental and Social Impacts of Hydropower

Factor	Potential Impact	Cause/Effect
Environmental	River hydrology changes	• Daily flow changes from peaking-power releases • Seasonal flow changes from storage-project releases • Conversion of a flowing river reach into a lake • Reduction in flood magnitude and frequency • Downstream river dewatering between the dam and powerhouse
	River geomorphology changes/degradation	• Reduction in downstream sediment load due to reservoir trapping • Increased downstream river bank and bed erosion due to reduced sediment load and "sediment-hungry water" • Changes to grain-sized distribution of sediment downstream of HPPs • Occasional release of large volumes of sediment when periodically flushing the reservoir/pond or desanding basin
	Coastline and delta erosion/degradation	• Reduction in downstream sediment load due to reservoir trapping • Seasonal changes in flow regime
	Water quality changes/ deterioration	• Reduced water quality from the seasonal detention of water in storage-project reservoirs (e.g. changes in temperature, dissolved oxygen content and nutrient levels) • Periodic release of sediment from a reservoir/pond/desanding basin
	Aquatic ecosystem/ biodiversity degradation/ loss	• Aquatic ecosystem degradation/loss of aquatic biodiversity from river flow and geomorphological changes, alteration of water quality, and loss of river system connectivity/creation of impassable obstacles to fish migration
	Terrestrial ecosystem/ biodiversity degradation/ loss	• Direct loss of terrestrial biodiversity on the project site, primarily from the reservoir area • Loss of terrestrial habitat connectivity due to reservoirs • Indirect loss from induced resource harvesting due to improved access into hydropower-development areas
Social and Socio-economic	Land acquisition and resettlement/loss of private agricultural and forestry land	• Acquisition of private land and assets • Physical displacement/resettlement of households • Loss/conversion of existing productive land uses (e.g. agriculture, forestry, grazing) and river uses (e.g. fisheries) to hydropower facilities
	Loss of or reduction in communal natural resources supporting livelihoods or	• Removal of forests, grassland, fisheries, and water supply (for irrigation and domestic consumption), etc. • Disruption of the natural river-flow regime used for religious, cultural and/or recreational purposes

	cultural/religious practices	
	Loss of important natural/cultural heritage/religious sites	• Inundation or removal of unique sites
	Access/transport restrictions	• Curtailing or reducing river transport and cross-river access
	Community safety	• Safety risks associated with: - the sudden release of a large volume flow (generation flow and/or spill flow) - structural failure/dam break resulting in the sudden release of a large volume of stored water (a highly unlikely event)
	Impacts on indigenous peoples	• Potential differential impacts on indigenous peoples' livelihoods and physical displacement
	Conflict	• Potential aggravation of grievances and conflict
Cumulative impacts	Cumulative sub-basin and basin impacts	• The combined impacts of multiple water-resource developments along a river or in a sub-basin

6.2 Stakeholder Environmental and Social Issues of Importance

A key aim of the SEA included enhancing decision makers' understanding of the range of stakeholder's environmental and social values that should be considered in formulating the SDF, improving the dialogue among stakeholders, and obtaining the best available information. Ongoing consultations were important in identifying environmental and social issues associated with hydropower development at all levels to determine the SEA's key themes. Information gathered was incorporated in the baseline assessment reports and informed the various findings of the SEA. The important issues, concerns, and opportunities raised during engagements through all phases of the SEA are summarized below.

6.2.1 Informing the Baseline Assessment and Key Themes

Regional river-basin consultations conducted early in the SEA process engaged local CSOs, EAOs, government officials, and other stakeholders at the basin and state/regional levels. Many planned large-scale hydropower projects are in conflict-prone areas and legacy issues of past hydropower projects have not been resolved, resulting in widespread concerns on the links to armed conflict and historical displacement. Therefore, CSOs in the Upper Ayeyarwady, Thanlwin, Tanintharyi, and Sittaung basins all expressed concerns around conflict, control of natural resources, and the rights of ethnic minority groups.

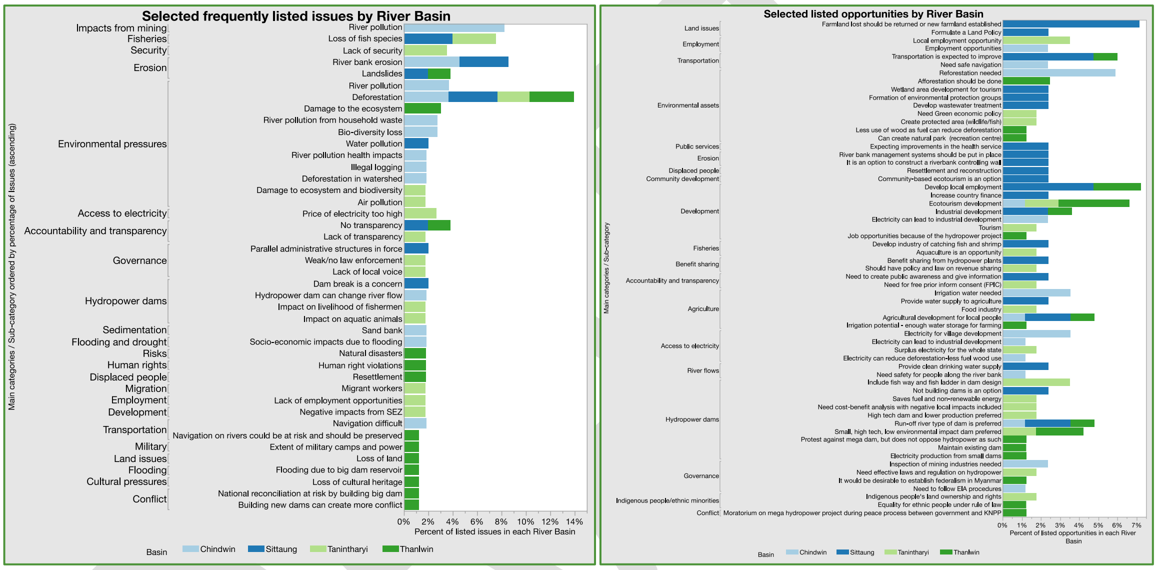
During engagements, stakeholders raised the following impacts and benefits of existing hydropower:

- **Impacts:** changes in water flow and water quality, sedimentation and riverbank erosion, flooding, deforestation, biodiversity loss, food security and nutrition (e.g. loss of agricultural land, riverbank gardens, orchards, and capture fisheries), loss of livelihoods, land grabbing, conflict, and social welfare issues (e.g. drugs and mental health); and
- **Benefits**: access to electricity, improved access to services (health, education, and transport), socio-economic development and higher living standards, opportunity for irrigation (multi-purpose projects), local employment, and opportunities to develop small and medium enterprises.

Furthermore, environmental governance, including the lack of local voices and public participation in decision-making, was highlighted as a major concern. For example, poor coordination between central, regional, and local governments as well as the latter's limited authority was reported. Governance was further complicated by parallel administrative systems and poor enforcement of existing laws. In the Tanintharyi basin, local people were forced to agree to development projects but experienced no benefits from gas exports – they continued to suffer from lack of access to electricity and high prices. Stakeholders also complained about a lack of transparency and accountability, misinformation by companies about projects, low local acceptance of projects, and lack of compensation payments to people affected. To date, EIAs have been weak and often omitted information on negative impacts.

Security was also raised as a concern as local people said they felt that foreign investments in development projects threatened their livelihoods and negatively affected vulnerable communities. These concerns were often drawn from past experiences of the development of special economic zones. Figure 6-1 shows the frequency of identified issues and opportunities. The graphs indicate the percentages of selected issues in the main categories for each basin engaged during the river-basin consultations. The selection of individual issues and opportunities is based on the frequency of listing, excluding similar issues to avoid overlap. Thus, the graphs show the most important single issues identified. In the case of identified opportunities, selecting the most important one was more difficult due to the broad range of suggestions made under many categories.

Figure 6-1: Selected Frequency of Listed Issues and Opportunities by River Basin



Stakeholders in the Sittaung basin, the most intensively developed basin for hydropower to date, have reported changes in flow, sedimentation and riverbank erosion, loss of fisheries, and social issues associated with existing projects. Assessing the impacts, benefits, and cumulative effects of the nine existing HPPs in the Sittaung was important in informing sustainable hydropower development in other major basins. For example, during a consultation at the Upper Paung Laung 140-MW HPP, villagers reported that their livelihood restoration programs had been insufficient. Suitable replacement agricultural land had not been provided, resulting in significant income loss, unemployment, and other social issues. Loss of agricultural land associated with the HPP also encouraged shifting cultivation and the harvesting of fuelwood in watershed areas, leading to deforestation. Information on the resettlement and compensation process was not clear and opportunities for public participation was limited.

Mining was raised as a significant issue in the Upper Ayeyarwady and Chindwin river basins as it polluted river water, caused riverbank erosion and increased sedimentation. Deforestation and illegal logging were highlighted as issues in all basins. In addition to mining and forestry, agriculture and transportation, including inland water transport, were identified as the key economic sectors having impacts on or being affected by basin-wide processes. Similar to the consultations held with villages affected by the Upper Paung Laung HPP, the existing Lower Yeywa 790 MW HPP, which was commissioned in 2010 on the Myitnge River in the Ayeyarwady basin of the Mandalay region, also validated perceived environmental and social impacts of existing projects. Both communities said project development led to improved access to roads, schools, healthcare, water supply and electricity.

However, they also reported that river flows, water quality, fisheries, and food security were affected during construction and operation of both projects.

Stakeholders listed hydropower development, governance, transparency, accountability, and benefit sharing as both issues and opportunities. They agree that existing and planned hydropower projects bring not only environmental and social impacts but also potential benefits such as access to electricity, improved public services, and agricultural and economic development. Although some CSOs oppose large HPPs until the peace process is resolved, there is a starting point for dialogue on HPPs that may benefit local communities and generate revenue for state/regions.

6.2.2 Recommendations from River-Basin Discussions

Toward the end of the SEA process, a final round of regional river-basin consultations was conducted with CSOs and state/regional government officials to share and discuss the draft key findings of the SEA. Below are recommendations grouped by project, sub-basin and basin, state/regional, and national levels.

Project: Stakeholders reported a lack of transparency and limited public participation in EIAs for many hydropower projects. They said reports were often not disclosed to the public and environmental management plans were not enforced or monitored. Many recommendations were on strengthening the EIA process and coordination to:

- Consult with local communities before project siting and design to select projects with the least environmental and social impacts;
- Incorporate local knowledge and livelihoods and community concerns into decision making and EIA processes;
- Assess impacts and develop mitigation plans and livelihood-restoration programs in consultation with communities affected;
- Assess potential for fish passage and other mitigation options to reduce impacts;
- Conduct social baseline research, covering health, education, gender, ethnic minority groups, and social welfare;
- Develop communication mechanisms between government, hydropower developers, and local communities, improve capacity, and allocate budget for environmental monitoring and management; and
- Provide local employment opportunities rather than relying on migrant labor.

Sub-basin and basin: Stakeholders highlighted the need to conduct more research on water level and flow (hydrology), sediment transport, dam safety, and water pollution, and to improve governance at the sub-basin/basin level. They suggested enhancing watershed management and protection in sub-basins to mitigate the impacts of mining, hydropower, and deforestation, and collecting and analyzing data on aquatic and terrestrial fauna. Cultural values and areas of significance also need to be considered in future sub-basin evaluations. Cumulative Impact Assessment (CIA) was recommended in sub-basins with more than one HPP, mining or large-scale irrigation project planned.

State/region: Recommendations centered on improving coordination and strengthening regional policy and planning for hydropower and other sectors. Groups highlighted the need for regional energy policy, especially in the Tanintharyi region with low access to energy and high electricity costs. CSOs said regional energy plans should include potential for renewable energy such as small hydropower, wind and solar, but exclude large dams. They also promoted off-grid and mini-grid solutions in remote areas.

Capacity building and coordination between Union and state/regional governments as well as among regional departments was also recommended. Groups highlighted the need for land-management laws and procedures as well as regional guidelines on implementing hydropower, mining, and other development projects. CSOs called for the final SDF to ensure that both state/regions and local communities benefit from hydropower development, as there is a perception that urban populations benefit more from hydropower while rural populations bear most of the impacts.

National: Recommendations mainly focused on revenue-sharing mechanisms between Union and state/regional governments to ensure local communities also benefit from hydropower development, as well as the establishment of policies and plans for land, resettlement, renewable energy, and environmental and social protection. Stakeholders called for adequate compensation and suitable livelihood restoration for local communities in case of resettlement. They said the lack of formal land tenure was making it difficult to calculate compensation for loss of agricultural land. When planning hydropower, a policy recognizing the cultural and traditional values of ethnic areas and respecting customary law as well as a green or renewable-energy policy framework would be important to guide future development.

A representative of groups protesting the now suspended Myitsone project from Tan Phae village in the Ayeyarwady basin indicated that local communities depend on the Mali Hka and N'mai Hka rivers for natural resources and farming, and the confluence has significant cultural values for Kachin people. Representatives of the Kyun Ta Htaung Myay Foundation, the Taunggyi CSOs Network, and the Salween River Network presented statements at the Taunggyi consultation. Their key messages in relation to hydropower development were:

- Respect ethnic cultures and traditions and protect the livelihoods of local people in the Thanlwin basin;
- Ensure all development projects (including hydropower) are in line with Extraction Industries Transparency Initiatives (EITI) standards as stated in the Nationwide Ceasefire Agreement (NCA);
- Recognize that the presence of armed groups and conflict in the Thanlwin basin makes it difficult to conduct in depth research required for EIA preparation;
- Promote public participation and include stakeholder views in the EIA as well as provide training to the local communities;
- Consult with leaders of ethno-political parties in relation to hydropower projects; and
- Create opportunities for CSOs and technical experts in project implementation.

7 HYDROPOWER BUSINESS-AS-USUAL DEVELOPMENT IMPACTS

7.1 BAU Development Scenario

An analysis of BAU hydropower development was undertaken to identify the significant adverse environmental and social impacts that would result from this development pathway. The scenario assumes that all 69 proposed and identified projects would be developed on a project-by-project basis over the next three decades with no consideration for sub-basin or basin sustainability.

While it is impossible to accurately predict which projects will eventually be installed due to the many development hurdles and market forces at play, the 69 projects provide an indication of the location, type, and scale of projects that would most likely be developed under this scenario.

BAU development would involve medium-to-large-scale storage and run-of-river HPPs located on most medium to large rivers across Myanmar, including:

- major mainstem development on the Ayeyarwady, Chindwin, and Thanlwin rivers, which are currently free-flowing; and
- project development in 35 sub-basins – increasing the number of developed sub-basins from 17 at present to 43.

BAU development would result in the Ayeyarwady and Thanlwin basins having around 28,000 MW (53%) and 21,000 MW (40%), respectively, of total hydropower capacity in the country. The development of all proposed and identified HPPs in the other six basins would add 3,134 MW of capacity, with each basin having between 20 MW and 1,220 MW total capacity.

7.2 Basin BAU Development Impacts

7.2.1 Ayeyarwady Basin BAU Impacts

The Ayeyarwady basin has been a focus of hydropower development, with 14 projects of 10 MW capacity or greater (totaling 2,100 MW) in 10 sub-basins: Dapein, Ma Gyi Chaung, Mali Creek, Mone Chaung, Mu, Myitnge Lower, Myittha, N'mai Hka, Shweli, and Zawgyi/Myogyi). The Ayeyarwady River mostly retains its large-scale geomorphic functioning, while the Chindwin River catchment is almost intact with only a single project (Myittha HPP – 40 MW) regulating less than 2% of this drainage area.

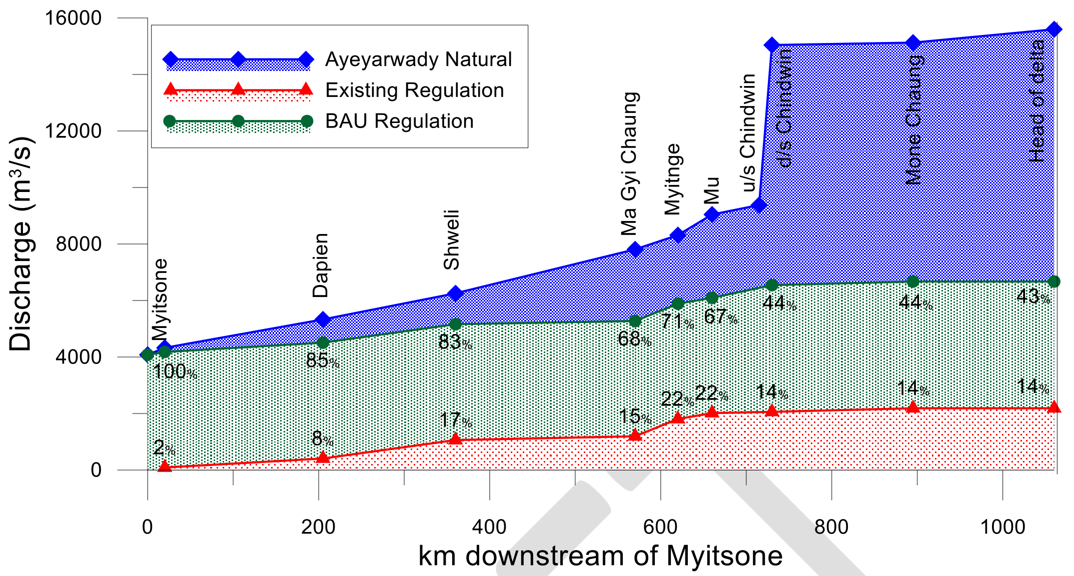
Hydrology and geomorphology: BAU hydropower development in this basin can fundamentally and irreversibly alter the nature of the river through the cumulative impact of each individual project causing changes to the flow regime and affecting coastal and marine ecosystems. BAU development would involve the construction of 30 projects. They include eight large projects with capacities ranging from 1,200 MW to 6,000 MW each (two mainstem ones, Myitsone and Tamanthi HPPs, five on the N'mai Hka, and one on the Mali Hka) and 22 smaller projects across the basin.

BAU development would change the river system's hydrologic, sediment transport, and geomorphic functioning as well as raise the regulated portion of the basin by HPPs from 16.1% to 38.6%. Mainstem connectivity within the upper 19% of the basin would be cut by the Myitsone and Tamanthi HPPs, trapping a substantial volume of sediment and seasonally altering the flow regime discharging from this area, which accounts for an estimated 47% of total basin discharge.[28]

Figure 7-1 compares (i) estimated pre-regulation flow rates in the Ayeyarwady (based on Lehner and Ouellet Dallaire, 2014) with (ii) existing regulated flow rates and (iii) regulated flow rates under BAU development. The comparison shows that the existing level of flow regulation in the Ayeyarwady is low in the upper basin but increases to around 20% in the mid-basin between the Myitnge and Mu before reducing to less than 15% with the inflow of the unregulated Chindwin River.

[28] HIC, 2017. *Ayeyarwady State of the Basin Assessment (SOBA) 2017: Synthesis Report, Volume 1*. Yangon, December 2017.

Figure 7-1: Ayeyarwady River Natural and Regulated Flows



Source: Flow data from Lehner and Ouellet Dallaire (2014).

BAU development would result in extreme flow regulation of the Mali Hka and N'mai Hka headwater outflows, with 100% of this discharge regulated by the Myitsone project, which makes up an estimated 42%[29] of the total Ayeyarwady basin flow. This would affect the Ayeyarwady along the entire downstream course of the river, exceeding 65% flow regulation until the Chindwin inflow decreases this to around 44%, substantially altering hydrologic patterns, geomorphic functioning, and sediment transport processes.

Under BAU development, no large free-flowing tributaries would be retained, and river connectivity would be substantially reduced. Sediment delivery from mountainous areas in the headwaters would be eliminated, while the composition of the sediment load from other parts of the basin where hydropower projects are installed would change due to the preferential trapping of gravels and sand in large reservoirs. The reduction in sand to the lower tributary channels would increase erosion and alter the morphology of tributary confluences. The Ayeyarwady mainstem would undergo a major geomorphic adjustment as the channel adapts to reduced sediment inputs, with a likely increase in bank erosion. In areas underlain by bedrock, the sand deposits would ultimately be removed, exposing more bedrock. In alluvial areas, the channel could continue to adjust for decades to centuries as sediment volumes and grain-size change, until the bed of the river is "armored" (covered by gravels and larger materials that cannot be transported by the modified flow regime). As sand is removed from the system and not replaced, the channel is likely to become less braided and potentially more incised, as has occurred in the lower Shweli. The losses of outflowing sediment to the coastal zone would lead to coastal erosion and a reduction in the productivity of coastal and deeper water fisheries.

The altered flow regime would reduce high flows, increase low flows, and potentially change the seasonality of river flows due to the number of storage impoundments with large live-storage volumes. As the slope of the Ayeyarwady is extremely low, close to zero in some places, lower peak flows will decrease sediment transport, which could further reduce the slope of the river bed. The existing level of flow regulation in the middle Ayeyarwady, combined with increased sediment input due to mining,

[29] Ibid.

deforestation and other land-use activities, may be contributing to the navigation difficulties in this reach of the river due to increased sediment deposition.

Aquatic biodiversity: Aquatic ecology and fisheries in the two headwater rivers, the Mali Hka and N'mai Hka, would be significantly impacted by the six large dams on these tributaries and the Myitsone HPP at the confluence of these rivers, creating an 8.4% degree of regulation[30] at the confluence. The projects would create a series of reservoirs that would cumulatively flood an estimated 518 km of these major rivers, converting free-flowing aquatic habitat into a series of deep-water and slow-moving reservoirs separated by flowing river sections in places. These projects would also alter water quality due to the large volume of seasonal storage. Additional BAU development in the Dapein, Mali Creek, Ma Gyi Chaung, Myitnge, Namtabak, and Shweli sub-basins would unlikely cause significant changes on wider aquatic ecology as these areas are already substantially modified by existing hydropower development.

The Tamanthi HPP on the Chindwin mainstem would significantly affect aquatic ecology and fisheries, cutting off connectivity to the upper 33,000 km^2 catchment and trapping a high percentage of sediment. The Manipur HPP on the Manipur River would have a moderate impact on high-diversity endemic fish and other aquatic species, with a greater impact on river connectivity and flow regulation. Before the confluence of the Chindwin with the Ayeyarwady, the combined degree of regulation of the Tamanthi, Manipur, and Myittha HPPs would be around 8.8%.

The altered flow regime, with reduced high flows and increased low flows, is likely to detrimentally affect the migration of fish species triggered by pulses of freshwater entering the system, increasing flow velocity and water levels.

Terrestrial biodiversity: Mainstem project development would cumulatively result in the direct loss of an estimated 1,235 km^2 of aquatic and terrestrial habitat. There will also be potential indirect impacts on an estimated 20,910 km^2 of Key Biodiversity Areas (KBAs) and 16,270 km^2 of intact forest, incorporating around 13,640 km^2 of overlapping KBA/intact forest.

The greatest risk to terrestrial biodiversity would occur in the five contiguous headwater sub-basins containing five protected areas and 72.2% intact forest cover, representing around 34.6% of Myanmar's total remaining intact forest. The area supports three relatively intact ecoregions that, within Myanmar, are only found in the Upper Ayeyarwady basin: (i) Northern triangle temperate forests; (ii) Northern triangle sub-tropical forest; and (iii) Nujiang-Langcang Gorge alpine conifer and mixed forests. This area is an important habitat for several critically endangered and endangered species.

Two additional KBAs that may be affected by the proposed Dapein HPP are: (i) Ninety-Six Inns KBA, a habitat for the critically endangered white-rumped vulture (*Gyps bengalensis*), and (ii) Mehon (Doke-hta Wady River) KBA, a habitat for the endangered green peafowl (*Pavo muticus*).

The substantial influx of construction workers (cumulatively estimated at 78,000 for all Ayeyarwady basin BAU projects) and camp followers (providing services to workers over the four- to six-year construction period on larger projects) would increase encroachment on forests and exploitation of non-timber forest products (NTFPs) as well as put pressure on wildlife and fish stocks.

The three BAU HPPs are all located in the sub-basins with the highest biodiversity value (Chindwin Headwaters 1 and Chindwin Headwaters 2). Implementation of these projects could pose significant impacts on terrestrial biodiversity.

Social: Resettlement and the loss and degradation of natural resources are the main social and livelihood impacts from the BAU development HPPs. A high number of people would likely be resettled to establish project structures, primarily reservoirs, but no accurate estimates are available. These impacts would be concentrated in the N'mai Hka, Mali Hka, Shweli, Myitnge Upper, and Myitnge Lower sub-basins, where most large projects are proposed. An estimated 195,000 people residing in the area of

[30] Grill, G. A. 2016. *Hydropower Development Options and Their Environmental Impact in the Greater Mekong Region for Different Energy Development Scenarios*. WWF – Greater Mekong Program.

influence (AOI) of these projects may be indirectly affected, in addition to more than 259,000 people estimated to be living in the immediate upstream AOI or reservoir area of these projects; some households would require resettlement and/or land compensation. Some of the estimated 232,000 people living in the immediate downstream AOI and the extended upstream and downstream AOI of these BAU projects would also be directly or indirectly affected.

Conflict: BAU development, particularly the seven very large HPPs in the N'mai Hka and Mali Hka headwaters, is expected to aggravate grievances and conflict in the Ayeyarwady basin, which has the highest conflict vulnerability in Myanmar. CSOs in this area, especially those connected to Kachin communities, have expressed strong concerns about the environmental and social impacts of these projects (e.g. cultural heritage, land rights, poverty, and the rights of displaced populations) and have linked them to the peace process. Some displaced people would be at risk from proposed HPPs and they would likely be marginalized from consultation processes. Without legal land tenure, they face difficulties in receiving compensation, livelihood restoration measures, and other mitigation benefits provided by the projects.

The Myitsone project is opposed by ethnic Kachin communities, while Dapein 1 HPP was the initial site of conflict between the Myanmar Army and the Kachin Independence Organization (KIO) precipitating the breakdown of the 17-year KIO ceasefire in 2011. The KIO conflicts with the Myanmar Army in some of the Chindwin sub-basins, especially the Uyu, which recorded a very high number of conflict incidents between 2012 and 2017.

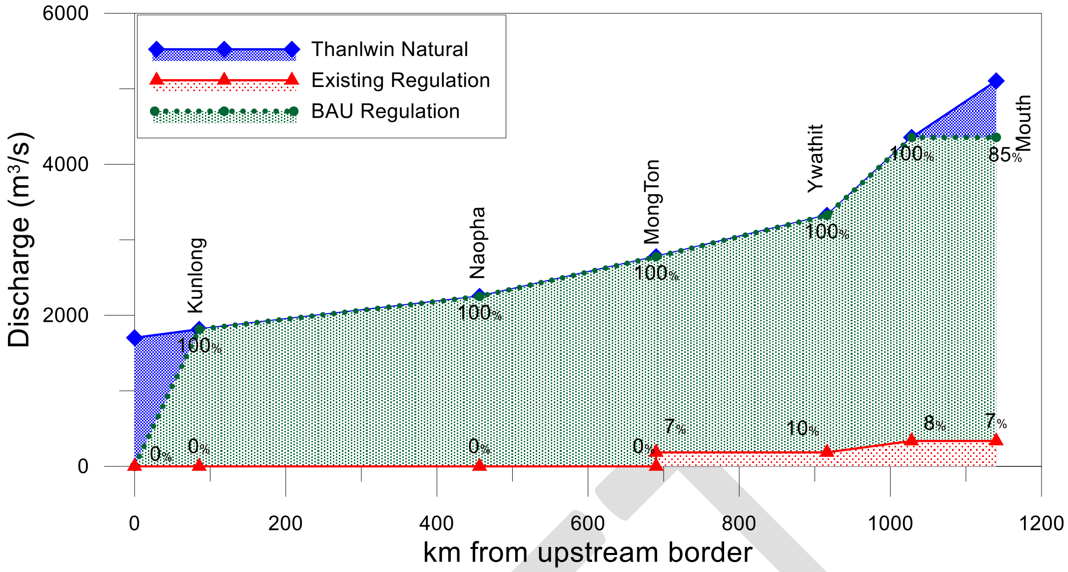
7.2.2 Thanlwin Basin BAU Impacts

The Thanlwin is an undeveloped river with respect to hydropower. There is no mainstem development in Myanmar or China, with only four HPPs totaling 302 MW in two sub-basins – 248 MW in two operational projects and one under construction in Baluchaung, and a 54-MW project in Nam Teng. The Thanlwin is one of the few remaining Asia rivers that retains its large-scale geomorphic functioning.

Hydrology and geomorphology: BAU development of five very large mainstem projects ranging between 1,200 MW and 7,000 MW would completely alter the river system's hydrologic, sediment transport, and geomorphic functioning. These projects would break river connectivity, trap sediment, and alter the flow regime at a basin scale. Installing an additional 17 proposed and identified HPPs in eight sub-basins (six of which are unregulated) would also change their natural features, albeit primarily at a local scale. Regional coastal and marine ecosystems would also be affected.

Figure 7-2 compares (i) estimated pre-regulation flow rates in the Thanlwin based on Lehner and Ouellet Dallaire (2014) with (ii) existing regulated flow rates and (iii) regulated flow rates under BAU development. The comparison shows that effectively 100% of the flow in the mainstem Thanlwin would be regulated from 100 km downstream of where the river enters Myanmar from China, to within around 180 km upstream of where it flows into the sea. This scale of development would result in the loss of connectivity of the entire system, with little sediment entering the coastal zone or sea, and substantial changes to the flow regime, leading to coastal erosion, losses in protective coastal habitats, and a reduction in the productivity of coastal fisheries. Water-quality changes are also likely, such as increased or decreased temperatures associated with extended periods of seasonal storage in a series of very large impoundments.

Figure 7-2: Thanlwin River Natural and Regulated Flows



Source: flow data from Lehner and Ouellet Dallaire (2014).

Aquatic biodiversity: The five very large mainstem HPPs will fragment and alter aquatic habitat, blocking important fish migration as well as removing and isolating rare river-reach types. The furthest downstream project – the Hutgyi HPP with a 118-m high dam located around 180 km upstream of the coast – will isolate 91.0% of the entire basin (80.6% of the basin area within Myanmar) from connectivity with the sea. The five mainstem dams would convert the Thanlwin River to a series of deep-water, slow-moving reservoirs separated by flowing sections of the river with altered flow rates and water quality. The reservoirs would inundate a combined 691 km (58%) of the 1,200-km long mainstem river within Myanmar as well as the downstream end of some important tributaries such as the Nam Pang. As a result, the assemblage of fish along the flooded mainstem and tributaries would be substantially changed. Those habitat changes and the loss of system connectivity would also alter fish species distribution in non-flooded sections of the Thanlwin and adjoining tributaries. Moreover, the reduced nutrient content of Thanlwin flows would exert additional pressure on lower Thanlwin and coastal fisheries. Project development in the sub-basins would further fragment riverine habitat, change the flow regime, and alter water quality.

Terrestrial biodiversity: Mainstem development alone would lead to the direct loss of an estimated 1,030 km^2 of aquatic and terrestrial habitat, and indirectly affect an estimated 12,000 km^2 of KBA (27% of the basin's total KBA area) and 3,500 km^2 of intact forest (24% of its total intact forest area), including around 1,940 km^2 of overlapping KBA and intact forest. The greatest risk would occur in the Thanlwin Middle sub-basin, which is nearly 85% KBA and forms part of the Golden Triangle. The sub-basin, especially the notable Nam San Valley, is an important habitat for the critically endangered white-rumped vulture and the slender-billed vulture as well as other endemic and endangered species.

The substantial influx of construction workers (cumulatively estimated at 97,000 for all Thanlwin BAU projects) and camp followers would increase encroachment on forests and exploitation of NTFPs as well as put pressure on wildlife and fish stock.

Social: BAU development would require massive resettlement, although no accurate estimates exist on the likely number of people affected. The Thanlwin Middle and Nam Pawn sub-basins also have the highest social vulnerability ratings in the basin, indicating that people's resilience to major livelihood changes is low in these areas. At this stage, there is insufficient information to estimate the extent of adverse impacts on local peoples' livelihoods, including the loss of commercial and subsistence fishing, forest and grassland access, and river sediment fertilizing riverside vegetable gardens and nearby farmland. But an estimated 45,000 people live in the extended downstream AOI that would be affected by river-flow changes caused by the Hutgyi HPP. Significant commercial and subsistence fisheries in the lower Thanlwin River and receiving coastal waters would be placed under greater pressure, potentially leading to a significant reduction in fish catch.

Conflict: The Thanlwin basin has historical patterns of contested governance, human rights abuses, and armed conflict. BAU development has high potential of aggravating grievances and conflict, and this would mostly likely occur in the mainstem HPPs with substantial impacts on natural resources. Opposition to hydropower development is most pronounced in the Thanlwin basin, crossing ethnic identity lines and giving rise to vocal civil society movements objecting on conflict, environmental, and social grounds. The basin traverses areas of high ethnic diversity, where HPPs may have implications for cultural heritage, land rights, poverty, and the rights of displaced populations. In some instances, armed conflict has been directly linked to HPPs in the Thanlwin basin (e.g. the Hutgyi HPP).

7.2.3 Mekong Basin BAU Impacts

The Mekong basin within Myanmar is relatively small with four sub-basins, comprising just 2.7% (21,947 km^2) of the total Mekong basin area. The basin has only one existing hydropower project of 10 MW capacity or greater – the 66 MW Mongwa HPP in the Nam Lwe sub-basin, which regulates most of the sub-basin.

Hydrology and geomorphology: Seven proposed and identified projects would be installed, with four totaling 618 MW in the Nam Lwe sub-basin, two 30 MW projects in the Nam Hkoke sub-basin, and a 36 MW project in the Nam Lin sub-basin; no development has been proposed in the Mekong Other sub-basin.

Hydropower development in the Mekong tributaries in Myanmar would decrease the connectivity and sediment delivery as well as alter flow patterns at the sub-basin level. The Nam Lwe flows directly into the Mekong, with four BAU projects sited in addition to the existing Mongwa HPP. The most upstream project is the run-of-river 170 MW Keng Tong HPP, which is estimated to have a low to moderate impact on river connectivity and sediment movement. The Suo Lwe HPP (240 MW), located upstream of the Mongwa, is a large storage project with the potential to alter flows at a sub-basin scale and increase the dry-season flow in the Mekong. He Kou (138 MW), near the confluence with the Mekong, and Kang Yang (70 MW) are both run-of-river projects downstream of the Mongwa HPP and would not substantially increase impacts on existing conditions.

The Nam Hkoke is a tributary of the Nam Me Kok, a major Mekong tributary in Thailand. There is insufficient information related to the two BAU projects planned/identified in the Nam Hkoke sub-basin to evaluate potential impacts, although sediment and flow delivery would be altered.

The Nam Lin HPP (36 MW) proposed in the small undeveloped Nam Lin sub-basin is located at the downstream end of the sub-basin and would break river connectivity between the mainstem Mekong and the sub-basin. The project storage is small, suggesting that it would not substantially alter the discharge from the sub-basin but would diminish the sediment load.

Aquatic biodiversity: Mekong River tributaries in Myanmar are of value for their connectivity to the mainstem and support to important fisheries, even though they only contribute 2% of total Mekong basin flows. The Mongwa HPP on the Nam Lwe has already cut river connectivity. Of the four dams planned on the Nam Lwe, only the Suo Lwe HPP would significantly alter the river's flows and degree of regulation, so it is considered to have high impacts on the aquatic ecology and fish.

While the Nam Lin HPP is expected to have little impact on aquatic ecology, its location near the confluence with the Mekong would effectively eliminate any fish migration and connectivity with this river. Its use as a fish migration route would have to be checked before approval of this dam.

The two dams on the Nam Hkoke are of concern because the Nam Hkoke is a transboundary river that flows into Thailand (where the river is known as the Nam Mae Kok) and is an important tributary of the Upper Mekong. The Mong Hsat HPP is located relatively high up in the catchment and will have very low impact on the aquatic ecology, but the Nam Hkoke HPP, being closer to the border, may have significant transboundary impacts.

Terrestrial biodiversity: There are no critical or endangered ecoregions in the Mekong basin within Myanmar; however, there are significant swathes of KBA and intact forest, including areas located within the AOI of BAU hydropower projects. The Nam Hkoke, Name Lwe, and Mekong Other sub-basins collectively contain more than 6,000 km^2 of total KBAs.

The Nam Lwe sub-basin would be the most significantly impacted, with nearly 1,500 km^2 (88%) of KBA expected to be affected by proposed projects, while the Mekong Other sub-basin may be indirectly affected due to the proximity of planned HPPs such as the Nam Lin and He Kou projects. Four additional projects with AOIs covering 3,645 km^2 – Keng Yang, He Kou, Keng Tong, and Suo Lwe – have the potential to degrade over 700 km^2 of the 2,000 km^2 of intact forest in the Nam Lwe sub-basin and nearly 1,400 (84%) of its KBAs. Although there is little KBA in the Nam Lin sub-basin, the planned project may potentially negatively impact on nearly all that remains.

Social: Resettlement would likely be the main social impact as a result of BAU development in the Mekong basin. An estimated 26,000 people live in the immediate upstream AOI of the seven proposed and identified HPPs, including about 9,600 people upstream of the Nam Lin HPP. In addition, around 15,000 people living in the extended upstream and downstream areas of the proposed HPPs could also be indirectly affected. For example, fisheries-based livelihoods, including part-time seasonal fishers, would be affected by river-flow changes and reduced fish movement.

Conflict: Historically, the Mekong, one of Myanmar's smaller basins, has been the site of many conflicts, though this has lessened in recent decades. Two sub-basins, Mekong Other and Nam Hkoke, have undergone significant historical population displacement. Multiple EAOs influence these sub-basins, but they are generally unlikely to engage with the Myanmar Army under current conditions. These groups include the Restoration Council of Shan State, a signatory to the 2015 NCA, and the United Wa State Army, which has constitutionally demarcated territory and rarely fights with the Myanmar Army. These indicators, combined with low landmine contamination, suggest low potential conflict impact, which is highly unusual for HPPs in eastern areas of the country populated by ethnic minorities.

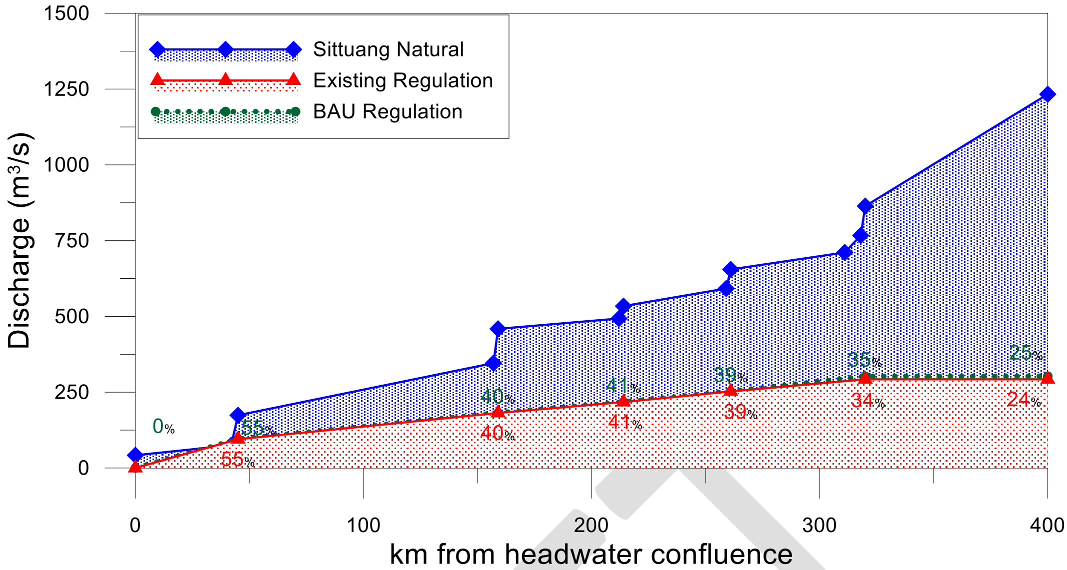
7.2.4 Sittaung Basin BAU Impacts

The Sittaung is a relatively small river basin (34,913 km^2) with a high level of hydropower development. Nine HPPs of 10 MW capacity or greater (totaling 810 MW) have been developed in the three sub-basins: five (230 MW) in the Sittaung Other sub-basin, three (460 MW) in the Paung Laung sub-basin and one (120 MW) in the Bawgata. About half of the upper basin flow is already regulated (Figure 7-3), with the percentage decreasing to about 35% in the lower basin and 24% at the mouth of the river. This level of regulation has a substantial risk of inducing geomorphic changes and may be contributing to changes in the coastal area, such as a reduction in sediment deposition.[31]

Hydrology and geomorphology: Three BAU projects totaling 410 MW would be installed, one in each sub-basin. They include two proposed projects and one identified one: Bawgata HPP 160 MW, Paung Laung Middle 100 MW, and Thauk Ye Khat 1 150 MW. Two of these projects are located upstream of existing hydropower plants and would not increase the volume of flow regulated, although they may alter flow patterns. The third project, Bawgata HPP, would regulate an additional 10 m^3s^{-1} resulting in a 1% increase in the regulated flow of the lower catchment, posing a limited impact.

[31] Anthony et al., 2017.

Figure 7-3: Sittaung River Natural and Regulated Flows



Source: Flow data from Lehner and Ouellet Dallaire (2014).

Aquatic biodiversity: While the Sittaung basin is already under considerable pressure from human activities, the proposed Bawgata HPP is expected to have a high impact on aquatic ecology and fisheries. This storage project would create a very high degree of flow regulation (82%) on one of the last intact tributaries in the basin that does not have a medium or large hydropower project. The loss of the intact Bawgata tributary would create further pressure on these depleted resources and the highly productive coastal Ramsar site in the Gulf of Mottama. This HPP poses a high risk for the Sittaung River, as the fisheries are highly dependent on fish migration and the loss of basin connectivity has already affected those in the lower Sittaung and coastal waters.

The Paung Laung Middle and Thauk Ye Khat 1 HPPs are unlikely to have significant impacts on aquatic ecology and fisheries because they are each located upstream of an existing dam that has already fragmented riverine habitat and altered river flows. With the three additional proposed and identified HPPs, the degree of flow regulation in the Sittaung estuary would be around 14.4%.

Terrestrial biodiversity: The three BAU projects in the Sittaung basin may further degrade the 10% remaining intact forest in the region due to unauthorized forest encroachment, NTFP harvesting, and poaching. Deforestation is likely to increase in the undeveloped Bawgata sub-basin. The broad AOI of the Bawgata HPP contains 21 km^2 of intact forest and 158 km^2 of KBA that contains an important biodiversity corridor. The Paung Laung HPP AOI comprises 162 km^2 of intact forest and 630 km^2 of KBA that provides an important habitat for leopards, guar, elephants, and several species of cave invertebrates.

Social: BAU development poses a high social risk as an estimated 11,000 people live in the immediate upstream areas of the proposed Bawgata and Paung Laung projects; many people also live in the extended downstream AOI of the Bawgata HPP.

Conflict: Conflict vulnerability ranges from low to medium. EAOs including the Karen National Union (KNU) and the Karenni National Peoples' Party (KNPP) are influential in the three sub-basins. The KNU is a signatory to the 2015 NCA, while the smaller KNPP is not. The KNU, via a subsidiary company, is a proponent of the proposed Bawgata HPP. Recent conflict in these sub-basins is low, though historically conflict and population displacement have been high. Ceasefires in the absence of comprehensive political settlements do not guarantee the long-term stability of these areas, but the impact of BAU HPPs is considered low under current conditions. This may, however, change as the development proceeds.

7.2.5 Bago Basin BAU Impacts

No hydropower projects are planned or identified in the small Bago basin (10,261 km^2), so no BAU impacts will occur.

7.2.6 Bilin Basin BAU Impacts

Covering just 3,056 km^2, the Bilin basin contains no existing hydropower project of 10 MW or greater capacity. A single project is proposed in the basin, Bilin HPP (280 MW), on the Bilin River, that would regulate 74% of the basin. This storage project, with substantial reservoir live storage and an estimated retention period of 578 days, would alter river flows, change water quality, and cut river connectivity. It would also block sediment passage and potentially impact coastal processes.

The Bilin River is likely to have a low ecological value due to a relatively uniform and common river-reach structure, and the absence of endemic or threatened species. Despite this, the river provides the usual riverine ecosystem and hydrological functions, migratory fish species move up the river to spawn because of its proximity to the Gulf of Mottama. Human pressure is high, given the substantial rural population and high-intensity agriculture in the catchment, leading to a presumed decline in river health status. No information is available on the fisheries of the Bilin River.

BAU development is expected to have a very high impact on aquatic ecology and fisheries. As a large storage dam, the Bilin HPP would block connection between the Gulf of Mottama and the higher reaches, affecting water quality and regulation of flows. The river has a very high degree of regulation, with multi-annual capacity for water storage.

The Bilin HPP AOI incorporates 730 km^2 (57%) of KBA in the Bilin sub-basin. The new project is expected to further degrade intact forest, with deforestation likely to expand with the construction of this first hydropower project.

The basin is influenced by the KNU, which has a ceasefire with the GoM and the Myanmar Army. The area has been home to very high historical population displacement and some conflict, contributing to a medium vulnerability rating. The proposed HPP is rated as minimal impact based on current conditions, subject to appropriate mitigation and management.

7.2.7 Tanintharyi Basin BAU Impacts

The Tanintharyi basin (44,876 km^2) consists of the Tanintharyi sub-basin (17,865 km^2) draining via the Tanintharyi River into the sea and a collection of coastal watershed within the Tanintharyi Other and Glohong Kra sub-basins. This basin has no existing hydropower projects equal to or greater than 10 MW.

Hydrology and geomorphology: Five BAU projects totaling 696 MW were proposed and identified in two of the three sub-basins. In the Tanintharyi sub-basin, the 600-MW Tanintharyi HPP is a large storage project on the Tanintharyi River that would regulate about 9,870 km^2 (55%) of the sub-basin area within Myanmar and inundate around 585 km^2. This river provides high inflow to the coastal zone (around 900 m^{3}s^{-1})[32]. The large impoundment has substantial live storage that would alter river flows on a sub-basin scale and have a very high sediment trapping efficiency. There are three other identified projects between 11-25 MW each located on smaller tributaries. One HPP is immediately upstream of the Tanintharyi HPP and the other two are on the southern arm of the Tanintharyi River, with each having a moderate catchment area of between 1,140 km^2 and 1,565 km^2.

The identified project in the Glohong Kra sub-basin (Glohong Kra HPP – 40 MW) is in a headwater stream and would regulate flow from 6% of the catchment area in Myanmar and Thailand combined.

While little information is available on the hydrologic, geomorphic, or sediment-transport characteristics of these sub-basins, they are in an area of high rainfall and likely play a vital role in

[32] Based on the estimate of Lehner and Ouellet Dallaire, 2014.

providing nutrients and freshwater inputs to the coastal zone, which together support vegetation that offers protection from storm surges.

Aquatic biodiversity: The Tanintharyi River is considered to have a very high ecological value due to its diverse and rare river reaches. Its fish and other aquatic endemicity is high with low human pressures, indicating that river health is probably good. Other coastal rivers are considered to have a medium ecological value because of their shorter and less diverse river reaches; they have medium human pressures from populations living along the coastal plains.

The Tanintharyi HPP is estimated to create a 44% degree of regulation in the Tanintharyi River. It would likely impose a significant impact on the river's unique aquatic ecology and fisheries, cutting connectivity between the upper half of the catchment and the coast as well as changing seasonal flows and water quality. The identified HPPs in the basin are each expected to have a lower impact on aquatic ecology, commensurate with their upstream location and smaller size.

Terrestrial biodiversity: The Tanintharyi basin has exceptional biodiversity and forests, with 64.7% of the basin designated as KBAs, 53.2% of intact forest, and 4.2% of protected areas. The proposed Tanintharyi Forest Corridor is being considered as a World Heritage site, containing one of the largest remaining areas of unprotected low- and mid-elevation seasonal evergreen forest in Southeast Asia. The basin contains numerous globally threatened species including the Indochinese tiger, Asian elephant, gibbon, langur, Gurney's Pitta, and Sunda Pangolin. Despite these very high biodiversity values, the area is under pressure from forest harvesting and road construction.

The Tanintharyi HPP has the potential to affect an estimated 2,590 km^2 of KBA that incorporates 1,460 km^2 of intact forest, equivalent to 16% of the total KBA area and 13% of total intact forest area in the sub-basin. Wildlife would be threatened by the estimated 7,200 construction workers and camp followers associated with the Tanintharyi HPP. They would likely increase encroachment on forests and exploitation of NTFPs in the area. The Glohong Kra HPP may put a large area of intact forest and KBA at risk.

Social: Resettlement and the loss or degradation of natural resources used for livelihoods would be the key social impacts from BAU development in the basin. The Tanintharyi HPP has an estimated 7,000 people living in the immediate upstream zone and some of these people will likely need to be resettled. Around 2,000 people live in the extended upstream zone above the dam and some may be indirectly affected. No people live in the immediate and extended downstream zones of the Tanintharyi HPP.

Conflict: The Tanintharyi and Other Tanintharyi sub-basins are considered to have high conflict vulnerability, while Glohong Kra is deemed moderate. Although the Tanintharyi and Tanintharyi Other sub-basins have not been sites of armed conflict recently, there were high rates of historical battle deaths and population displacement in the past. The KNU, the leading non-government signatory to the NCA with relatively good relationships with the GoM and the Myanmar Army, is influential across much of these sub-basins, more so in highland than lowland areas. The proposed HPPs are considered to have low to medium potential to exacerbate conflict based on current conditions. Hydropower development may risk reinforcing the grievances of ethnic minority communities, including CSOs championing conservation of these areas.

7.2.8 Rakhine Basin BAU Impacts

The Rakhine basin (55,387 km^2 within Myanmar) consists of seven sub-basins: Six drain into the sea via a main river, while Rakhine Other, the largest sub-basin at 25,796 km^2, drains via a series of small disconnected watersheds directly into the sea. Five sub-basins are relatively small, ranging in size from 1,061-2,331 km^2, with Kaladan (13,618 km^2) and Lemro (9,955 km^2) making up the remainder.

The basin has no operational HPPs equal to or greater than 10 MW, but construction of the Thahtay HPP (111 MW) in the Thahtay sub-basin was around half completed in 2017. There are six BAU development including two proposed projects – Lemro 1 (600 MW) and Lemro 2 (90 MW) in the Lemro sub-basin – and four identified projects ranging between 28 MW and 200 MW in four different sub-basins. Apart from project capacity and site, no other details are available for the identified projects.

Hydrology and geomorphology: The two Lemro HPPs are in the lower reaches of the main river (Strahler Order 3) and would have a significant impact on river connectivity and sediment delivery. Lemro 1 is a large storage project with a reservoir volume of 9.1 km^3 and surface area of 193 km^2. This large project has the potential to trap virtually all sediments and alter the flow regime on time-scales of months to seasons. The downstream Lemro 2 HPP is a small capacity project with the discharge pattern controlled by releases from Lemro 1.

The identified Mi Chaung HPP (200 MW) in Kaladan sub-basin would regulate flow from about 10% of this catchment; therefore, the effect on flows and sediment is likely to be relatively low. The three other identified projects – Saing Din HPP, Than Dwe HPP, and Kyein Ta Li HPP – will regulate 40%, 54%, and 82% of their respective sub-basins. Each of these projects will likely have substantial impacts at the sub-basin level due to the dependence of the coastal plains on sediment delivery. Development in these small catchments needs to be considered on a regional level, as each small river contributes to an important coastal plain environment. Altering the pattern of flow and quantity of sediment to the coastal area can induce substantial changes.

Aquatic biodiversity: The Rakhine coastal basin has a few small rivers emerging from the Chin Hills in the north and the Rakhine Yoma. In general, these rivers have a low ecological value with low to medium human pressures but still provide the usual ecosystem services of rivers. The Kaladan and Thahtay Rivers have high ecological value, while the Lemro River has a lower value. The eventual operation of the Thahtay HPP currently under construction is expected to have a high impact on this river, altering flows and blocking river connectivity.

The Lemro 1 HPP is likely to have a high impact on aquatic ecology and fisheries from flow regulation and the cutting of river connectivity. The Lemro 2 HPP would result in the loss of a large area of river and terrestrial habitat with the establishment of a large reservoir. The Mi Chaung HPP on the Kaladan River is expected to have a significant impact on this high ecological-value river. The three smaller proposed projects in the Rakhine basin – the Saing Din HPP in the north and the Thandwe and Kyein Ta Li HPPs in the south – are expected to have low impacts on rivers with a low ecological value.

Terrestrial biodiversity: The AOIs of the planned and under-construction HPPs in the Rakhine coastal basin contain 3,422 km^2 of KBA (13.2% of total KBA) and 1,846 km^2 of intact forest (12.3% of total intact forest). However, only the Lemro sub-basin, covering 2,564 km^2 of KBAs (63%) and 1,342 km^2 (34%) of intact forest, would be significantly influenced by planned HPPs.

The Thahtay HPP and two identified HPPs, Kyein Ta Li and Than Dwe, would potentially affect the Rakhine Yoma Elephant Range, a wildlife reserve for the wild Asian elephants in Myanmar, eight other mammal species, the critically endangered native Rakhine forest turtle (*Heosemys depressa*), and 123 avian species.

BAU development of the Lemro 1 and 2 HPPs is expected to have a direct and indirect impact on terrestrial biodiversity in the sub-basin, with the AOI including 63% of KBAs and 34% of intact forest. The influx of construction workers and camp followers during the construction phase of the six BAU projects is likely to cause further forest encroachment and harvesting of NTFPs and wildlife. This deteriorating forest degradation may increase sub-basin erosion and sediment loads in streams and rivers.

Social: An estimated 33,000 people live in the immediate upstream AOI of the Lemro 1 (15,000 people) and Lemro 2 (18,000 people) HPPs. Some of them will likely be resettled and lose agricultural land and access to natural resources. Around 51,000 people are estimated to be living in the extended downstream area of Lemro 2.

Conflict: The Rakhine coastal sub-basins are highly conflict-affected and vulnerable. The presence of armed conflict and armed groups in these sub-basins has changed rapidly since 2012. The violence and displacement that has occurred since then has distinct but overlapping causes compared to other parts of the country and involves wrestling with human rights, security, citizenship, and religious identity issues, in addition to the ethno-political contests over governance and territory that prevail elsewhere. In recent years, armed groups such as the Arakan Army (AA) and the Arakan Rohingya Salvation Army (ARSA) have increased activity in several sub-basins. The army's violent activities in 2017 prompted very strong responses from security forces that have displaced hundreds of thousands of people, in addition to those that were already displaced since communal violence commenced in 2012.

The 2012 violence was spread throughout much of the Rakhine State, affecting the Rakhine Other sub-basin and lower reaches of the Kaladan and Lemro sub-basins. The 2017 violence and displacement has been more concentrated in northern Rakhine State, affecting the Rakhine Other sub-basin in the north, the Saing Din sub-basin, and the lower reaches of the Kaladan and Lemro sub-basins. The 2017 violence occurred after SEA baseline assessment and conflict mapping was completed. Exact locations of violence have not been mapped to sub-basins, but the precautionary principle has been followed, upgrading the vulnerability of surrounding sub-basins even if violence or displacement has not been confirmed in these locations.

The Lemro HPPs were initially given a low conflict rating due to their location among ethnic Chin populations, away from the violence associated with Rakhine and Rohingya communities. These analyses should, however, be treated with caution given the conflict and displacement that has recently occurred in proximity to these projects.

Top social themes concerning hydropower development in Rakhine include poverty (the Rakhine sub-basins are among the poorest in Myanmar) and rights and citizenship issues. Any HPP development in areas previously occupied by Rohingya people could be mired in challenges concerning their right of return and lack of citizenship.

7.3 Summary of BAU Development Impacts and Lessons Learned

BAU development would result in broad-scale biophysical changes to Myanmar's rivers, including:

- altered seasonal and daily river flows in most river basins – increased dry-season flows and reduced wet-season flows from storage projects, daily-flow fluctuations from peaking generation, a delay in the onset of monsoonal-river flows while large reservoirs refill, and potential decrease in flood flows;
- a substantial increase in total basin area with flow regulation and fragmented river systems (Table 7-1);
- changes to water quality, a result of the seasonal detention of water in reservoirs;
- reduced downstream sediment loads, altered sediment size distribution, and increased bank erosion resulting in changes to river and delta geomorphology;
- aquatic habitat fragmentation, with most dams and altered flow conditions preventing fish, larvae, and egg movement upstream and downstream;
- terrestrial habitat fragmentation and reduced biodiversity – from the construction of reservoirs, roads, and transmission lines, and any illegal forest harvesting by the workforce and camp followers; and
- loss of riverine and terrestrial natural resources and reliant livelihoods.

Major basin-scale irreversible changes would occur to the flows, geomorphic, and ecological processes and functions of the Ayeyarwady and Thanlwin basins that cover three-quarters (74.5%) of the country.

Table 7-1: Extent of Basin Area Regulated/Fragmented – Existing and BAU Hydropower Projects

Basin	Total Basin Area in Myanmar (km^2)	Existing Basin Area Regulated in Myanmar[a]		Existing + BAU Basin Area Regulated in Myanmar[a]	
		km^2	%	km^2	%
Ayeyarwady	372,905	59,983	16.1	144,061	38.6
Thanlwin	127,493	16,492	12.9	102,759	80.6

Mekong	21,947	7,819	35.6	14,472	65.9
Sittaung	34,913	11,258	32.2	11,518	33.0
Bilin	3,056	0	0	2,250	73.6
Bago	10,261	1,098	10.7	1,098	10.7
Tanintharyi	44,876	0	0	12,318	27.5
Rakhine	55,387	0	0	13,488	24.3
Surma-Meghna	792	0	0	0	0
Total	**671,652**	**96,650**	**14.4**	**301,964**	**45.0**

a. Excludes irrigation dams.
Note: All BAU projects are assumed to have a dam wall that will disconnect aquatic habitat.
Assumed project areas: The Tamanthi HPP catchment area in the Chindwin Upper sub-basin is estimated at 20,700 km^2; the Hutgyi HPP catchment area in Myanmar is taken as 102,736 $km^{2,}$ with 24,758 km^2 of the basin located downstream within Myanmar.

BAU hydropower development across Myanmar would triple basin fragmentation from 14.4% of the national land area at present to 45.0%, covering just over half of the country. The effect of BAU development in fragmenting a basin is well illustrated by the two different outcomes for the Thanlwin and Sittaung basins. Such development would raise the percentage of the Thanlwin basin longitudinally disconnected from the sea from 12.9% to 80.6% due to its lowest HPP, the Hutgyi. By comparison, in the highly developed Sittaung basin, the BAU development of three projects totaling 410 MW would only increase the percentage of the basin longitudinally disconnected from the sea from 62.9% to 68.8%.

8 SUSTAINABLE DEVELOPMENT FRAMEWORK

A Sustainable Development Framework (SDF) for hydropower development in Myanmar has been prepared with the aim of ensuring that each basin maintains critical processes, functions, and values while producing reliable and cost-effective hydropower.

River processes and functions are usually taken for granted and viewed as a constant provider of "goods and services" until the effects of degradation noticeably reduce essential ecosystem services on which people rely. As the effects of hydropower development are incremental with each additional project coming into operation, whole-of-basin planning is critical to optimizing project siting to avoid significant negative impacts and maintaining basin sustainability.

Hydropower projects are major capital investments designed with a lifespan of more than a century; therefore, the resulting impacts are felt over a prolonged period. The only opportunity to avoid significant cumulative impacts on basin processes and functions is during project selection, siting, and design, before the problems are created. SDF implementation would enable informed decisions to be made about acceptable siting, type, design, size, and operation of proposed hydropower projects.

This first edition of the SDF is based on best available information, but many of its key areas should be regularly revised as more information is obtained and implementation undertaken.

8.1 Integrated Hydropower Planning

Environmental and social planning of proposed hydropower projects is recommended at three integrated levels to ensure that each project is sited, designed, constructed, and operated in accordance with environmental and social sustainability requirements to achieve whole-of-basin sustainability. This three-tier planning consists of:

(i) **Site screening against the SDF Basin Zoning Plans** for all projects larger than or equal to 10 MW capacity;

(ii) **CIA** for sub-basins or watersheds where new or additional HPPs are proposed; and

(iii) **EIA** or **Initial Environmental Examination** (IEE) for projects summarized in Table 8-1.

While each successive tier of planning involves greater detail as the proposed project moves from concept and feasibility to detailed design, significant-impact avoidance and minimization is usually achieved at the initial project siting and design stages when the proposal is open to change.

Project site screening: Every proposed HPP of 10 MW capacity or greater should be screened against the relevant Basin Zoning Plan at project concept stage to ensure that it is sited in accordance with this Plan. The eight Basin Zoning Plans provide developers and others with clear information on the proposed reserved mainstem rivers and sub-basins, where HPP development should be restricted, and those sub-basins potentially suitable for development. It is recommended that the project proponent submit the project concept design to a joint MOEE/MONREC Planning Committee for screening at the earliest possible stage. Projects that are sited in accordance with the Basin Zoning Plan should be given a "Clearance" certificate[33], which is a prerequisite for the granting of the project Memorandum of Understanding (MoU) that in turn permits a Feasibility Study and a EIA/IEE to be prepared. Projects proposed on reserved mainstem reaches should not be permitted to apply for an MoU. Large-scale projects proposed in high-value sub-basins should also not be granted an MoU, while it is proposed to identify opportunities to meet the needs of rural and remote communities by screening smaller scale,

[33] Issuance of a "Clearance" certificate by the GoM would not provide any approval beyond allowing for the developers to apply for a project MoU. Projects that are granted the "Clearance" certificate may be rejected at any subsequent stage of planning if the environmental and/or social impacts are deemed to be unacceptable.

lower impact projects in these drainage areas against additional criteria to determine if they should proceed.

Table 8-1: Hydropower Project Environmental and Social Planning Stages

Planning Tool	Project Planning Stage	Application	Purpose	Key Guidance
Basin Zoning Plan	Concept – pre-MoU	All HPPs ≥10 MW	Project site screening	Basin Zoning Plan
CIA	Concept – pre-MoU	As determined by the MOEE/MONREC Planning Committee	Project site screening and design	CIA guideline SDF design requirements
EIA/IEE	Feasibility Study and Detailed Design	EIA - HPPs ≥15 MW, or reservoir volume ≥20,000 M m^3, or reservoir ≥400 ha IEE – HPPs 1 to <15 MW	Detailed project impact assessment and management planning	EIA Guideline for Hydropower Projects

CIA: A CIA is a useful tool in planning multiple hydropower projects in a sub-basin or watershed. It is designed to identify and assess significant cumulative impacts to determine the level of development (carrying capacity) that is sustainable in relation to the number, type, scale, and location of new HPPs as well as other proposed developments in the area, such as mines and forest harvesting, and to plan appropriate management measures for these combined development impacts.

The need for a CIA should be identified by the MOEE/MONREC Planning Committee, either when multiple projects are being considered in a sub-basin or watershed, or when a project proposal is submitted. A CIA is ideally conducted for an undeveloped sub-basin or large watershed where multiple medium-to-large-scale hydropower projects are proposed, or where such projects are proposed in a partly developed drainage area.

EIA: A project-specific EIA or IEE is the final and most detailed level of project planning required for any project more than or equal to 1 MW in accordance with the Myanmar EIA Procedures (2015)[34]. An EIA is required for hydropower projects with either an installed capacity equal to or greater than 15 MW, or a reservoir volume equal to or greater than 20 million m^3, or a reservoir area equal to or greater than 400 ha. An IEE is required for HPPs with a capacity of between 1 MW and less than 15 MW, and a reservoir volume less than 20 million m^3, and a reservoir area less than 400 ha.

The EIA process should commence during project siting and design, which is consistent with good international industry practice, with close collaboration between the engineering and environmental teams during this early work. This allows the EIA/IEE to contribute to project siting and design improvement to avoid and mitigate major environmental and social impacts before the design is finalized.

8.2 Basin Zoning

A hydropower Basin Zoning Plan has been developed for each basin to guide sustainable hydropower development. The Plan defines (i) areas for reservation from hydropower development, where hydropower development is not consistent with sustainable development due to the unduly degradation or loss of essential basin processes, high natural values, and ecological importance, and (ii) potential development - lower value areas that are potentially suitable for hydropower development.

[34] The GoM, 2015. *Environmental Impact Assessment Procedure*. The Government of the Republic of the Union of Myanmar, Ministry of Environmental Conservation and Forestry. Notification No. 616 / 2015, Nay Pyi Taw, the 3rd Waning Day of Nadaw, 1377 M.E., (29 December 2015).

The Basin Zoning Plan recognizes two natural units that contribute to the overall ecological functioning and health of river systems:

- **mainstem river** – the main trunk river within a basin that connects sub-basin drainage areas with the sea, providing unimpeded system connectivity for river flows, sediment, and aquatic ecosystems, maintaining these essential basin processes and functions;

- **sub-basin drainage areas** – areas that either drain into the mainstem river/main basin tributary or directly into the sea, providing the primary land/water interface where physical, chemical, and biological processes influence the ecological functioning of the basin.

The Basin Zoning Plan sets out separate management zones and controls for mainstems and sub-basins. When used to site new hydropower projects and supported by policies, plans, guidelines and studies, the Plan would underpin sustainable hydropower development.

8.2.1 Mainstem Reservation

A basin's mainstem river provides essential hydrological, geomorphological, and ecological connectivity within the system required for maintaining basin processes and functions. Unimpeded mainstem connectivity provides the pathway for water, sediment, fish, and other aquatic organisms to move between sub-basin drainage areas and the sea. Basin functions supported by mainstem connectivity include:

- water cycling and flow characteristics, including seasonality and water levels;
- river channel maintenance;
- aquatic ecology cues and processes (e.g. for fish migration) and riverine habitat maintenance;
- flushing of land-derived nutrients from the basin and delivery to coastal and marine areas;
- sediment replenishment in marine areas that maintain coastal landforms;
- natural hazard regulation – floods and coastal protection; and
- prevention of saltwater intrusion in delta regions.

The construction and operation of large dams on a mainstem river cuts connectivity, longitudinally fragmenting this trunk waterway into semi-connected parts by creating barriers. Dam operation usually results in system degradation due to:

- flow changes – from daily and/or seasonal flow regulation from the detention of water in reservoirs;
- water-quality degradation – changes to temperature, light penetration, oxygen content, and nutrient content from reservoir storage;
- geomorphic changes - reduced downstream sediment load, changes to sediment composition, and related geomorphological changes – from reservoir sediment trapping; and
- aquatic habitat fragmentation –prevention of fish movement along the river channel by dam barriers and the conversion of flowing river into deep, slow-flowing reservoirs, creating a series of semi-disconnected and altered aquatic habitats.

Although similar impacts are created by HPPs in sub-basins, they only affect a portion of the total basin flow and aquatic habitat, whereas HPPs on the mainstem river affect the entire river discharge at that point and thus create a substantially higher magnitude of impact.

Box 1: The Importance of Basin Health and Fish Production

Basin health is critical to maintaining freshwater and marine fish production, an important sector of the Myanmar economy. Changes to seasonal flows, water quality, and river geomorphology all degrade natural freshwater habitat. Outflows from Myanmar's major rivers into the sea provide nutrients for marine life and help maintain natural coastal processes essential to coastal fisheries production.

National fish production in 2014 was 5,047,530 metric tons (provisional), accounting for around 3% of the world's fish production. This consisted of 27.3% from inland fisheries, 53.5% from marine fisheries, and 19.1% from aquaculture. National fish production is important to livelihoods, with an estimated 3.2 million people employed in the fisheries sector (800,000 full-time, 2.4 million part-time).

Fish production is the fourth-largest contributor to Myanmar's GDP and also the fourth-largest source of foreign exchange earnings. It provides an important source of animal protein to the population (estimated at an average of 30 kg per person a year).

Source: Fisheries Statistics 2014, Department of Fisheries Myanmar.

Mainstem zoning defines the extent of each basin's mainstem recommended for reservation, where hydropower development and other structural water-resource developments (e.g. irrigation dams) should be excluded. Maintaining connectivity along this reach retains most sub-basins would maintain an unimpeded connection from the point where they discharge into the mainstem to the sea. This allows decisions on sub-basin utilization and management to be made based on sub-basin values, independently of concerns over downstream connectivity.

Mainstem rivers recommended for reservation are identified in five basins. The rivers are defined as a Strahler Order of 4 or greater in the Ayeyarwady, Thanlwin and Mekong basins (based on the greater Mekong sub-region database) are recommended for reservation. This classification was selected as the best identifier of large rivers with critical basin processes and functions that also have a major influence over other areas (i.e. delta and coastal processes)[35]. Two exceptions were made to this classification where Strahler order of 4 river reaches were not classified as mainstems: (i) where the lower reaches of Myitnge River in the Myitnge Lower sub-basin and (ii) the Manipur River in the Manipur sub-basin (both in the Ayeyarwady basin).[36] Instead, these river reaches are recognized as part of each sub-basin for continuity of planning but are still identified as very important for ecological functioning.

The Mekong River reach along Myanmar's eastern border with Lao PDR, whilst regulated further upstream and downstream, has been reserved to maintain reach ecological conditions along this important river. Immediately above this reach China has cancelled the Mensong HPP to maintain connectivity for fish migration. A mainstem river reach on the Sittaung River has also been defined for reservation even though it is not a Strahler Order of 4. Reservation of this lower section of the Sittaung is warranted, given the existing high level of HPP regulation in the sub-basins.

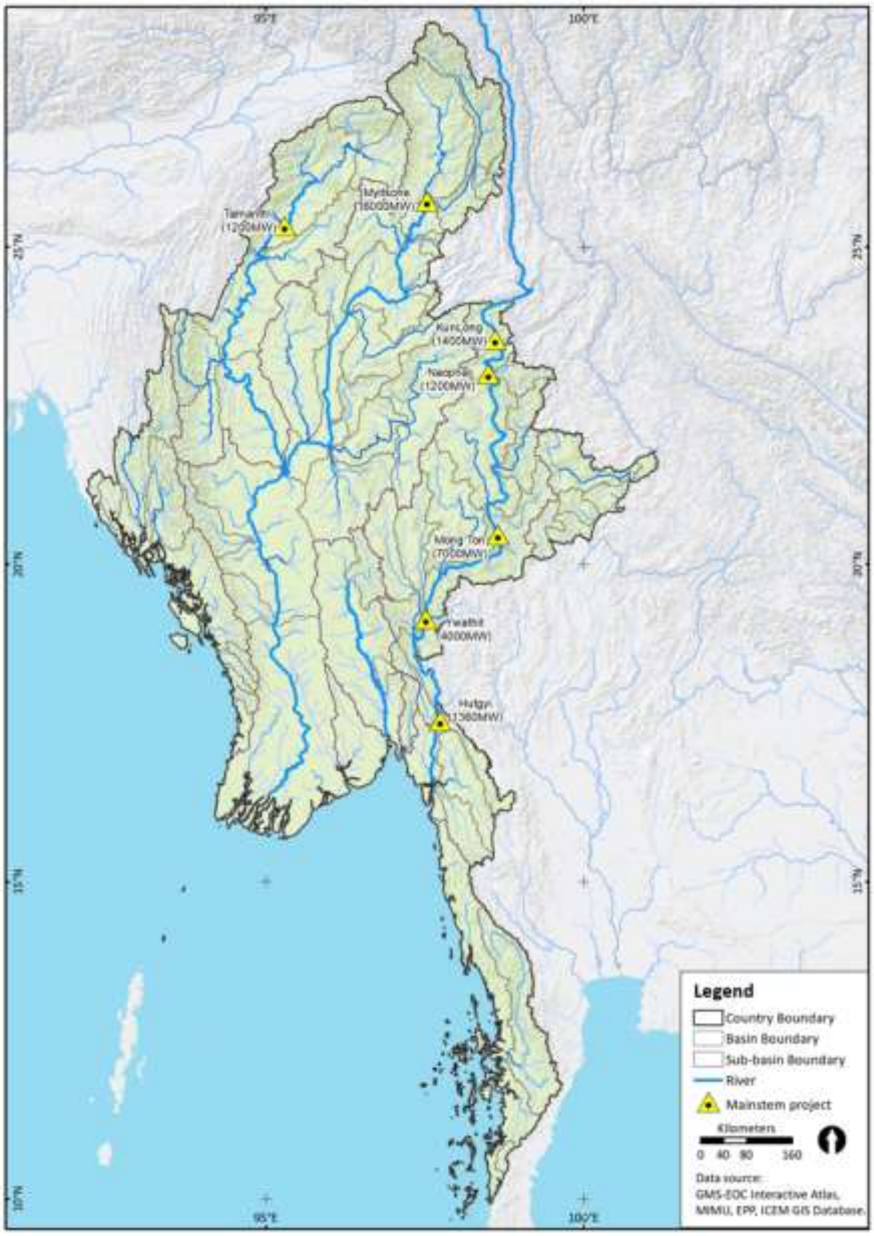
This delineation of mainstem reaches recognizes the importance of maintaining connectivity between all sub-basins and the sea. This is not to imply that development of sub-basins would not affect downstream processes. However, maintaining the mainstems as an unimpeded conduit would provide the best opportunity for minimizing sub-basin hydropower impacts at a basin scale by allowing flow and sediment inputs from unregulated sub-basins to modulate the impacts from regulated basins, and to provide basin-wide fish migration routes.

[35] The reserved mainstem is recognized as a corridor that covers the bed and banks of the river and the immediately adjoining land. Where the mainstem is a braided river such as on the Ayeyarwady delta, all braided streams are classed as mainstem.
[36] Around 100 km of the Myitnge River and 30 km of the Manipur River classified as Strahler 4 are not classed as mainstem rivers.

The defined mainstems in Myanmar, illustrated in Figure 8-1, are:

- Ayeyarwady – commencing at the Mali Hka-N'mai Hka confluence;
- Chindwin – commencing at the confluence of Headwater 1 and 2 sub-basins between Shin Bway Yang and Shin Long Ga townships;
- Thanlwin – commencing at the Myanmar-China border;
- Mekong – 180 km along the Myanmar-Lao border; and
- Sittaung – commencing at the Sinthay River confluence downstream of the Lower Paunglaung dam.

Figure 8-1: Proposed Hydropower Projects on Mainstem Rivers



Mainstems for reservation were not defined for the Bago and Bilin basins as these are relatively small catchments (10,261 km^2 and 3,056 km^2 respectively) with low Strahler Order mainstems. At present, no mainstem river for reservation is defined in either the Tanintharyi and Rakhine basins as they consist of multiple low Strahler Order rivers that flow to the sea, and there is insufficient information available to prioritize reservation of one waterway over another. Further investigation is required to better understand the flow, sediment, and ecological attributes of the main to determine if any major rivers would be delineated as mainstems for reservation.

Mainstem reservation implies excluding all hydropower projects on these river reaches. The seven proposed projects sited on mainstems, totaling 22,160 MW capacity (Table 8-2), are not consistent with sustainable hydropower development and hence should not be approved. These projects include the Myitsone and Tamanthi HPPs (totaling 7,200 MW), that were suspended pending further GoM review, as well as the Mong Ton HPP, where redesign at a reduced capacity is being considered by the developer.

Table 8-2: Proposed Mainstem Hydropower Projects

Mainstem	Hydropower Project	Capacity (MW)
Ayeyarwady	Myitsone (S)	6,000
Chindwin	Tamanthi (S)	1,200
Thanlwin[1]	Kun Long	1,400
	Naopha	1,200
	Mong Ton	7,000
	Ywathit	4,000
	Hutgyi	1,360
TOTAL		22,160

1. Projects listed in order from upstream to downstream.
S. Suspended by the GoM.

The severity of mainstem hydropower development impacts on river-system processes is illustrated by the changes that would result from the Myitsone HPP (Table 8-3). This single project would disconnect and regulate flows from 11.6% of the Ayeyarwady basin area that contributes an estimated 42% of the total basin discharge, flowing from the Mali Hka (27%) and N'mai Hka (15%) rivers[37], as well as reduce a substantial proportion of the basin sediment load. The effect of the Thanlwin mainstem development would be even more marked, with the proposed Hutgyi HPP disconnecting over 96% of the basin catchment area from the sea, and preventing the delivery of a large sediment load to a coastal area dependent on this material to maintain coastal processes.

Table 8-3: Loss of Basin Connectivity from Proposed Mainstem Hydropower Development

Basin	Lowest Proposed Mainstem HPP	Total HPP Catchment Area (km^2)	Total Basin Area (km^2)	% of Total Basin Area Regulated / Disconnected
Ayeyarwady	Myitsone	47,723	412,500	17.2
Chindwin	Tamanthi	23,314		
Thanlwin	Hutgyi	311,167	324,000	96.4

Two other impacts resulting from the of loss of connectivity are the fragmentation of different river-reach types and the degree of regulation of flows, indicating the extent to which seasonal-flow patterns

[37] AIRBMP, 2017.

are changed by reservoir live storage (i.e., increased flows in the dry season and lower peak flows in the wet season).

Maintaining mainstem connectivity in the Ayeyarwady-Chindwin system will retain connectivity between 36 different river-reach types, of which 24 are classed as very rare and five are rare (based on the percentage of the total length within the basin). If the Myitsone dam is constructed, it would fragment and isolate 17 river-reach types in the Mali Hka and 19 river-reach types in the N'mai Hka from the rest of the system. Nearly 80% of these reach types are considered rare, including four very rare types. The Tamanthi HPP on the Chindwin River would also have a very high impact on aquatic ecology, isolating 17 river reach types from the rest of the Ayeyarwady-Chindwin system, with the degree of regulation at the dam site estimated at 14.2%.

Similarly, the Mong Ton HPP on the Thanlwin River, with a 380-km-long storage reservoir that would extend up the Thanlwin mainstem and into the Nam Pang tributary, would isolate 15 river-reach types between the dam and the Myanmar-China border, nine of which are rare or very rare.

Box 2: the Mong Ton HPP Mainstem Impact

The proposed Mong Ton HPP on the Thanlwin River would be the 26th largest reservoir by volume in the world. No details are available on predicted impacts but given its size and location, it will create significant adverse impacts on mainstem processes, including:

- significant changes to the flow regime, including a substantial increase in dry-season flows and a decrease in the frequency and size of high-flow events; a 44% degree of regulation at the dam site, only reducing to 25% at the Thanlwin River estuary;
- a substantial adverse impact on water quality due to changes in temperature, oxygen, and nutrient content during reservoir storage;
- a major reduction in river-sediment load, in turn degrading the downstream river channel and all but eliminating sediment delivery to the coastal zone;
- prevention of upstream and downstream fish migration; and
- replacing a long length of lentic river habitat with a deep-water lotic habitat.

Main design specifications: 241 m high dam, 870 km^2 reservoir area, 380 km reservoir length, 37,399 hm^3 live storage (94% of total storage) with a 156-day retention period.

8.2.2 Sub-Basin Zoning

Sub-basins, having the primary land-water interface within a basin, are in effect the engine rooms of basin ecological functioning. They are the source of flows and sediment and the main determinant of water quality, providing substantial aquatic habitat in the basin. Sub-basin zoning based on natural-resource values provides a sustainable hydropower suitability plan for the initial screening of proposed project sites. This plan balances hydropower development with natural-resource retention to deliver sustainable development within each basin.

Sub-basins with notable high values are considered unsuitable for sustainable hydropower development except in limited instances with strict restrictions; therefore, they should be zoned for reservation. Sub-basins with lesser values may be suitable for sustainable hydropower development, where the GoM may grant an MoU that permits detailed project investigations, but still imposes the formal project-approval process incorporating appropriate project siting, design, construction, and operation. The following sub-basin zoning forms an initial plan based on limited information in key areas. As more detailed information is obtained on natural and social resources, some sub-basins may be re-zoned in light of their recognized values.

Sub-basin zoning is based on the relative value of three biophysical features: geomorphology, aquatic ecology, and terrestrial ecology. Geomorphology and aquatic ecosystems in sub-basins are directly affected by medium-to-large-scale hydropower projects well beyond site impacts due to the extent of hydrologic alteration, sediment-flow changes, and river longitudinal fragmentation. Terrestrial ecology is directly affected by project-site impacts and indirectly affected by the creation of new or improved access into an area (from the reservoir, roads, and transmission line), as well as forest and wildlife harvesting by the project workforce and service businesses during construction and operation.

Socio-economic conditions were also evaluated but not applied to determine sub-basin zoning as the level of detail obtainable on relevant features was considered inadequate and a poor indicator of the values impacted by hydropower. Unlike geomorphology and aquatic ecology whose intrinsic values are a function of cumulative river and stream attributes across the sub-basin, socio-economic features affected by hydropower development are highly site dependent. Therefore, a value for the entire sub-basin is a poor indicator of these specific features.[38] Despite the absence of socio-economic evaluation in determining zoning, the evaluation of biophysical conditions provides an indicator of the health of a sub-basin's natural resources in relation to local livelihoods dependent on them. Similarly, the status of armed conflict was also evaluated but not applied to determine sub-basin zoning as conflict is a fluid situation subject to rapid change, and, in some instances, can also be resolved and managed.

Sub-basin zones were determined by totaling the evaluation scores for geomorphology, aquatic ecology, and terrestrial ecology to calculate an overall sub-basin rating. A scale was then applied to delineate "High," "Medium," and "Low" value zones to guide future utilization, with the aim of balancing hydropower development with natural-resource maintenance.

- **"High" value zone** means the sub-basin has a high ecological value due to its important contribution to overall basin processes (e.g. high flows, large sediment load) and/or unique natural values (e.g. important aquatic habitat) for at least two biophysical factors.
- **"Medium" value zone** means the sub-basin does not contain high ecological value features over a notable area for two biophysical factors, although it may contain notable values for a single factor or such values in pockets.
- **"Low" value zone** means the sub-basin does not contain high ecological value features over a notable area for any biophysical factor (except for three sub-basins with a high score for a single factor), although it may contain pockets of high value.

A sub-basin with a minimum score of 11 and at least two biophysical factor scores of four or more was zoned High in recognition of the cumulative value of biophysical features in the catchment. Sub-basins with scores of 8-10 were zoned Medium, while sub-basins with a score of 7 or less were zoned Low. This classification resulted in 10 sub-basins zoned High, 21 sub-basins zoned Medium, and 27 sub-basins zoned Low (Table 8-4). The distribution of these three zones is summarized by percentage of basin area in Table 8-5.

Table 8-4: Sustainable Hydropower Zoning Scale

Zone	Total Sub-Basin Rating	Additional Criteria	Number of Sub-Basins	Suitability
High	11 and above	At least two factors with a score of 4 or more	10	Reservation to maintain high conservation values – HPPs are excluded apart from smaller scale, lower impact

[38] High-value terrestrial ecosystems such as Protected Areas, KBAs, and critical habitat can exist near medium to large hydropower projects without undue adverse impact if the project does not create new or improved access to or near the ecosystem.

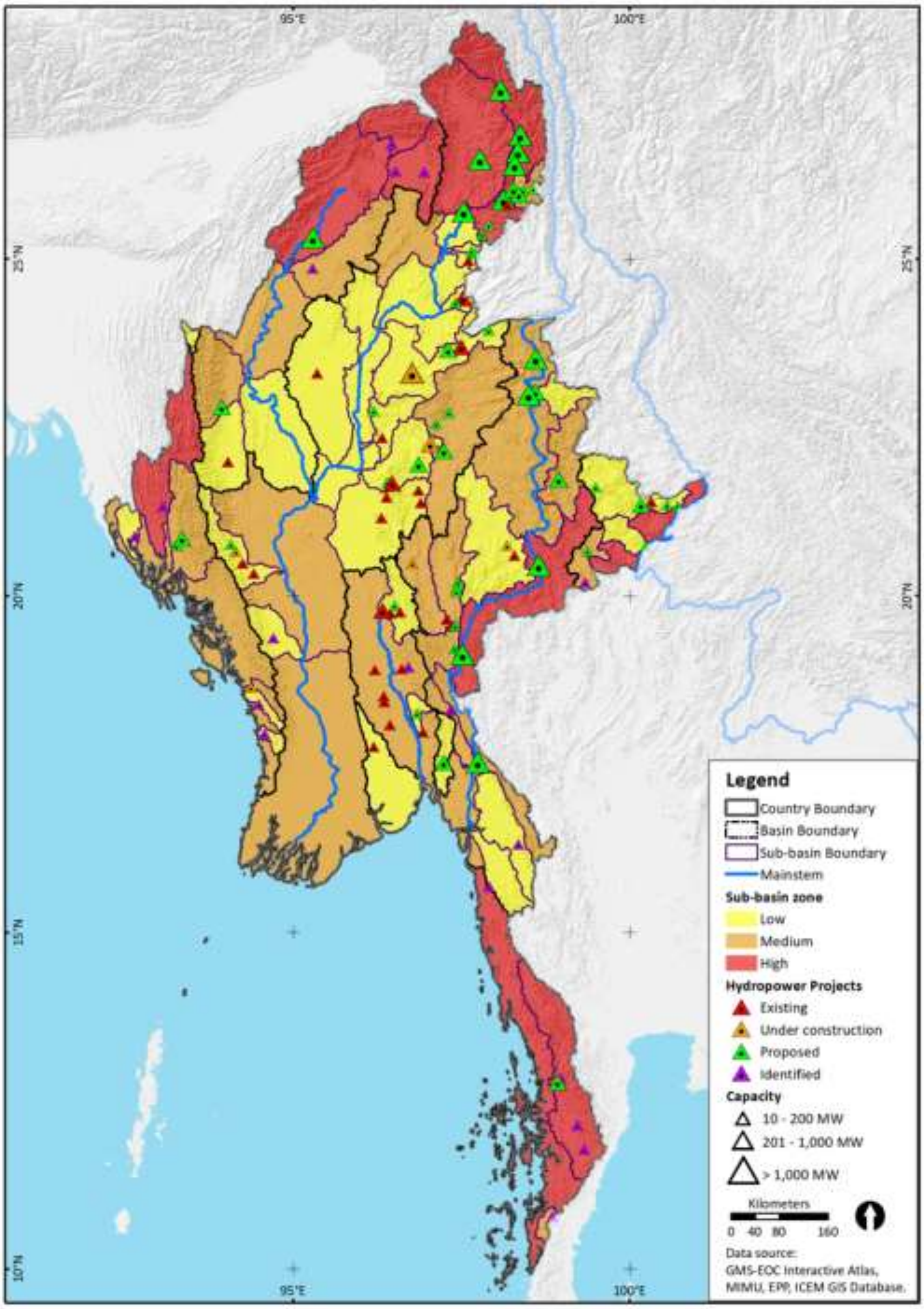
				projects considered on a case-by-case basis
Medium	8-10	Sub-basin (1) with a score of 11 but only one factor score of 4 or more	21	Potential for sustainable HPP development
Low	4-7	-	27	Potential for sustainable HPP development

Table 8-5: Sub-Basin Zone Distribution by Percentage of Basin Area

Basin	% of Myanmar Basin Area[1]		
	High	**Medium**	**Low**
Ayeyarwady	20.9	28.6	50.5
Thanlwin	15.9	57.9	26.2
Sittaung	-	82.2	17.8
Mekong	29.8	15.5	54.7
Bilin	-	-	100
Bago	-	-	100
Tanintharyi	97.8	2.2	-
Rakhine	24.6	66.8	8.6
Surma-Meghna	-	-	100
Total	**24.2**	**37.3**	**38.5**

Note: Basin area within Myanmar.

Figure 8-2: Sub-Basin Zoning



High Zone

Each of the 10 High-zone sub-basins (Table 8-6) retains significant biophysical values. They are located around the border regions of Myanmar, mostly in remote hilly and mountainous areas with a lower population density and generally less intensive use of natural resources. Large HPPs in these catchments would result in significant, direct adverse impacts on seasonal river flows, water quality, geomorphology and/or ecosystems. In many instances, major hydropower development would provide new or improved road access into these areas, leaving them vulnerable to indirect impacts such as increased forest harvesting. Keeping these high-value sub-basins free of larger-scale HPPs is recommended to maintain basin health and/or unique and representative natural values.

Five High-zone sub-basins cover a contiguous block in the headwaters of the Ayeyarwady (with two sub-basins) and Chindwin (with three sub-basins) rivers in northern Myanmar. This combined area has a low population density of less than 20 people per km^2 and notable terrestrial ecosystems that include Hkakabo Razi National Park, four Wildlife Sanctuaries, numerous KBAs, and around 34.6% of Myanmar's remaining intact forest (above 80% crown cover)[39]. Covering 20.9% of the Ayeyarwady basin within Myanmar, this high rainfall area contributes an estimated 47% of the total Ayeyarwady discharge and is, therefore, an important driver of the entire river system. Another significant geomorphic value is the contribution of a substantial volume of the basin's sediment load.

Two High-zone sub-basins are in the Tanintharyi basin, while the other three are in Thanlwin, Mekong, and Rakhine basins. Four of these sub-basins received a high to very high score for geomorphology and aquatic ecology, with the Tanintharyi Other sub-basin receiving medium score for aquatic ecology.

The sub-basins with the most notable biophysical values in Myanmar are the Mali Hka and the N'mai Hka in the Ayeyarwady headwaters and the Tanintharyi in the far south, each having high to very high values for all three biophysical factors.

Table 8-6: High-Zone Sub-Basin Scores

Basin	Sub-Basin	Geomorphology and Sediment	Aquatic Ecology	Terrestrial Ecology	Total Score
Ayeyarwady	Mali Hka	5	5	5	15
	N'mai Hka	5	4	5	14
(Chindwin)	Chindwin Headwater 1	3	4	5	12
	Chindwin Headwater 2	2	5	5	12
	Chindwin Upper	5	3	4	12
Thanlwin	Thanlwin Middle	5	4	3	12
Mekong	Mekong Other	4	5	2	11
Tanintharyi	Tanintharyi	5	5	5	15
	Tanintharyi Other	5	3	4	12
Rakhine	Kaladan	5	4	2	11

Medium Zone

The 21 Medium-zone sub-basins have mixed scores, with 20 sub-basins having a high or very high score for at least one biophysical factor and just one receiving medium scores or less across all three factors (Table 8-7). The sub-basins range in location across the country. Just two of them have existing HPPs on the main tributary.

Medium-zone sub-basins may be suitable for sustainable hydropower development but would require the full application of good siting, design, and management principles to avoid and mitigate adverse impacts.

[39] HMIS, 2011.

Table 8-7: Medium-Zone Sub-Basin Scores

Basin	Sub-Basin	Geomorphology and Sediment	Aquatic Ecology	Terrestrial Ecology	Total Score
Ayeyarwady	Ayeyarwady Lower	4	2	2	8
	Ngaw Chang Hka	2	3	5	10
	Namtabak	3	3	2	8
	Myitnge Upper	5	2	1	8
	Indawgyi Lake catch. trib.	3	4	3	10
	Delta	4	2	2	8
(Chindwin)	Chindwin Middle	4	3	3	10
	Uyu	3	1	4	8
	Manipur	4	4	2	10
Thanlwin	Baluchaung	2	5	2	9
	Nam Hka	4	2	2	8
	Nam Pawn	5	3	1	9
	Thanlwin Lower	3	4	3	10
	Thanlwin Upper	5	2	1	8
	Yunzalin	2	4	3	9
Sittaung	Sittaung Other	4	2	2	8
Mekong	Nam Hkoke	2	5	2	9
Tanintharyi	Glohong Kra	1	3	4	8
Rakhine	Lemro	5	3	3	11
	Thahtay	1	4	4	9
	Rakhine Coastal Other	5	2	3	10

Low Zone

The 27 Low-zone sub-basins (Table 8-8) each has a low overall biophysical value largely due to significant modification by relatively intensive use of land and water resources. Fourteen of these sub-basins have existing HPPs on the main tributary. Despite this zoning, these sub-basins may retain watersheds that are largely unmodified, including pockets of rare and critically endangered ecoregions and habitats.

Many Low-zone sub-basins have large areas of lower slope land with a high percentage of agricultural land use and higher population density, where the natural ecosystem has been substantially modified. Nine of these sub-basins are at least partly located in the central Dry Zone that is intensively utilized for agriculture.

Low-zone sub-basins may be suitable for sustainable hydropower development but would require the full application of good siting, design, and management principles to avoid and mitigate adverse impacts.

Table 8-8: Low-Zone Sub-Basin Scores

Basin	Sub-Basin	Geomorphology and Sediment	Aquatic Ecology	Terrestrial Ecology	Total Score
Ayeyarwady	Ayeyarwady Upper	3	2	2	7
	Ayeyarwady Middle	2	1	2	5
	Mali Creek	1	3	2	6
	Dapein	1	2	2	5
	Shweli	3	2	2	7
	Ma Gyi Chaung	2	2	2	6
	Myitnge Lower	2	2	1	5
	Zawgyi/ Myogyi	3	2	1	6
	Mu	3	1	1	5
	Mone Chaung	1	1	2	4
	Mindon	1	2	2	5
(Chindwin)	Chindwin Lower	2	1	1	4
	Myittha	2	1	2	5
Thanlwin	Nam Ma	3	2	1	6
	Nam Teng	1	2	2	5
	Lam Pha	2	3	1	6
	Myet Taw Chaung	1	3	1	5
Sittaung	Paung Laung	2	2	3	7
	Bawgata	1	2	2	5
Mekong	Nam Lwe	3	2	2	7
	Nam Lin	1	2	2	5
Bago	Bago	2	1	2	5
Bilin	Bilin	2	1	2	5
Rakhine	Saing Din Creek	1	2	3	6
	Than Dwe	1	2	4	7
	Kyein Ta Li	1	2	4	7
Surma-Meghna	Barak	1	4	2	7

Strict Development Restrictions for High-Zone Sub-Basins

Strict hydropower development restrictions are recommended in High-zone sub-basins to ensure that these drainage areas retain the identified natural values driving basin processes and/or are unique to these areas or representative of values that are in decline and need protection. All larger scale and higher impact projects should be excluded from high zone sub-basins, but smaller scale and lower impact projects could be considered if these projects can be developed within watersheds without unduly degrading key natural resources and socio-economic values. Such projects can play a prominent role in supplying reliable and affordable off-grid and grid-connected renewable energy to communities, utilizing local natural resources and new technologies.

Every project proposed in a High zone sub-basin should be screened by the GoM at concept stage so that inappropriate projects are removed from further consideration early in the planning process. Projects that meet selected criteria should be considered for a "clearance" certificate allowing them to apply for an MoU, while those that do not meet the criteria should be prohibited in their proposed form.

Defining specific restrictions to achieve sustainable hydropower within High-zone sub-basins is difficult because of variability in local conditions that contribute to the significance of direct environmental and social impacts on the project site and within the AOI as well as indirect impacts in the AOI. Accordingly, proposed projects should be assessed on a case-by-case basis to account for the range of local conditions and potential project impacts. A screening framework should be jointly developed by the MOEE and MONREC setting out selection criteria, providing developers with a clear indication of the locations and types of projects that would be considered, and providing stakeholders with certainty about the upper limits of projects that may be acceptable.

The framework should be based on project siting criteria such as:

- project location – should exclude the main sub-basin river (except in the headwaters of that sub-basin where this river is small) or on any watershed over a specified maximum area in sub-basins that discharge via a single river;
- maximum degree of sub-basin flow regulation – taken as a cumulative of all HPPs above in the sub-basin;
- maximum project size – for example, dam height above river-bed level, reservoir volume, or MW capacity;
- a preference for run-of-river projects over storage projects; and
- avoidance of direct or indirect impacts on notable sites, for example, a protected area.

Each proposed project in a High-zone sub-basin should be considered collectively with any operational, under construction, or approved projects in that catchment (or other reasonably foreseeable landscape-altering activities, programs or projects) so that the resulting cumulative impact on the sub-basin is capped.

While some criteria such as project installed capacity (in MW) do not provide a good indication of the significance and extent of likely environmental and social impacts, specifying an upper limit provides a clear cut-off to developers which, when combined with the other criteria, would remove higher impact projects from further consideration at the earliest possible stage.

The total percentage of a sub-basin regulated by a HPP, either by percentage of total outflow or drainage area, is a good indicator of the effects that river-flow changes are likely to have on sub-basin processes and the extent of river habitat disconnection. (For example, a medium-scale project in a medium-sized sub-basin may have a similar impact on river flows as a small project in a small sub-basin, if local conditions and features are similar.)

Preference should be given to true run-of-river projects over daily peaking and seasonal storage projects due to the lower degree of flow regulation. A run-of-river project is likely to have a lower impact on river flows than a storage project at the same site. Similarly, a storage project with minimal live storage volume compared to the river flow rate would alter flows to a lesser degree than a project with a large live storage.

Another criterion that should be considered is banning extensive new road construction or major road upgrading for project access in high conservation-value terrestrial habitat (Protected Areas, KBAs, critical habitat, and intact forest), given the indirect impacts that could have on these areas.

In coastal basin watersheds that drain directly into the sea, the exclusion of all projects on the main sub-basin tributary is not recommended except where the watershed is large, as the impact from a single HPP in a small coastal watershed does not have a cumulative impact on flow regulation and connectivity over a large area. But a cumulative limit across all coastal watersheds in that basin is recommended to ensure that these natural resources are not unduly degraded.

Special considerations should be required for sub-basins with multiple discharge points, including (i) coastal sub-basins with multiple watersheds discharging directly into the sea and (ii) inland sub-basins with multiple watersheds discharging directly into the mainstem river.

Projects of less than 10 MW capacity should be permitted if they meet the needs of local communities, but they are still required to adhere to the standard project-approval process requiring the preparation of an IEE and should not be approved if they have unacceptable environmental and social impacts.

Balancing the Utilisation of Medium and Low Zone Sub-basins

Basin hydropower sustainability will require balancing Medium and Low zone utilisation and protection rather than developing most of this area (covering over 75% of the country) for hydropower. In the early stages of SDF implementation all Medium and Low zone sub-basins should be considered for potential development. As new information is obtained on natural and social resources, and basin modelling is undertaken and projects developed, GoM should make decisions on which of these sub-basins (and selected watersheds within some sub-basins) should be reserved from HPP development, against the development of other drainage areas, to ensure that key processes and unique and representative values are maintained. As this occurs the Basin Zoning Plans should be updated accordingly.

Box 3: Norway Basin Master Plan

Norway developed the national river-basin Master Plan in the 1980s to unify management of the county's waterways. The plan included consideration of hydropower projects based on the degree of conflict of each project with different user interests (including protection) and power-plant economics. The least conflicting and least expensive (Category I) projects were granted licenses, while the most costly or conflicting (Category II) ones were not licensed. Initially, hydropower projects up to 1 MW capacity were exempt from this process, but this exemption was raised to 10 MW capacity or with annual generation up to 50 GWh in 2005.

8.3 Priority Sub-Basins for Hydropower Development

Sub-basin priorities for hydropower development, in order of merit, consist of:

- Low-zone sub-basins with existing (operational and under construction) cascade hydropower development;
- Medium-zone sub-basins with existing cascade hydropower development;
- Low-zone sub-basins without any existing medium/large HPPs; and
- Medium-zone sub-basins without any existing medium/large HPPs.

The GoM should determine a balance between the development and reservation of Low- and Medium-zone sub-basins as more detailed information on natural resources and social baseline is obtained and new HPP proposals are received. During this process, it is likely that some sub-basins or watersheds within sub-basins will be targeted for development or traded off against other sub-basins and watersheds that will be retained intact with no medium/large HPPs permitted.

8.3.1 Cascade Development

To increase power generation, cascade hydropower development in a limited number of sub-basins is usually preferable to similar total installed capacity developed across many sub-basins to reduce environmental and social impacts. In partly developed sub-basins where medium/large HPPs have already significantly modified river processes and aquatic ecology, further development raises the cumulative impact in these drainage areas (e.g. length of river affected and loss of cultivation land). This net increase, however, is usually far lower than the total cumulative impact of new projects on numerous undeveloped, free-flowing rivers with an equivalent installed capacity.

Cascade HPP development also allows generation to be maximized from the storage and regulation created by multiple HPPs on a tributary. Water stored in upstream reservoirs can be utilized by all downstream projects to generate power, thus increasing power generation in the dry season. This further development of existing “workhorse” sub-basins allows free-flowing sub-basins to be retained while still meeting power-generation targets. In addition, cascade development provides the opportunity to coordinate environmental and social mitigation and management measures across the landscape and between different developers. It also makes it possible to share a common high-voltage transmission line connection to the grid, thereby reducing related impacts.

More than 80% (3,912 MW) of Myanmar’s medium/large-scale HPP are in sub-basin cascade arrangements. There are seven existing sub-basin cascades and four sub-basins with a single HPP and at least one additional proposed project that will form a cascade upon development. Eight of these sub-basins are zoned Low partly due to river regulation and fragmentation by existing HPPs. Two sub-basins (Baluchaung and Sittaung Other) are zoned Medium. Myitnge Upper has been included in this group as it is part of a single natural drainage area with the Myitnge Lower sub-basin. Proposed and identified projects in these 11 sub-basins total 2,760 MW, accounting for 37.7% of all projects proposed in Low- and Medium-zone sub-basins across Myanmar (Table 8-9).

Table 8-9: Developed Sub-Basins with Existing or Proposed Cascade Arrangements

Sub-Basin	Sub-Basin Zone	Total Catchment Area[b] (km^2)	Sub-Basin Area – Myanmar (km^2)	Existing /Under Construction Projects (MW)	Total Exist. / Under Const. (MW)	Proposed/ Identified Projects (MW)	Total Proposed (MW)
Ayeyarwady							
Dapein	Low	7,077	1,235	Dapein 1	**240**	Dapein 2	**140**
Ma Gyi Chaung	Low	4,341	4,341	Sedawgyi	**25**	Upper Sedawgyi	**64**
Mone Chaung	Low	5,974	5,974	Buywa Upper (150) – const. Mone Chaung (75) Kyee Ohn Kyee Wa (74)	**299**	Buywa	**42**
Myitnge Lower (& Myitnge Upper[a])	Low (Med.)	30,517	30,517	Yeywa Upper (280) – const. Yeywa (780)	**1,060**	Yeywa Middle (700) Deedoke (66) (Myitnge Upper = Nam Tu (100), Nam Hsim (30), Nam Lang (210))	**766 (340)**
Shweli	Low	22,965	13,141	Shweli 1 (600) Shweli 3 (1,050) - const.	**1,650**	Nam Paw (20)[c] Shweli 2 (520)	**540**
Zawgyi/Myogyi	Low	16,327	16,327	Zawgyi I (18) Zawgyi II (12) Myogyi (30)	**60**		**0**
Thanlwin							
Baluchaung (tributary of Nam Pawn)	Med.	7,837	7,837	Baluchaung Upper (30) – const.	**278**		**0**

				Baluchaung 1 (28) Baluchaung 2 (168) Baluchaung 3 (52)			
Nam Teng	Low	15,386	15,386	Upper Keng Tawng (54) – const. Keng Tawng (51)	**105**		**0**
Sittaung							
Paung Laung	Low	4,986	4,986	Paung Laung Upper (140) Nancho (40) Paung Laung Lower (280)	**460**	Paung Laung Middle	**100**
Sittaung Other	Med.	28,698	28,698	Thauk Ye Khat 2	**120**	Thauk Ye Khat 1	**150**
Mekong							
Nam Lwe	Low	9,364	9,364	Mongwa	**66**	Keng Tong (170) Suo Lwe (240) Keng Yang (70) He Kou (138)	**618**
Total					**4,363**		**2,760**

Projects listed in order from upstream to downstream.
a. Myitnge Upper is considered with Myitnge Lower as this sub-basin has lost downstream connectivity due to the operation of the 700-MW Yeywa HPP.
b. Includes catchment within China.
c. On a tributary to the Shweli River.

This aggregation of projects is the result of a combination of suitable sub-basin/tributary features for hydropower generation (such as flow, topography, and geology), the generation advantage gained from river regulation by multiple projects, and proximity to load centers. The potential for further development of medium/large HPPs in these sub-basins, beyond current proposals, is unknown.

Five of the six Low-zone sub-basins with at least two existing (operational and under construction) medium/large-scale projects – Mone Chaung, Myitnge Lower, Shweli, Nam Teng, and Paung Laung – are prime candidates for further development from a biophysical perspective, given the larger scale of impacts that have occurred already, subject to further investigation. The Dapein sub-basin, with an existing HPP in Myanmar, also falls into this group as its upstream catchment has been substantially developed in China. Four of these sub-basins have at least one HPP located on the main tributary of that sub-basin. The sixth Low-zone sub-basin, Zawgyi/Myogyi, has a low degree of regulation, but 37% of its catchment area is regulated; therefore, it is on a slightly lower priority for development. It is unclear what hydropower studies have been completed to identify project opportunities in these sub-basins. As such, a review of any existing studies and more detailed feasibility assessment is recommended.

The seventh sub-basin with at least two existing medium/large-scale HPPs, Baluchaung, is zoned Medium due to its very high value aquatic ecosystem attributed to Inle Lake. The lake, the second-largest freshwater lake in Myanmar, has a unique biodiversity of fish and mollusks, with many endemic species, probably the result of its high karst location. An estimated 170,000 people reside around the lake and primarily rely on floating gardens for their livelihoods. But water quality and biodiversity in the lake are declining because of human activities, including unregulated tourism development and the introduction of exotic fish species. The three existing HPPs and the proposed Baluchaung Upper HPP are all located downstream. As there are no medium/large-scale HPPs in the lake's watershed, no HPPs are recommended upstream of the lake, but further hydropower development downstream could be considered.

Box 4: Sub-Basin Flow Regulation in China

The degree of flow regulation in Myanmar is affected by upstream dam development in three sub-basins with headwaters in China. The Dapein, Namtabak, and Shweli sub-basins have about 82%, 57% and 43%, respectively, of their total catchment in China; in each case, these headwaters are highly regulated with existing dams along the main tributary. Combined with existing development in the Dapein and Shweli sub-basis in Myanmar, these three cross-border sub-basins are prime targets for further hydropower development, which is expected to result in an incremental increase in overall impact if appropriate sites are selected with designs and management measures developed (subject to investigation). As these three sub-basins are all in high rainfall areas in the upper Ayeyarwady, the cumulative impact of altering the flow regime in these catchments needs to be considered, as flow regulation has the potential to affect the middle and lower Ayeyarwady.

Despite its notable geomorphology value, the Myitnge Upper sub-basin is also a possible target for cascade development as the 130-m-high Yeywa HPP dam, with an over 50-km-long reservoir in the Myitnge Lower sub-basin, already prevents sediment from reaching the mainstem Ayeyarwady. Upstream and downstream fish migration has also been cut off by this project.

Next on the lower priority for cascade development are two Low-zone sub-basins with an existing medium/large-scale HPP – Dapein and Ma Gyi Chaung – and at least one proposed HPP, Mongwa. The Medium-zone Sittaung Other sub-basin is modified by six HPPs in the low-order headwaters (none on the main tributary), collectively affecting 24% of the sub-basin, and forms the next level of development priority.

Five undeveloped sub-basins are considered for cascade development with no existing HPPs larger than or equal to 10 MW capacity (Table 8-10). Each sub-basin is zoned Medium and combined a total 38.5% (2,820 MW) of all proposed HPP capacity in sub-basins potentially suitable for development (out of 7,323 MW proposed and identified in Low- and Medium-zones). These proposed cascade developments could be considered by the GoM subject to detailed investigation. It should be noted, however, that the Namtabak sub-basin has a very high conflict rating and Nam Pawn and Lemro both have high conflict ratings.

Table 8-10: Developed Sub-Basins with Existing or Proposed Cascade Arrangements

Sub-Basin/s	Sub-Basin Zone	Total Catchment Area[1] (km^2)	Proposed/Identified Projects (MW)	Total (MW)
Ayeyarwady				
Namtabak	Med.	1,684 (718)	Nam Tabak 1 (141) Nam Tabak 2 (144)	285
Ngaw Chang Hka	Med.	2,554	Gaw Lan (120) Hkankawn (140) Tongxingqiao (340) Lawngdin (600)	1,200
Thanlwin				
Nam Pawn	Med.	11,553	Hpak Nam (105) Hpiy Seng (45) Upper Nam Pawn (150) Lower Nam Pawn (105) (note 1) Hawkham (180) (note 1)	585

Mekong				
Nam Hkoke	Med.	3,380	Mong Hsat (30) Nam Hkoke (30)	60
Rakhine				
Lemro	Med.	9,990	Lemro 1 (600) Lemro 2 (90)	690
Total				**2,820**

( ) Sub-basin area in Myanmar.
Note 1. Unlikely to go ahead due to geotechnical issues at dam site and very large resettlement requirements.

In summary, three-quarters (5,580 MW) of all proposed and identified HPPs in Low- and Medium-zone sub-basins are in a cascade arrangement. The potential for additional medium/large-scale HPPs in these sub-basins needs to be reviewed. Depending on how extensive past hydropower feasibility surveys of these sub-basins were, further investigation is recommended as a priority to assess if there are additional sites with hydropower potential that could be developed in preference to projects in undeveloped sub-basins.

8.4 Sustainable Hydropower Sector

The future direction of Myanmar's hydropower sector is difficult to predict given that it will be determined by many factors, including future power demand, the cost of hydropower over alternative power sources, and power export opportunities. The sector will also be influenced by the feasibility of individual projects, armed conflict in target areas, opposition to proposed projects, and other factors. But it is likely that new medium- and large-scale hydropower projects will play a significant role in the energy-supply mix in Myanmar.

Implementing the Basin Zoning Plans will move future hydropower development away from a concentration of large projects along the Thanlwin mainstem and in the N'mai Hka sub-basin (accounting for 60% of proposed hydropower capacity with the inclusion of the Myitsone HPP). This approach will disperse proposed projects (excluding identified projects) across 18 other sub-basins toward further cascade development in several priority Medium- and Low-zone sub-basins and their watersheds, in addition to some dispersed identified projects in other sub-basins in proximity to load centers.

Application of the Basin Zoning Plans excluding all mainstem hydropower development on the Ayeyarwady, Chindwin, and Thanlwin rivers would curtail the development of seven projects totaling 22,160 MW. These projects consist of five HPPs on the Thanlwin River totaling 14,960 MW (Table 8-2), the suspended Myitsone HPP (6,000 MW) on the Ayeyarwady River, and the Tamanthi HPP (1,200 MW) on the Chindwin River (the remaining 32.5% of mainstem projects) to retain these major essential waterways as free-flowing rivers. The Mong Ton project (7,000 MW) on the Thanlwin River is reportedly being redesigned as a cascade development with two or three lower dams and lower total installed capacity, but no details are known.

The reservation of 10 High-zone sub-basins would result in no large proposed projects developed totaling 13,895 MW (Table 8-11) on the main tributary of three sub-basins (Mali Hka, N'mai Hka, and Tanintharyi). Development on side streams (watersheds) in these 10 sub-basins may provide important opportunities for renewable energy generation but should only be considered in accordance with yet-to-be developed criteria restricting development to smaller scale, lower impact projects that cumulatively will not result in undue degradation of important processes and values in each sub-basin.

Table 8-11: High-Zone Sub-Basins – Proposed and Identified Projects

Basin	Sub-Basin	Planned HPPs	Planned Capacity (MW)	Identified HPPs	Identified Capacity (MW)
Ayeyarwady	Chindwin Headwater 1	0	0	1	150
	Chindwin Headwater 2	0	0	2	65
	Chindwin Upper	0	0	0	0
	Mali Hka	1	1,900	0	0
	N'mai Hka	7	11,395	0	0
Thanlwin	Thanlwin Middle	0	0	0	0
Mekong	Mekong Other	0	0	0	0
Tanintharyi	Tanintharyi	1	600[1]	3	56
	Tanintharyi Other	0	0	0	0
Rakhine	Kaladan	0	0	1	200
Total		**9**	**13,895**	**7**	**471**

Note: Sub-basins do not include mainstem projects.
1. The proposed Tanintharyi HPP (600 MW) has been suspended by the GoM.

Hydropower development could be permitted in Low- and Medium-zone sub-basins when the GoM deems that a project is appropriate based on site, design, and operating and management regimes. Some of these sub-basins, however, should be reserved to balance development with the protection of natural and social resources. To provide an indication of the hydropower capacity that may be suitable for development in these sub-basins, it is assumed that all proposed and identified HPPs in Low- and Medium-zone sub-basins will be developed. Some of these projects may prove to be unfeasible for development due to economic viability, engineering difficulties, or other reasons, but at the same time new projects are likely to be identified and developed. Therefore, proposed and identified projects only provide a rough indication of the magnitude of hydropower development in these areas over the next 30 years.

The installed capacity of proposed and identified projects within Medium- and Low-zone sub-basins potentially suitable for development totals 7,323 MW, as summarized in Tables 8-12 and 8-13.

Table 8-12: Medium-Zone Sub-Basins – Proposed and Identified Projects

Basin	Sub-Basin	Planned HPPs	Planned Capacity (MW)	Identified HPPs	Identified Capacity (MW)
Ayeyarwady	Ayeyarwady Lower	0	0	0	0
	Chindwin Middle	0	0	0	0
	Delta	0	0	0	0
	Indawgyi Lake catch. trib.	0	0	0	0
	Manipur	1	380	0	0

	Myitnge Upper	3	340	0	0
	Namtabak	2	285	0	0
	Ngaw Chang Hka	4	1,200	0	0
	Uyu	0	0	1	12
Thanlwin	Baluchaung	0	0	0	0
	Nam Hka	1	210	0	0
	Nam Pawn	5	585	0	0
	Thanlwin Lower	0	0	0	0
	Thanlwin Upper	0	0	0	0
	Yunzalin	0	0	1	100
Sittaung	Sittaung Other	0	0	1	150
Mekong	Nam Hkoke	1	30	1	30
Tanintharyi	Glohong Kra	0	0	1	40
Rakhine	Lemro	2	690	0	0
	Rakhine Other	0	0	0	0
	Thahtay	0	0	0	0
Total		**19**	**3,720**	**5**	**332**

Table 8-13: Low-Zone Sub-Basins – Proposed and Identified Projects

Basin	**Sub-Basin**	**Planned HPPs**	**Planned Capacity (MW)**	**Identified HPPs**	**Identified Capacity (MW)**
Ayeyarwady	Ayeyarwady Middle	0	0	0	0
	Ayeyarwady Upper	0	0	0	0
	Chindwin Lower	0	0	0	0
	Dapein	1	140	0	0
	Ma Gyi Chaung	1	64	0	0
	Mali Creek	0	0	0	0
	Mindon	0	0	1	18
	Mone Chaung	1	150	0	0
	Mu	0	0	0	0
	Myitnge Lower	2	766	0	0
	Myittha	0	0	0	0
	Shweli	2	540	0	0
	Zawgyi/ Myogyi	0	0	0	0
Thanlwin	Lam Pha	0	0	1	20
	Myet Taw Chaung	0	0	1	10
	Nam Ma	1	225	0	0
	Nam Teng	0	0	0	0
Sittaung	Bawgata	1	160	0	0
	Paung Laung	1	100	0	0
Mekong	Nam Lin	1	36	0	0

	Nam Lwe	4	618	0	0
Bago	Bago	0	0	0	0
Bilin	Bilin	1	280	0	0
Rakhine	Kyein Ta Li	0	0	1	28
	Saing Din Creek	0	0	1	77
	Than Dwe	0	0	1	39
Surma-Meghna	Barak	0	0	0	0
	Total	**16**	**3,079**	**6**	**192**

Hydropower projects are planned or identified in 12 of the 21 Medium-zone sub-basins (Table 8-12), two of which already have at least one existing HPP over 100 MW. Hydropower projects are planned or identified in 17 of the 27 Low-zone sub-basins (Table 8-13), six of which already have at least one existing HPP over 100 MW.

As a rough guide to the overall scale of future sustainable hydropower development, the following indication is provided although development is dependent on many factors:

- Existing projects = **3,300 MW**
- New hydropower generation = **8,900 MW + +**
  - Under construction = **1,600 MW**
  - Indicative Medium- and Low-zone development = **7,320 MW**
  - Lower impact HPPs in High-zone sub-basins = **impossible to estimate**
  - HPPs less than 10 MW capacity = **impossible to estimate**

Total sector = 12,200 MW + Lower impact HPPs in High-zones + HPPs less than 10 MW capacity

With hydropower investigations in priority sub-basins, it is possible that capacity could be added over time.

8.5 Social and Livelihood Issues

An evaluation of social and livelihood issues was undertaken to identify and assess socio-economic conditions in sub-basins across Myanmar, but as described earlier this evaluation was not used to determine sub-basin zoning because socio-economic issues are often far more specific to locations within sub-basins and the data available is broad scale and hence not a good indicator of HPP impact. The most appropriate level of analysis is the project area of influence and catchment. Accordingly, socio-economic impact assessment needs to commence once a potential project site has been identified, ensuring that these issues are considered in decisions about final site selection, and project design.

The sub-basin evaluation was restricted to data from the 2014 national census at the township level, which presented a challenge for analysis. To allocate township-level data the centroid points of the townships were overlain on sub-basins, which may have created some (unquantified) error in the statistical values for each sub-basin. Moreover, sub-basins typically have several townships, therefore the mean values of all townships in a particular sub-basin were applied, making it difficult to determine significant differences within sub-basins.

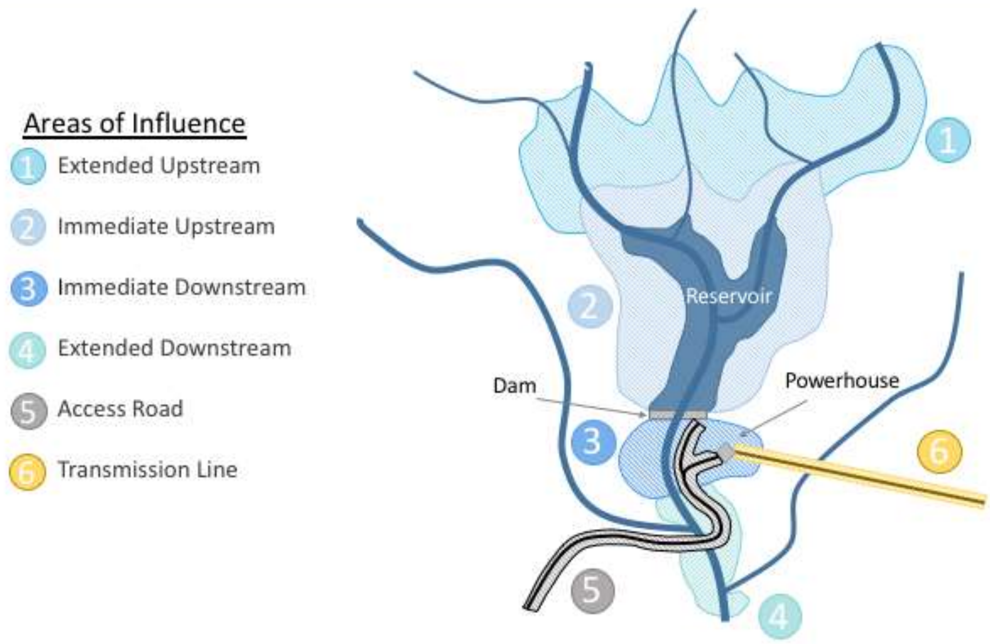
The analysis was also limited by the validity of using proxy poverty indicators for dependence on natural resources for livelihoods and social vulnerability. Proxy indicators were used in the absence of poverty data, as the data from the Myanmar Poverty and Living Conditions Survey 2015-16 was not suitable for spatial analysis and the 2009-10 Integrated Household Living Conditions Assessment was outdated.

Because of these limitations, the sub-basin ratings for social livelihoods were not used to inform the zoning plans as the indicators were not a good representation of the sub-basin or the type, scale, and severity of impacts associated with hydropower development. It can also be assumed that sub-basins with high and very high ratings for aquatic ecology/fisheries and geomorphology provide relatively healthy ecosystems services that are utilized. The focus of social and livelihoods is at the project level and the local communities living in the AOI of planned HPPs.

8.5.1 Project Level and Area of Influence

Recognizing that the impacts of hydropower are more localized, an areas of influence approach can be used to assess social impacts, collect socio-economic data and design effective stakeholder engagement. The AOI can make use of higher resolution village tract and village-level population data and incorporate specific technical data for hydropower plants. The six AOIs of a typical HPP are illustrated in Figure 8-3.

Figure 8-3: Hydropower Project Area of Influence



This approach identifies different types of potential impacts possibly experienced by people living within the AOIs, as summarized in Table 8-14. This is an indicative list as the scale and significance of impacts will vary depending on the size and type of HPP (e.g. run-of-river or storage), the operating regime (e.g. peaking versus baseload generation); social impacts associated with the construction of worker camps, access roads and transmission lines need to be assessed.

Table 8-14: Areas of Influence and Potential Socio-Economic Impacts

Zone	Potential Socio-Economic Impacts and Benefits
Zone 1: Extended upstream	• Fish migration blocked – impacts on fisheries for subsistence (most common) and commercial purposes (less common)
Zone 2: Immediate upstream	• Loss of land (agriculture, forest, communities, and cultural heritage sites) – reduced income, loss of family-owned assets, and loss of cultural identity • Resettlement of villages and habitations – major disruption of livelihoods and social situation • Loss of habitats for animals and reduced vegetation

	• Barrier to fish migration • Potential health impacts from stagnant water in reservoir • Potential for cage/pen aquaculture in larger reservoirs • Potential for tourism
Zone 3: Immediate downstream	• Severe reduction of flows – reduced availability for drinking water and irrigation as well as fishing possibilities • Dry river bed (if peaking plant of diversion) • Riverbank erosion affecting agricultural land
Zone 4: Extended downstream	• Variable or unseasonal flows • Reduced water quality and availability for drinking and irrigation • Bank erosion and sedimentation • Impact on fisheries • Impact on riverbank gardens and floodplain agriculture – reduced sedimentation and loss of soil fertility

8.5.2 Social Impact Assessment Provisions

The *Environmental Impact Assessment Procedure* (2015) includes requirements for social and socio-economic assessment and considerations. These are:

- **Socio-economic components:** income and livelihoods, living conditions and access to public services and natural resources, land-use maps, population distribution maps, maps and charts of other socio-economic indicators such as poverty, employment and education.
- **Public health components**: mortality and morbidity, occurrence of diseases, accidents and injuries, and social health determinants.
- **Cultural components:** description and maps of cultural, historical, and religious sites, structures and objects, and objects with high aesthetic value; description of traditional knowledge and beliefs, and cultural practices.

The Social Impact Assessment provisions, however, are not detailed. Review of existing EIAs in Myanmar show that public participation, gender, ethnic minorities groups or livelihoods issues have not been well covered. Stakeholders in this SEA process also highlighted a lack of transparency in the EIA process. Globally, hydropower has been shown to have widened gender disparities through the disproportionate share of impacts on women or the inequitable allocation of project benefits.

To improve EIAs, more guidance is needed on improving the Social Impact Assessment process. Where hydropower cascades are planned, CIAs should also provide opportunities to collect and analyze socio-economic data at either a catchment or sub-basin level, involving sample surveys of populations, mapping natural-resource use, livelihoods, vulnerability to flooding/drought and areas of cultural significance.

8.6 Conflict

Conflict between state and non-state armed groups was assessed as a fifth layer in the baseline evaluation of sub-basins as it is a significant constraint to hydropower development in many areas of Myanmar. In instances where the precursors of armed conflict are present, hydropower development can potentially exacerbate conflict. Therefore, early identification and consideration of the conflict status of an area proposed for a hydropower project is essential. The risks of conflict should be defined to enable informed decisions on whether a project should proceed and how to manage it.

Similar to the ‘social and livelihood’ baseline evaluation, the conflict evaluation ratings were not used to determine sub-basin zones as conflict can be in flux over the short to medium term and different situations can range from workable to off limits. As such, the conflict layer prepared from this evaluation provides an additional layer for developers to consider when identifying potential sites, and for GoM to consider when assessing a project application for a “clearance” certificate.

Many proposed projects are in areas associated with persistent armed conflict between the Myanmar Army, EAOs, and militias or border-guard forces. Even when EAOs have been cleared by the military from hydropower areas, there is little guarantee that they will not return to their indigenous territory, renewing conflict and threatening the security of project areas. Developing projects under these conditions exposes developers to unacceptable risks and can entrench existing divides between affected communities and the Myanmar State.

Conflict can also be understood as local or national public opposition to specific projects. Depending on its type and severity, conflict can impose a range of consequences for hydropower development, including an inability to work safely in a project area, challenges in obtaining finance, and project delays or even suspension. Conversely, hydropower development can worsen conflict by stoking public opposition and inducing armed conflict between state and non-state forces vying for territorial control, or by fueling long-term grievances over who has the right to control and benefit from resources in ethnic minority areas.

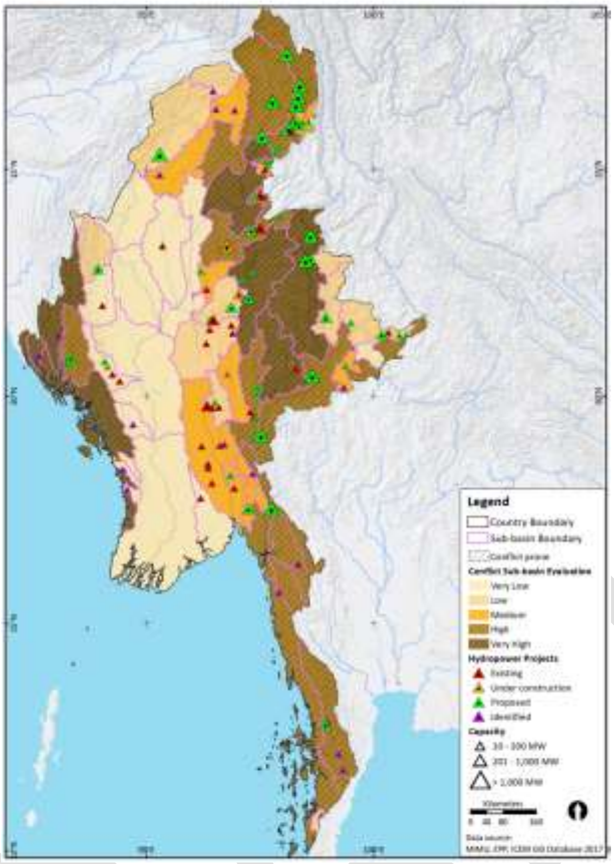
Conflict vulnerability was evaluated based on the current and historic status of armed conflict in each sub-basin, considering factors such as the presence of armed groups (disagreement over governance and territory); historic population displacement (a proxy indicator for equality and rights issues); conflict incidents between 2012 and 2016 (patterns of violence associated with contested territory); and estimated battle deaths between 1989 and 2015 (patterns of violence associated with contested territory). A map of armed-conflict geography was developed based on aggregated media reports of such incidents since 2011 and academic estimates of battle deaths according to location. Each factor was scored based on the highest level recorded for that factor in a sub-basin before assigning it an overall rating from 1 to 5 to indicate conflict vulnerability. To simplify the ratings for planning purposes, Very High (5) and High (4) ratings were grouped together to indicate “conflict-prone” sub-basins, and Medium (3), Low (2) and Very Low (1) ratings were grouped to indicate “non-conflict prone” (Figure 8-4).

8.6.1 Conflict as a Peace-Building Model

To achieve sustainable hydropower development, Myanmar needs to recognize that development can be an avenue toward peace rather than division and conflict. This requires more than “environmental and social compliance” or “risk mitigation.” Much of Myanmar’s hydropower resources is located where military and political control and resource use have been contested for decades if not centuries. In such areas, sustainable development requires addressing fundamental questions about who decides, owns, and benefits from hydropower development, similar to how the issues of political power and resource sharing are subjects of the peace process.

In general, mitigating conflict risk and promoting peace requires decentralized decision-making and the distribution of project benefits to stakeholders directly and indirectly affected by hydropower development.

Figure 8-4: Sub-Basin Conflict Rating



8.6.2 Conflict Assessment and Management

The risk that conflict poses to hydropower development, and vice versa, calls for the establishment and implementation of robust safeguards to ascertain and manage risks in conflict-prone geographies. While many issues causing conflict are deep seated and have not been resolved for extended periods, conflict is dynamic and affects different locations from year to year. The geographical analysis conducted during the SEA baseline evaluation provides a useful guide to the geographies of risk but is not a substitute for the latest and detailed conflict assessment specific to proposed hydropower developments in areas of risk. Conflict assessment and mitigation in subsequent stages of hydropower development should be viewed as a requirement that may increase initial costs and process complexity but ultimately safeguards the value and sustainability of the investment over a longer term.

Conflict assessment and mitigation during feasibility studies: The map and sub-basin ratings provided in Figure 8-4 can be used as a guide in the preliminary stages of project planning to identify if conflict may exist in the area. For potential hydropower projects in sub-basins with a high, or very high (4, or 5) rating, detailed conflict assessments should be conducted alongside feasibility or pre-feasibility stages. These assessments should:

- be undertaken by independent authorities with full transparency to project proponents, the GoM, CSOs, and the public at large;
- recommend appropriate strategies to mitigate conflict risks specific to projects and associated geographies and stakeholders;
- be incorporated into the hydropower development process and decisions, ensuring that costs for assessments and mitigation measures are adequately addressed and;
- be applied to projects in medium, high, or very high-risk locations in the current development pipeline, particularly for those in high- or very high-risk areas. Where development has

progressed to construction or operation, recommendations from conflict assessment should be focused on conflict management, which may entail further stakeholder consultation or benefit sharing as introduced in subsequent sections.

8.6.3 Broaden Stakeholder Engagement

Stakeholder engagement for hydropower development typically centers on people that are potentially directly affected by hydropower development in the specific locations slated for new dams. Improving consultation to meet this standard in Myanmar will go some way to addressing grievances concerning the past lack of public consultation and accountability in hydropower development, but it is not enough for a sustainable pathway under conflict conditions. The history of armed conflict in many areas with planned HPPs has displaced a lot of people and politicized questions of development in these long-contested areas. As a result, the range of "indirect stakeholders" linked to hydropower development in such areas is much broader than in other contexts. Failure to canvass and incorporate their perspectives leaves hydropower development processes vulnerable to armed and unarmed spoilers. Public engagement during feasibility studies should be expanded to include:

- **Consultation with displaced people**: The concept of "indirect stakeholders" should cover populations displaced by conflict from project-affected areas. Although these people no longer reside in areas proposed for development, they retain familial, historical, cultural, and livelihood links, so their situations and needs should be assessed. Environmental and social impact assessments (ESIAs) should estimate human population placement, ensure consultation with displaced communities, and incorporate their concerns and interests in resulting mitigation and management plans.

- **Consultation with non-state actors**: Public engagement needs to involve legitimate representatives of ethnic minority and other communities. Consultations and resulting environmental and social management plans should incorporate the perspectives of additional non-state actors (i.e. CSOs, EAOs, and ethnic political parties) who represent the broader rights and political interests of potentially affected populations. In some cases, it is difficult for government and project proponents to determine who the legitimate representatives of communities are, thus giving CSOs and local communities the opportunity to make this distinction is important.

- **Strengthening oversight and legitimacy of consultations, ESIA, and management plans:** Project proponents should avail themselves of the knowledge and networks of CSOs and mechanisms to ensure that they consult the right people, and that the resulting ESIAs and management plans are robust and trusted. Civil society networks, including the Myanmar Alliance for Transparency and Accountability (MATA), the Extractive Industries Transparency Initiative Multi-Stakeholder Group (EITI-MSG), or the Burma Environmental Working Group (BEWG) among others, could be included in consultation and assessment procedures. The GoM should avail itself of their technical expertise and local knowledge as well as provide resources to support the involvement of independent expert groups who can help ensure the quality of assessment processes and products.

8.6.4 Benefit-Sharing and Peacebuilding Potential

Sustainable hydropower development can only occur under peaceful conditions, which can only be maintained if the unique stakeholders and issues of Myanmar's peace and conflict history are taken into consideration when planning development. To explore and enact the peacebuilding potential of hydropower, particularly in relation to benefit sharing, it is recommended to:

- **Research related to hydropower benefit-sharing mechanisms, and how they relate to the peacebuilding challenges of Myanmar.** Prepare a white paper on hydropower benefit- sharing in contested states that outlines the risks and opportunities for peacebuilding in Myanmar. The paper should explore the possibility that hydropower can contribute to peacebuilding, specifically through the adoption of international best practices and standards tailored to the context of Myanmar's specific ethno-political challenges. Significant risks of this strategy should be first acknowledged and explored.

- **Incorporate ethnic minority and peace-and-conflict perspectives into hydropower policy and regulations**. Existing hydropower laws and policies do not adequately reflect the risks of armed conflict to sustainable hydropower development, or the risks of hydropower development to the peace process. This leaves project proponents in a difficult position to understand or respond to peace-and-conflict risks and opportunities. A range of civil society networks, e.g. the Ethnic Nationalities Affairs Council (ENAC), BEWG, and numerous CSOs, have produced substantive policy guidance regarding the development of natural resources in ethnic minority areas, and how this relates to the peace process. These perspectives should be included in policy and regulatory reforms. ENAC, BEWG, MATA, or the EITI-MSG as well as the Civil Society Forum for Peace provide mechanisms through which policies can be presented and perspectives shared. Inclusive policy processes are not without precedent and were used, for example, under the previous administration to produce the National Land Use Policy, which, like hydropower, has significant implications for ethnic and conflict-affected communities.

- **Incorporate discussions on hydropower development into the peace process.** Some EAOs – both signatories and non-signatories of the NCA – are involved in hydropower development and operations, while others have been approached as potential development partners, or have expressed an interest in doing so. The question of whether EAOs could play a role in Myanmar's hydropower development and how this could serve to support rather than undermine a transition toward federalism is worth exploring. This topic could be discussed further in the peace process, perhaps in the Panglong's natural resource and economic committees at the discretion of the Union Peace Dialogue Joint Committee. The concerns and potential watchdog roles of CSOs and international partners should not be neglected.

9 BASIN SUSTAINABILITY

The delivery of hydropower sustainability within each basin based on implementation of the SDF is described below, summarizing what each basin-zoning plan and related measures are likely to achieve in terms of balancing environmental and social sustainability with hydropower generation.

9.1 Ayeyarwady Basin Hydropower Sustainability

9.1.1 Environmental and Social Sustainability

Existing hydropower-storage projects regulate 16.7% (68,804 km^2) of the Ayeyarwady basin (Figure 9-1), while the catchments of existing run-of-river projects cover an additional 1.7% (6,844 km^2). In total, 18.4% of the basin is longitudinally disconnected from the rest of the basin by HPP dams, preventing the flow of sediment downstream and the movement of fish upstream or downstream. Most of these regulated sub-basins are in high rainfall areas and enter the Ayeyarwady river between the Myitsone confluence and the Myitnge confluence.

Mainstem reservation would maintain around 1,500 km of the Ayeyarwady River from the Myitsone confluence to the sea and 900 km of the Chindwin River from the Ayeyarwady confluence up to the headwaters of the Chindwin in the Hukawng Valley, Kachin State, in a free-flowing state. The intact mainstem would provide connectivity between the mainstem confluences of 24 sub-basins (91% of the basin within Myanmar) and the sea, with just three sub-basins (Ngaw Chang Hka, Myitnge Upper, and Myittha) separated from the mainstem by downstream sub-basins.

The proposed reservation of the five High-zone sub-basins, coupled with mainstem reservation, will maintain seven intact rivers with unregulated connection to the sea, covering a total drainage area of 77,892 km^2, or 20.9% of the Ayeyarwady basin within Myanmar:

- Chindwin Headwaters 1 (5,977 km^2) – Tarung Hka;
- Chindwin Headwaters 2 (7,813 km^2) – Ta Nai Hka;
- Chindwin Upper (23,314 km^2) – Chindwin River tributaries;
- Mali Hka (23,287 km^2) – Mali Hka; and
- N'mai Hka (17,501 km^2) – N'mai Hka and Nam Tamai.

Sub-basin reservation would maintain an estimated 47% of the total Ayeyarwady basin flow[40] in a natural state given the high contribution of these headwaters to river flows. A substantial but unquantified proportion of sediment is also derived from these river basins, which would remain available for transport through the mainstem and deposition in the delta and coastal areas. River functioning across the basin will also be vulnerable to changes associated with the establishment and operation of non-hydropower river/water-resource infrastructure, changes in land/forest cover (e.g. deforestation), the volume of river water extracted for other uses (primarily irrigation), and other land uses and developments within the basin.

The Ayeyarwady has 36 river reach types, 29 of which are rare or very rare. The maintenance of connectivity between the mainstem and the High zone sub-basins, especially in the basin headwaters (Mali Hka, N'mai Hka, and Chindwin) would ensure that many rare rive reaches remain connected to the rest of the river system. Some tributaries that are important for endemic species of fish and other aquatic flora and fauna would remain connected with the mainstem and intact rivers, including the Mali Hka around Putao town, the Indawgyi Lake tributary and in the Chin Hills, and on the eastern side of the Rakhine Yoma.

The exclusion of large-scale HPPs in the five High-zone sub-basins would avoid direct and indirect impacts on five protected areas (Hkakabo Razi National Park, Hponkan Razi, Hukawng Valley, and Bumhpabum and Htmanthi wildlife sanctuaries), KBAs, and above 80% canopy-cover intact forest, which covers 72.2% of this area (56,213 km^2), representing around 34.6% of Myanmar's total

[40] Proportional estimate based on catchment discharges contained in the *Ayeyarwady State of the Basin Assessment (SOBA) 2017: Synthesis Report, Volume 1.* Yangon, December 2017. HIC.

remaining intact forest. The area supports three relatively intact ecoregions that, within Myanmar, are only found in the Upper Ayeyarwady basin: (i) Northern triangle temperate forests – 100% of this ecoregion is in these five sub-basins; (ii) Northern triangle sub-tropical forest – around 84%; and (iii) Nujiang-Langcang Gorge alpine conifer and mixed forests – 80%, whose global condition is indicated as critical/endangered.

Other important processes and functions that would be maintained by the reservation of mainstem rivers and High-zone sub-basins include:

- Seasonal flows and sediment inputs into the river would help maintain navigational channels and promote bank stability. This is particularly relevant to the middle Ayeyarwady between Mandalay and Bagan, where river slopes are exceedingly low and sediment movement is directly dependant on the reservation of very high-flow events;
- The productive Ayeyarwady floodplains ecosystem downstream of Mandalay, which depends on the seasonal flood and low water patterns, would be affected to a lesser degree than full BAU development. This would help maintain key areas for fish and floodplain agriculture;
- The maintenance of seasonal patterns of flows would allow migratory fish, such as Hilsa, eel, and Macrobrachium prawns, to move up and down the river. Hilsa breeding sites have been recorded as far as Bhamo on the Ayeyarwady and up the Chindwin River, and Anguilla eels are known to reach Putao;
- The maintenance of flows and sediment transport that are critical in supporting the Ayeyarwady Delta ecosystems, mangrove forest cover, and the significant delta fishery, including the Meinmahla Kyun Ramsar site; and
- Minimizing HPP-related road development in forested areas would prevent large inputs of sediment from the disturbed areas. In the Ayeyarwady, this is a positive benefit as high sediment from land-use changes has been linked with channel infilling and navigation problems in the middle Ayeyarwady[41].

Unique values in the Ayeyarwady basin that would be protected from large-scale HPP impacts by mainstem and sub-basin reservation include:

- the high cultural value of the Ayeyarwady, considered by many as the mother river in Myanmar;
- the confluence of the Mali and N'mai rivers, recognized as the cultural homeland of the Kachin people[42]; and
- seven riverine KBAs located along the Ayeyarwady mainstem encompassing different reach types and habitats: (1) Myitkyina to Sinbo; (2) the Bhamo Section; (3) the Shwego Section; (4) the Ayeyarwady Dolphin Reach; (5) the Bagan Section; (6) the Singu Section; and (7) the Sinbyugyun to Minbu Section. These KBAs support endangered species including turtles, water birds, and the Ayeyarwady Dolphin, of which only about 70 remain.

In addition, the utilization of the 22 sub-basins zoned Medium (9) and Low (13), covering 31.4% (117,165 km^2) and 47.7% (177,848 km^2), respectively, of the Ayeyarwady basin, for hydropower development will provide considerable scope to balance power generation and the maintenance of natural and social resources.

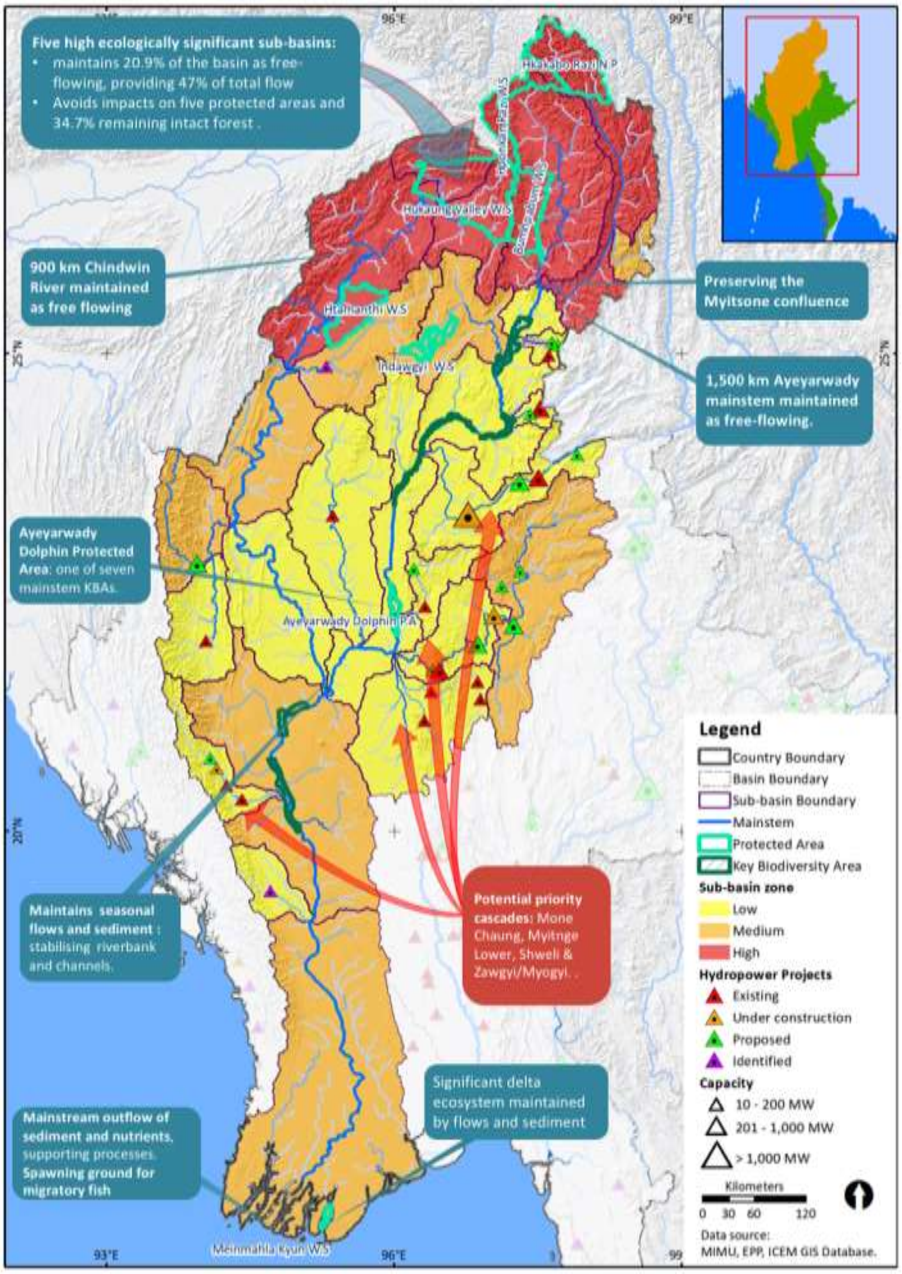
9.1.2 Power Generation

The total operational capacity of HPPs larger than or equal to 10 MW in the Ayeyarwady basin is currently at 2,100 MW, with a further 1,372 MW under construction. Proposed and identified HPPs in Low- and Medium-zone sub-basins of the Ayeyarwady total 3,895 MW. Subject to further investigations and constraints, additional potential hydropower may be found in many of these sub-basins, particularly the four with existing cascade development – Mone Chaung, Myitnge Lower, Shweli, and Zawgyi/Myogyi. Other priority sites include the Myitnge Upper (because the Myitnge

[41] WWF, 2017.
[42] Kiik, 2016.

Lower has cascade hydropower) and two other sub-basins – Dapein and Ma Gyi Chaung – one of which has an existing HPP and the other has at least one additional proposed/identified project. In addition, the Namtabak sub-basin, with headwaters already regulated in China, also has potential beyond the two proposed HPPs in Myanmar.

Figure 9-1: Ayeyarwady Basin Sustainability



9.2 Thanlwin Basin Sustainability

9.2.1 Environmental and Social Sustainability

Existing hydropower-storage projects in the Nam Teng and Baluchaung sub-basins regulate 12.9% (16,492 km^2) of the Thanlwin basin (Figure 9-2) within Myanmar, longitudinally disconnecting this area from the rest of the basin, which prevents the free flow of sediment downstream and the movement of fish up and downstream.

Maintaining the mainstem would reserve around 1,200 km of the Thanlwin as a free-flowing river from the Myanmar-China border downstream to the sea. Combined with mainstem reservation in China, there is potential to maintain connectivity along 2,800 km of the Nu-Thanlwin River[43]. Banning large-scale HPPs on the mainstem of the Thanlwin would reserve one of Asia's few remaining rivers that retains large-scale geomorphic functioning – with seasonal flow and sediment production from the steep, crystalline mountains – and maintains the fragile coastal environment.

The intact mainstem would provide connectivity between the confluences of 10 sub-basins in Myanmar and the sea. The reservation of the High-zone Thanlwin Middle sub-basin, combined with mainstem reservation, would maintain the Nam Pang, the largest tributary of the Thanlwin, as an intact river with connectivity to the sea, covering a total drainage area of 15.9% (20,264 km^2) of the basin within Myanmar. The mainstem also has connectivity with numerous very small tributaries that provide important habitats.

The Thanlwin has 37 different river-reach types, 29 of which are rare or very rare. Connectivity between the mainstem and the Nam Pang is critical for aquatic ecology and sediment transport. With a series of in-channel wetlands, rapids, and small waterfalls, the Nam Pang is ecologically significant for its river morphology, landscape, and likely spawning grounds for migratory fish. The "*Thousand Islands*"-landscape feature at the confluence of the two rivers has high biodiversity and significant cultural value for local communities.

Reserving the Thanlwin Middle sub-basin would avoid direct and indirect impacts on this catchment, comprising nearly 85% (17,202 km^2) of the KBA. The area supports two relatively intact ecoregions: (i) Kayah-Karen montane rain forests – 78.3% (15,864 km^2) of this ecoregion is in Myanmar – which are the fourth-richest type in the Indo-Pacific region for mammals, and (ii) Northern Indochina subtropical forests – 21.7% (4,400 km^2) in Myanmar.

Other important benefits that would result from the reservation of the mainstem and the Thanlwin Middle sub-basin include:

- Avoidance of large impoundments with potential to significantly alter connectivity, flow, sediment transport, and fish migration.
- Maintenance of flows and conduits for fish migration. There are an estimated 100 species of fish that migrate between the Thanlwin River and its tributaries. Maintaining seasonal-flow patterns will mean that migratory fish, such as Hilsa, will continue to move up and down the river.
- Maintenance of sediment and nutrient delivery to floodplains that support floodplain vegetation, agriculture, and fisheries. Wetlands support habitats for the Fishing Cat, the Asian Small-Clawed Otter, and the Siamese Crocodile.
- Maintenance of connectivity with the Nam Moei tributary that forms the border with Thailand, which is an area with rare and endemic fish and aquatic species.

Unique values in the Thanlwin that would be protected from large-scale HPP impacts include:

- Freshwater habitats for 92 amphibian species – the river has the world's greatest diversity of turtles, including the endangered Giant Asian Pond Terrapin and Bigheaded Turtle[44].
- Habitat for a wide variety of fauna, including sandpipers, turtles, bats, and tigers in the Thanlwin Lower sub-basin.
- No large hydropower development in the conflict-affected Thanlwin Upper, Middle, and Lower sub-basins.

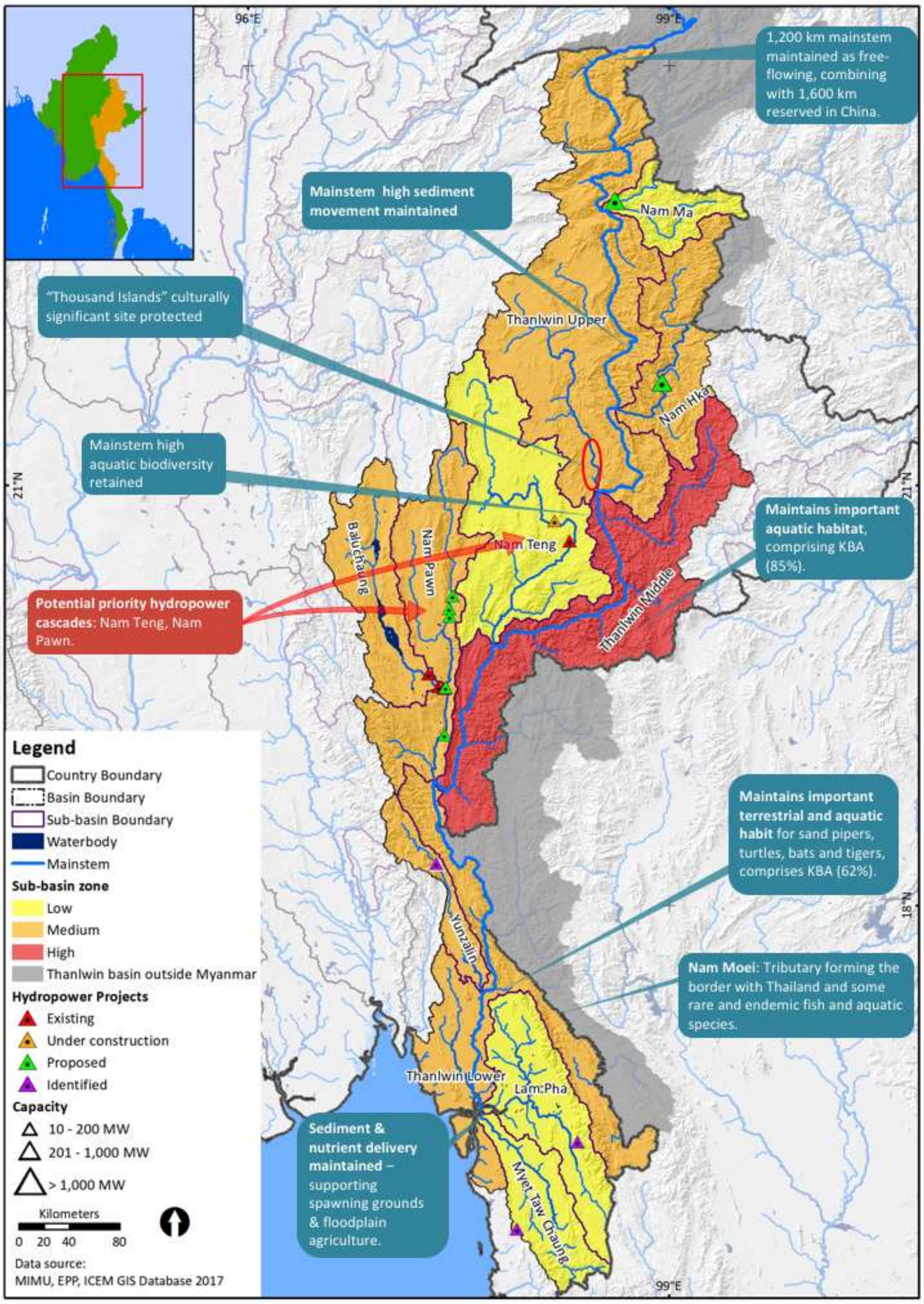
9.2.2 Power Generation

[43] In 2016, a 13-dam cascade on the Nu-Thanlwin River with a total installed capacity of 21,320 MW was suspended by the People's Republic of China due to environmental and social concerns.
[44] http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/river_decline/10_rivers_risk/salween_river/

The 10 sub-basins zoned Low (5) and Medium (5) comprise 57.9% (73,843 km^2) and 26.2% (33,386 km^2) of the Thanlwin basin within Myanmar, respectively, covering a combined total of 84.1% of the basin. Deciding which of these 10 sub-basins should be used for hydropower development or reservation adds considerable scope to balance sustainability with energy generation.

The total operational capacity of HPPs larger than or equal to 10 MW in the Thanlwin basin is currently at 302 MW. The Baluchaung sub-basin has three operational HPPs (248 MW) and one under construction (30 MW), while the Nam Teng sub-basin has one operational project (54 MW) and another under construction (51 MW). Additional potential hydropower may be found in these two sub-basins with existing cascades, or the Nam Pawn sub-basin where five HPPs are planned with installed capacity of 585 MW. Both the Nam Teng and Nam Pawn sub-basins, however, are conflict-prone areas and further conflict sensitivity analysis would be required.

Figure 9-2: Thanlwin Basin Sustainability



9.3 Mekong Basin Sustainability

9.3.1 Environmental and Social Sustainability

Myanmar contains 2.7% (21,947 km^2) of the Mekong basin area (Figure 9-3), which is estimated to contribute 2% of the total basin flow. An existing hydropower project in the Nam Lwe sub-basin (the Mongwa HPP – 66 MW) regulates 43% (9,364 km^2) of the total Mekong basin area in Myanmar, disconnecting it longitudinally from the rest of the basin and thereby preventing the free flow of sediment and fish migration between the upstream section of Nam Lwe and the Mekong mainstem.

Mainstem reservation would maintain around 180 km of the Mekong River along the Myanmar-Lao PDR border. The reach would provide modified aquatic habitat due to upstream regulation in China but would not add to these existing flow and sediment changes.

The reservation of the High-zone Mekong Other sub-basin would deliver three intact rivers with a direct connection to the Mekong mainstem (Nam Mae Kham and Nam Pho/Nam Ngaou), covering a total drainage area of 6,534 km^2, equal to 29.8% of the Mekong basin within Myanmar.

The Mekong Other sub-basin is effectively the Mekong mainstem along the Myanmar border from China to the Golden Triangle. It consists of 287 km of mainstem rock-cut river channel, containing seven river-reach types of which three are rare. Reserving the sub-basin would maintain connectivity, flow, and sediment input to the Mekong mainstem. The area has a very high ecological value due to the presence of migratory and critically endangered/endangered fish species. The length of the Mekong mainstem is recognized as a riverine KBA.

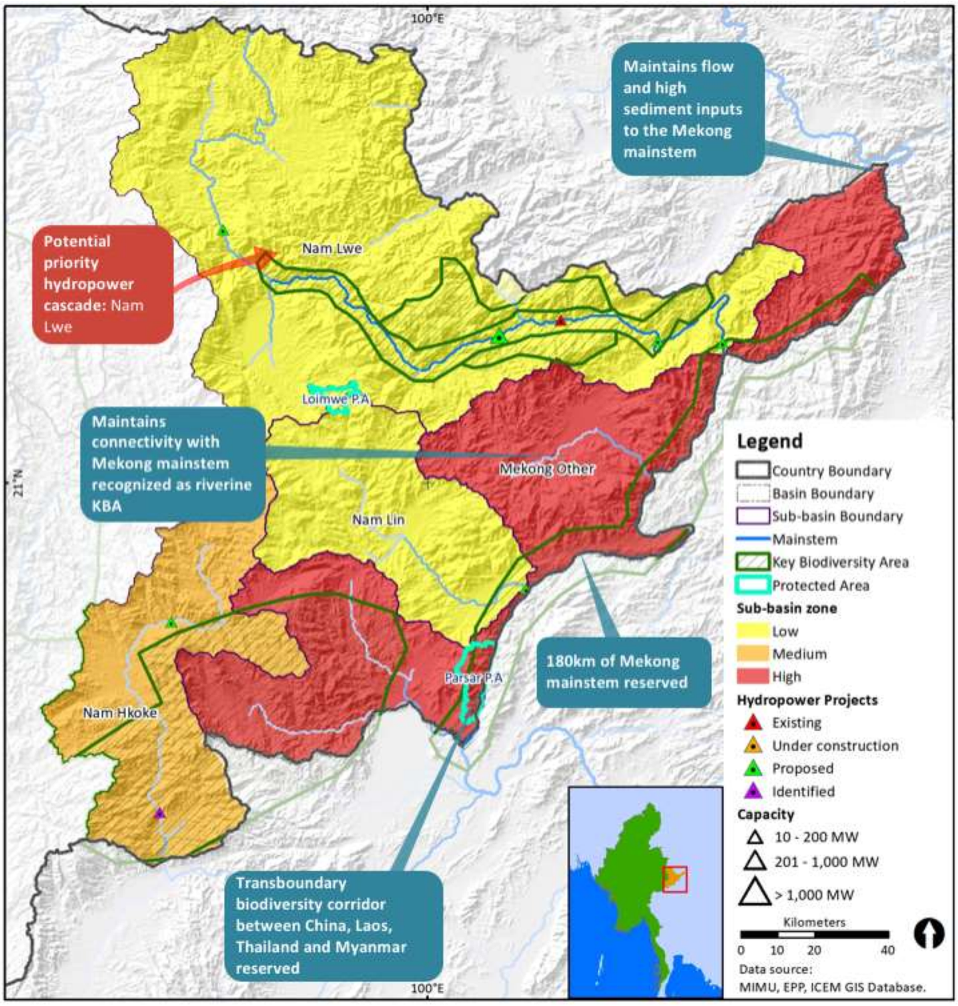
Sub-basin reservation would avoid direct and indirect impacts on an area comprising KBA (40%), intact forest (12%), and the Parsar Protected Area (2%). The KBA is an important habitat for small mammals and a transboundary biodiversity corridor between China, Lao PDR, Thailand, and Myanmar. The area falls within the Northern Indochina subtropical-forest ecoregion. Sub-basin reservation would also avoid large-scale hydropower development in this conflict-affected area.

9.3.2 Power Generation

The three sub-basins zoned Low (2) and Medium (1) cover a combined total of 70.2% of the Mekong basin within Myanmar, with Low-zone making up 54.7% (12,002 km^2) and Medium-zone making up 15.5% (3,411 km^2).

The total operational capacity of HPPs larger than or equal to 10 MW in the Mekong basin is currently at 66 MW, with one existing project in the Nam Lwe sub-basin. Potential cascade hydropower could be added in the Naw Lwe, where four HPPs are planned with total installed capacity of 618 MW. There may also be potential for a cascade in the Nam Hkoke where there is one planned HPP with 30 MW installed capacity and another identified potential site (Nam Hkoke – 30 MW). This, however, requires further investigation.

Figure 9-3: Mekong Basin Sustainability



9.4 Sittaung Basin Sustainability

9.4.1 Environmental and Social Sustainability

The Sittaung basin (Figure 9-4) has a high level of existing hydropower development, with nine HPPs (including seven storage ones) regulating 32.2% (11,258 km^2) of the basin. The projects disconnect these catchments from the sea and alter river-flow patterns, preventing the free flow of sediment downstream and the movement of fish upstream or downstream. In the upper catchment, about half of the flow is regulated, with the percentage decreasing to around 35% in the lower catchment and 24% at the mouth of the river. This level of regulation has a high risk of inducing geomorphic changes and may already be contributing to changes in the coastal area due to a reduction in sediment deposition[45].

Mainstem reservation would maintain around 400 km of the Sittaung River from the confluence of the Sinthay River to the sea in a free-flowing state. Although existing hydropower development regulates a third of the basin, protection of the intact mainstem would provide connectivity with each upstream sub-basin and ensure that the Sittaung River discharges sediment and nutrients into the Gulf of Mottama, which was recently designated as a Ramsar Site.

[45] Anthony et al., 2017.

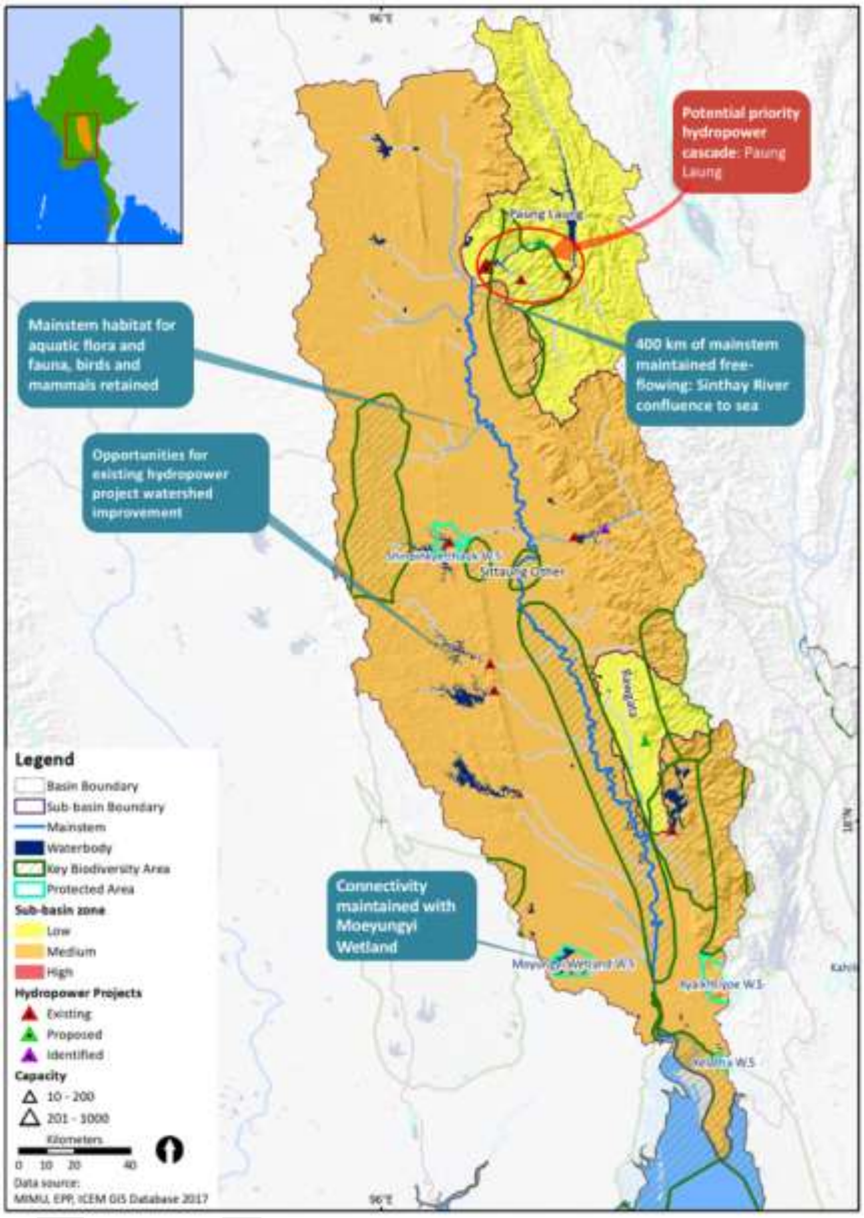
Other important processes and unique values that would be maintained by the reservation of the mainstem river include:

- coastal processes reliant upon natural outflows and sediment discharge;
- connectivity with the Moeyingyi Wetland Ramsar site, which plays an important role in providing wildlife habitat for freshwater wildlife (including migratory waterbirds), flood control, and irrigation water; and
- seasonal-flow patterns that allow migratory fish such as Hilsa to move along the mainstem.

9.4.2 Power Generation

The basin's three sub-basins are zoned Medium (Sittaung Other) and Low (Bawgata and Paung Laung), covering 82.2% (28,698 km^2) and 17.8% (6,215 km^2), respectively. The total operational capacity of nine HPPs larger than or equal to 10 MW in the Sittaung basin is currently at 810 MW. Proposed and identified HPPs in the three Low- and Medium-zone sub-basins total 345 MW. Additional potential hydropower may be identified in the basin, with a possible priority being on the Paung Laung sub-basin that already has cascade projects, subject to investigation. Where additional projects are sited, how they are designed and their operating regimes will dictate hydropower sustainability in the basin beyond the current level of development.

Figure 9-4: Sittaung Basin Sustainability



9.5 Bago Basin Sustainability

A single hydropower project, the Zangtu HPP (20 MW) on the Bago River, regulates 10.7% (1,098 km^2) of the small Bago basin (10,261 km^2). This storage project longitudinally disconnects this catchment from the rest of the basin, altering the flow pattern and preventing the free flow of sediment downstream and the movement of fish up or downstream.

The 200-km long Bago River has not been defined as a mainstem for reservation due to the relatively small catchment with a low Strahler Order main river. The single sub-basin has been zoned Low and is potentially suitable for hydropower development, although no projects have been proposed or identified. HPPs, if identified, should be required to apply sustainable project siting, design, and operation requirements. Where approved projects are sited, how they are designed and their operating regimes will dictate hydropower sustainability in the basin.

9.6 Bilin Basin Sustainability

No hydropower projects of 10 MW capacity or greater exist in the small Bilin basin (3,056 km^2). Therefore, natural river connectivity with the sea remains.

The 210-km long Bilin River has not been defined as a mainstem for reservation due to its relatively small catchment with a low Strahler Order main river. The single sub-basin has been zoned Low and is potentially suitable for hydropower development. So far, one project has been proposed in the basin: the 280-MW Bilin storage project, which has a high dam (131 m), a very large reservoir (310 km^2), and long reservoir-residence time (around 578 days), would substantially regulate flows from 73.6% (2,250 km^2) of the basin, longitudinally disconnecting this catchment from the rest of the basin, preventing the free flow of sediment downstream and the movement of fish up or downstream.

Additional HPPs identified in the basin should be required to undergo sustainable project siting, design, and operation requirements. Where approved projects are sited, how they are designed and their operating regimes will dictate hydropower sustainability in the basin.

9.7 Tanintharyi Basin Sustainability

9.7.1 Environmental and Social Sustainability

The Tanintharyi basin (Figure 9-5) has no existing or under-construction hydropower projects of 10 MW or greater; therefore, these rivers remain unregulated. The Tanintharyi, its main river, has a catchment covering 39.8% (17,865 km^2) of the basin, while much of the rest of the basin is composed of small coastal watersheds. No mainstem reservation is recommended at this stage due to the size of the Tanintharyi River and lack of information on this resource.

The reservation of the two High-zone sub-basins – Tanintharyi and Tanintharyi Other, covering 97.8% (43,884 km^2) of the basin – would deliver six intact rivers with unregulated connection to the sea:

- Tanintharyi – Tanintharyi, Sarawa, and Ngawan Chaung rivers
- Tanintharyi Other – Ye, West Coast, and Lenya rivers

Sub-basin reservation would maintain key processes such as river discharge and sediment supply, supporting large coastal areas. These areas include mangrove forests, the estuarine Kyunsu KBA, and the marine Myeik Archipelago KBA.

The reservation of these two sub-basins would avoid direct and indirect impacts on three PAs: (i) Moscos Kyun Wildlife Sanctuary; (ii) Lampi Island Marine National Park; and (iii) Tanintharyi Nature Reserve, with 64.7% of the area covered by terrestrial, riverine, and marine KBAs. These areas host six ecoregions, with half the area dominated by Tenasserim-South Thailand semi-evergreen rain forests (64%), and two critical/endangered ecoregions – Irrawaddy dry forests (0.1%) and Myanmar coastal mangroves (2.9%).

Impacts from larger-scale HPPs would also be avoided on:

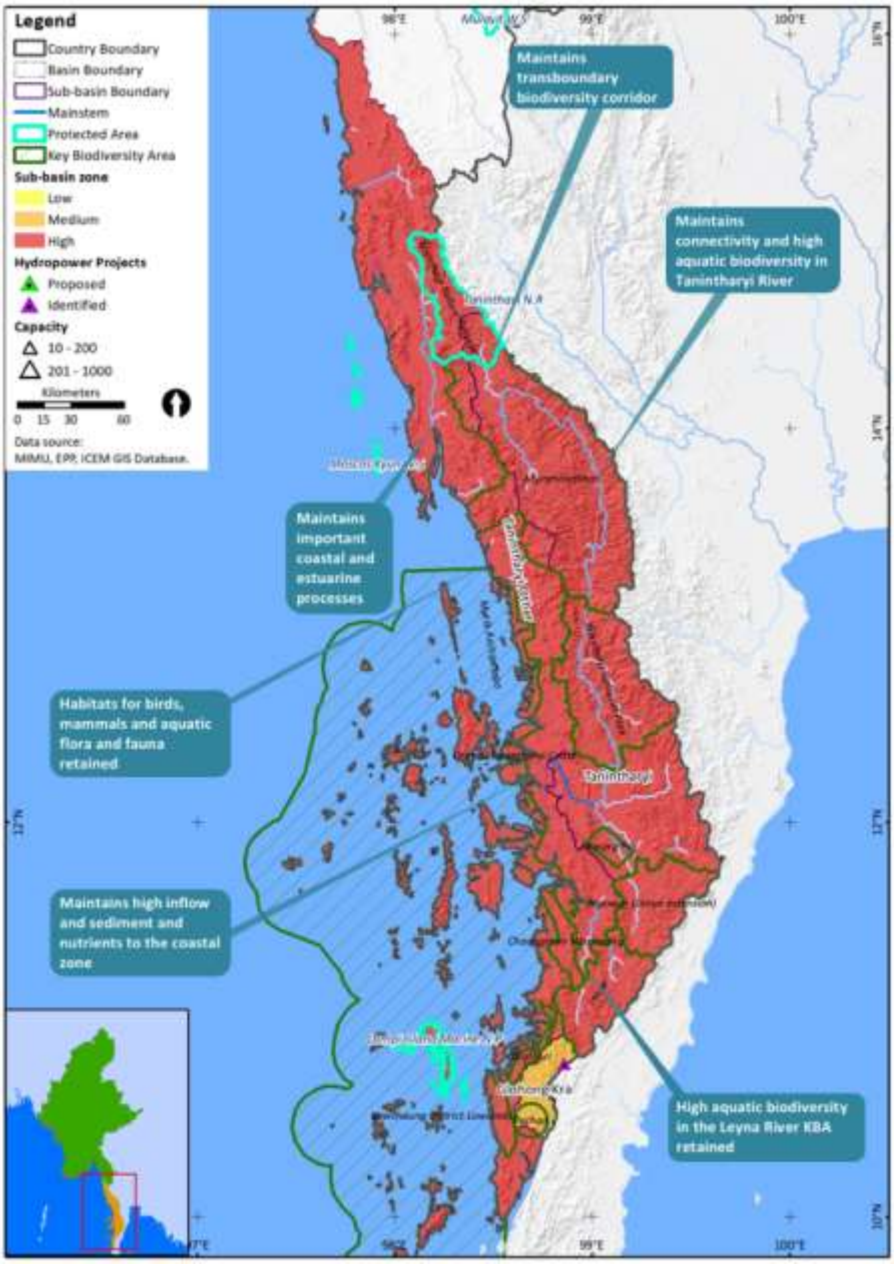
- The Tanintharyi Forest Corridor, an important habitat for tigers and elephants in the sub-basin that is being considered for World Heritage listing. The sub-basin consists of 90% KBA and 64% intact forest; and
- The Tanintharyi Other sub-basin, an important habitat for birds, mammals, and aquatic flora and fauna, comprising 46% KBA and 45% intact forest.

In addition, no large-scale hydropower development should occur in the areas of the Tanintharyi and Tanintharyi Other sub-basins that have been subject to armed conflict in the past.

9.7.2 Power Generation

There are no existing HPPs greater than 10 MW in the Tanintharyi basin. The Medium-zone Glohong Kra sub-basin with a single identified 40-MW project, covering 2.2% (992 km^2) of the basin, provides opportunities for hydropower development. Smaller scale, lower impact projects can also be considered in the two High-zone sub-basins.

Figure 9-5: Tanintharyi Basin Sustainability



9.8 Rakhine Basin Sustainability

9.8.1 Environmental and Social Sustainability

The Rakhine basin (Figure 9-6) has one hydropower project of 10 MW capacity or greater. The Thahtay HPP (111 MW) regulates 2.3% (1,293 km^2) of the basin, but it disconnects almost the entire Thahtay sub-basin from the sea, altering river-flow patterns and preventing the free flow of sediment downstream as well as the movement of fish up or downstream.

The reservation of the Kaladan High-zone sub-basin would maintain three intact rivers with unregulated connection to the sea (Kaladan, Tyao, and Boinu rivers), covering 24.5% (13,618 km^2) of the Rakhine basin. The Kaladan River is the largest among the coastal rivers and has high rainfall, with its discharge and sediment supply maintaining large coastal areas. It has been recognized as a riverine KBA with high aquatic ecological value due to the presence of endemic and migratory fish species.

The sub-basin's reservation avoids direct and indirect impacts on the Kyauk Pan Taung Wildlife Sanctuary. KBA covers 18% of the sub-basin, which contains an important transboundary wildlife corridor and habitat for elephants. The area supports three relatively intact ecoregions: (i) the Chin Hills-Arakan Yoma montane forests (of which 23% is contained in this sub-basin), (ii) the Mizoram-Manipur-Kachin rain forests, and (iii) the Myanmar coastal rain forests.

Other important processes and values that would be maintained by the Kaladan sub-basin reservation include:

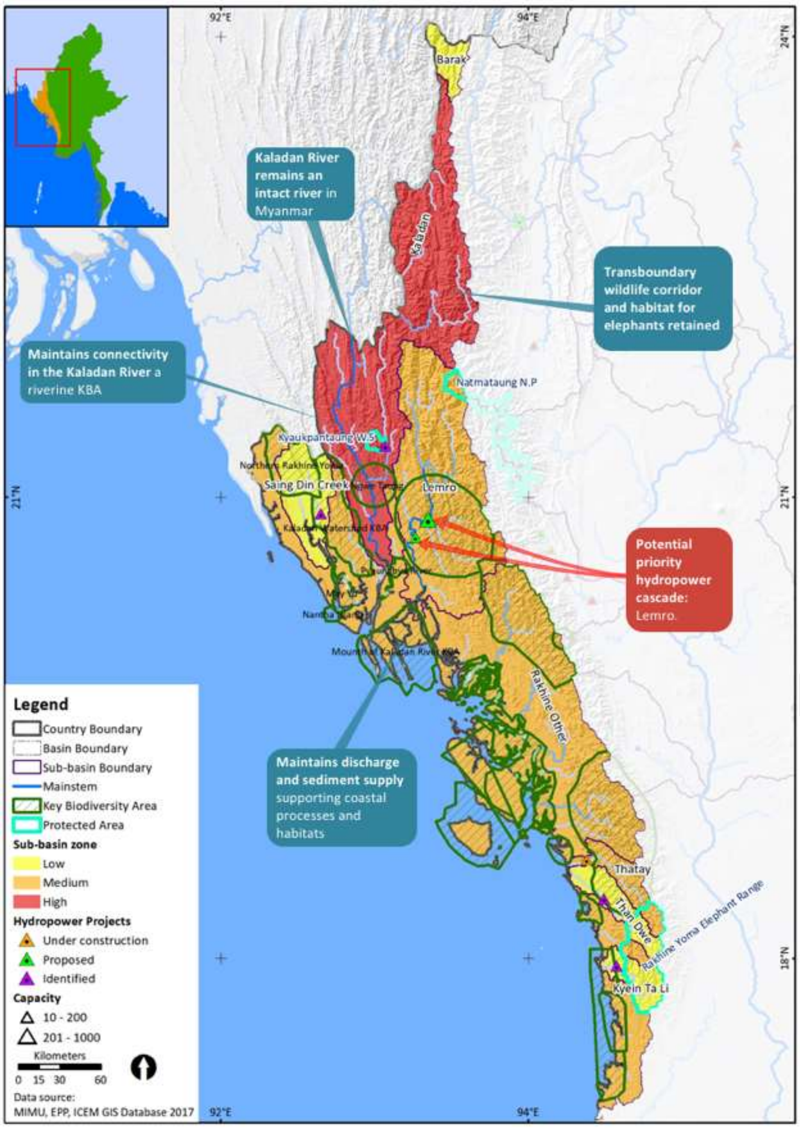
- river discharge and sediment supply supporting large coastal areas including mangrove forests;
- connectivity with the headwaters and Tyao and Boinu Rivers, supporting fish migration and endemic species;
- the Kaladan River marine KBA that is an important habitat for waterbirds, cranes, dolphins, and crabs; and
- three coastal region wetlands of international importance, which support both freshwater biodiversity and threatened bird species.

Sub-basin reservation would also avoid large-scale hydropower development in this armed conflict-affected sub-basin.

9.8.2 Power Generation

The six sub-basins zoned Low (3) and Medium (3) cover a combined total of 75.5% of the Rakhine coastal basins consisting of 8.6% (4,751 km^2) and 66.9% (37,040 km^2) respectively within Myanmar. Proposed and identified HPPs sited within the basin's Low and Medium zone sub-basins total 834 MW. Additional potential hydropower may be identified in the basin (subject to investigation). Where any additional projects are sited, how they are designed and their operating regimes will dictate hydropower sustainability in the basin, with some conflict prone sub-basins providing a development constrain.

Figure 9-6: Rakhine Basin Sustainability



10 SUSTAINABLE DEVELOPMENT FRAMEWORK IMPLEMENTATION PLAN

The implementation of the SDF requires a suite of policies, procedures, guidelines, and studies as well as the establishment of organizational arrangements to oversee and coordinate the implementation of basin zoning and other sustainable hydropower-development initiatives.

A three-year action plan has been developed to systematically implement the SDF focusing on the essential activities of:

- basin zoning implementation to improve project siting;
- improving sustainable hydropower project design;
- improving environmental and social impact assessment and management planning; and
- obtaining essential baseline data required for hydropower and basin planning.

The completion of activities over the initial three-year plan will identify priority actions that are needed in the following phase of implementation.

10.1 Joint Planning Committee

The establishment of an MOEE-MONREC Joint Hydropower Planning Committee is recommended to implement basin zoning and lead related SDF planning and data-gathering initiatives. The Joint Committee would build on the successful partnership between the MOEE and MONREC in preparing the SEA, providing a balance between hydropower development and natural-resource protection. The Joint Committee would be responsible for:

- developing a Sustainable Hydropower Policy;
- screening projects against the Basin Zoning Plans;
- planning and overseeing the implementation and monitoring of other SDF actions; and
- coordinating planning and data gathering with other government agencies.

Other government agencies that should be involved in planning and data gathering include:

- the Myanmar Investment Commission and the Ministry of Planning and Finance, which grant project approval;
- the MOALI regarding the development of irrigation and multi-purpose water-resource projects;
- the National Water Resource Committee and the Directorate of Water Resources and Improvement of River/Department of Meteorology and Hydrology (DWIR/DMH) under the Ministry of Transport and Communications regarding river-basin planning and water-data management; and
- other technical ministries.

Coordination between the Union and state/regional governments will also be critical in implementing the SDF for all hydropower projects of 10 MW capacity or greater as the states/regions have approval rights for HPPs of less than 30 MW capacity that are not connected to the grid. Despite this approval right projects over 1 MW capacity must still adhere to the national environmental impact assessment process.

10.2 Sustainable Hydropower Policy

An overarching Sustainable Hydropower Policy should state the government's vision for and commitment to sustainable development as well as the main principles on which it is based. It is recommended that the policy incorporate the SEA vision and the following main planning principles:

- whole-of-basin hydropower planning;
- balanced natural-resource utilization;
- natural-resource capacity-based development;
- retention of intact rivers/sub-basins; and

- incorporation of environmental and social considerations into project decision-making from the outset.

10.3 Basin Zoning Implementation

10.3.1 Publication of Basin Zoning Plans

The eight Basin Zoning Plans and accompanying planning information on HPP siting restrictions should be made available to developers and the public on the MOEE's website. This information shall provide clear guidance on reserved mainstem rivers where HPP development should not be permitted, and Low- and Medium-zone sub-basins that are potentially suitable for development.

10.3.2 Screening Against Basin Zoning Plans

A project screening procedure is needed to formally screen all proposed HPPs of 10 MW capacity or greater against the eight Basin Zoning Plans to ensure that each project is sited in accordance with the relevant Plan. The procedure should be integrated into the project MoU process to ensure that only appropriately sited projects are considered for an MoU.

A developer should be required to submit the concept-project proposal to the Joint Committee for screening prior to applying for an MoU. Where the project is sited in a Low- or Medium-zone sub-basin, the Joint Committee should issue a "Clearance Certificate"[46] that allows the project developer to apply for an MoU. Projects proposed on reserved mainstem rivers and large projects proposed in High-zone sub-basins should not be considered further. Smaller scale, lower impact projects proposed in High-zone sub-basins that are designed to meet the needs of rural and remote communities could be considered, but they should be screened against strict additional criteria to determine if they should proceed.

The procedure should also outline how the Basin Zoning Plans could be applied to proposed projects to be developed by a state/regional government but that are still subject to the EIA procedure. Proposals for multi-purpose projects need to include the MOALI in project screening, which should determine if the developer is recommended to prepare a CIA for a defined sub-basin or watershed.

The development of the procedure would be supported by capacity building for Union and state/regional governments on project restrictions and screening under the Basin Zoning Plans.

10.3.3 Project Screening Criteria for High Zone Sub-Basins

Screening criteria is required for smaller scale and lower impact projects in High zone sub-basins to determine if they can be developed without unduly degrading key natural resource and socio-economic values in these catchments. Projects that meet the pre-defined selection criteria should be granted a 'clearance' certificate, allowing them to apply for an MoU. Projects deemed to be inappropriate should be removed from further consideration in their proposed form.

A screening framework should be developed by the Joint Committee setting out clear selection criteria, indicating the locations and types of projects that may be considered. The framework should be based on project-siting criteria such as:

- project location should exclude the main sub-basin river (except in the headwaters of that sub-basin where the river is small) and any watershed over a specified maximum area in sub-basins that discharge via a single river;
- maximum degree of flow regulation taken as a cumulative of all HPPs and irrigation dams in the sub-basin;
- maximum project size (e.g. dam height above river-bed level, reservoir volume, and MW capacity);

[46] Issuance of a "Clearance Certificate" by the GoM would not provide any approval beyond permission for project investigations to proceed to the pre-feasibility stage. Projects that are granted a "Clearance Certificate" may be rejected at subsequent stages of planning if the environmental and/or social impacts are deemed to be unacceptable.

- a preference for run-of-river projects over daily peaking projects and seasonal storage projects due to the lower degree of flow regulation; and
- no extensive new road construction or major road upgrading for project access permitted in high conservation-value terrestrial habitat (e.g. Protected Areas, KBAs, and critical habitat).

Each proposed project in a High zone sub-basin should be considered against cumulative impact thresholds that account for any operational, under-construction or approved projects in that catchment so that the total impact does not exceed the specified cap. For example, a limit on the total percentage of a sub-basin regulated by a HPP, either by percentage of total outflow or catchment, would limit the effect that flow changes and aquatic habitat fragmentation would have on sub-basin processes and values.

While some criteria such as project installed capacity do not provide a good indication of the significance and extent of likely environmental and social impacts, specifying an upper limit provides a clear cut-off to developers which, when combined with the other criteria, will remove higher impact projects from further consideration at the earliest possible stage.

10.4 Sustainable Hydropower Design

10.4.1 Sustainable Design Guidelines

Following project siting, the design of a hydropower project is the next most important opportunity to avoid and minimise major environmental and social impacts. Key design options that should be considered in project design include:

- **Environmental-flows (EFlows) release:** EFlows releases should be incorporated into the design of each HPP. IFC has issued a good practice handbook on EFlows[47] and Yangon Technical University, World Wildlife Fund (WWF), and UNESCO-IHE are currently advancing work on EFlows in Myanmar.

- **Hydropower generation off the EFlows release**: Generation using a small turbine on the Eflows should be investigated and installed where feasible, with the electricity supplied to local communities at low voltage. Such supply can form an important part of a local benefit-sharing package.

- **Variable height intake**: A headrace tunnel intake tower with multiple height intakes should be investigated for larger storage projects with drawdown, allowing water to be drawn off the water column with the best possible quality (i.e. temperature, oxygen content, suspended sediment and nutrient levels).

- **Reservoir mixing at the intake**: Different water-mixing options should be assessed to improve water quality at the intake of HPPs with storage.

- **Re-regulation weir**: A re-regulation weir downstream of the powerhouse should be considered where peaking-power releases would create substantial downstream river-flow changes daily (volume, velocity, depth) over distance, thereby affecting aquatic habitat and safety.

- **Fish passage**: Current fish-passage technology is ineffective for fish species in the Mekong region where a head difference of more than 10 m exists. The potential for fish passages could be assessed for dams or small irrigation weirs with heads lower than this height. Fish passages can be used in series, where local topography allows, to overcome higher heads. A prototype fish lift to overcome a much higher head has been built at the Xayaburi HPP on the Mekong River. Depending on its performance, this design may be appropriate for projects with higher dams. Fish-friendly turbines may be appropriate for small and medium run-of-river projects.

[47] https://www.ifc.org/wps/wcm/connect/2c27d3d8-fd5d-4cff-810f-c6eaa9ead5f7/Eflows+for+Hydropower+Projects_GPH_03022018finalWEB.pdf?MOD=AJPERES

- **Sediment flushing**: the potential to flush sediment from a proposed reservoir should be investigated. The incorporation of low-level flushing gates that can be operated independently of flood gates and other structures and measures may be appropriate to maintain downstream sediment flows and extend the life of the project.

- **Multi-project coordinated releases**: The coordinated release of water from multiple projects along a tributary in a sub-basin or watershed should be investigated to maximize generation, optimize the EFlows, and reduce the incidence of flooding.

The *Myanmar Hydropower Standards*[48] prepared by MOEE with the support of the Government of Norway, recommends design requirements for hydropower facilities to ensure they provide adequate safety for human life and livelihoods, and protection of the environment and public and private assets.

10.4.2 Guidelines for Hydropower Cascade Operation Optimization

Three-quarters of all proposed and identified HPPs in Myanmar in Low- and Medium-zone sub-basins are sited in cascade arrangements, but there is no coordination between project operators to optimize generation and environmental management. Such an arrangement complicates the design, construction, and operation of a HPP because the project affects and/or is affected by other HPPs in terms of power generation and environmental and social impact mitigation. The optimal operation of cascade power plants requires a sophisticated dispatch regime to safely maximize generation and minimize impacts. Guidelines are recommended to ensure the ongoing management and monitoring of impacts, joint hydro-met systems, modelling and forecasting, compliance with dam safety, flow-dispatch rules and optimization of power generation.

The system dispatch center and dam operators should coordinate flow release to optimize generation, while operators could coordinate minimum flow releases to maintain the riverine ecosystem. The process would involve capacity building for the MOEE and consultation with hydropower companies, as different developers will need to develop joint mechanisms for the operation of cascades. The guidelines would also include communication between cascade-reservoir operators and managers, hydropower plants and dispatch, and energy and water governance for multiple owners and cross-boundary issues.

10.5 Impact Assessment and Management Planning

10.5.1 Improved Implementation of the Environmental and Social Impact Assessment Procedure

The existing framework for ESIAs under the Environmental Conservation Law 2012 and Myanmar EIA Procedures (2015) needs to be reviewed to improve implementation. Based on the experience of implementing this SEA as a pilot for the hydropower sector, it is recommended that a SEA procedure be further developed under the Environmental Conservation Law 2012 to provide regulatory guidance on when an SEA is required for sectors including mining, transportation, or areas such as special economic zones). The procedure would also provide guidance on development/project screening, review, and approval process under the SEA.

Key focus areas to improve existing procedures include:

- ensuring that the environmental assessment process commences during project siting and design; ensuring this timing allows the EIA/IEE to improve on siting and design to avoid and minimize major environmental and social impacts;

- integrating Social Impact Assessment provisions into the existing EIA procedures, recognizing the weak legislative and procedural instruments for social safeguards in medium-to-large-scale developments, including hydropower;

- broadening guidance on stakeholder engagement in the Draft Guidelines for Public Participation in the EIA (2016) prepared for MONREC to ensure that consultation is undertaken

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[48] MOEE, 2017. *Myanmar Hydropower Standards,* March 2017. The Republic of the Union of Myanmar.

before, during, and after project construction, not just as part of the EIA or resettlement process; and

- approving and implementing the EIA guidelines for hydropower projects developed by IFC for the MOEE and MONREC.

10.5.2 Hydropower Cumulative Impact Assessment Procedure

A CIA is used to identify and assess the combined cumulative impacts of multiple projects/developments on valued environmental and social components in a defined area (geographical or administrative). The CIA is a useful tool in determining the level of development (carrying capacity) that is sustainable relating to the number, type, scale, and location of new HPPs (as well as other proposed developments within the region) and planning appropriate management measures for these combined impacts.

A CIA procedure for hydropower in Myanmar is recommended, setting out when a CIA is needed and what it should contain. The CIA should assess other developments, i.e. small HPP designed to provide power for mines and special economic zones, agriculture (diversions/reservoirs), and mining (water-use pollution).

The need for a CIA should be identified by the Joint Committee, either when a project proposal is submitted for a “clearance” certificate, or when multiple projects are being considered in a sub-basin or watershed. A CIA should ideally be conducted for a project proposed in an undeveloped sub-basin or a large watershed where multiple medium/large-scale HPPs are proposed, or where such projects are proposed in a partly developed watershed.

10.5.3 Conflict Sensitivity Analysis Guideline

A guideline on conflict sensitivity analysis is required to ensure that projects proposed in conflict prone areas (sub-basins rated very high or high for conflict) explicitly assess the risks of conflict at the project concept stage, in feasibility studies, the EIA and management plans.

While available data on conflict vulnerability at a sub-basin level is relatively reliable, there is insufficient data to confidently assess the conflict vulnerability of individual projects. This challenge is compounded by the dynamic nature of conflict, with the tendency for conflict patterns and armed group presence to shift over time.

The developer should appoint an independent team at the project-concept stage to assess the conflict risk and consult with stakeholders in the project AOI. This assessment should identify whether the area is influenced by armed groups, the status of any ceasefire or political settlement, autonomous zones, landmine contamination, and armed conflict over the last five years. A media-discourse assessment could identify whether a project has potential to exacerbate conflict. Stakeholder engagement should be broadened to include historically displaced populations, EAOs, and ethno-political parties, covering a wider geographic area. For example, consultation in pre-feasibility studies for the Bawgata HPP included Karen CSOs based in Mae Sot, Thailand as some people previously displaced from the project area by conflict now reside outside the country.

10.5.4 Resettlement Procedure

A national resettlement procedure is recommended to improve resettlement, land acquisition, and livelihood-restoration planning and implementation in Myanmar, which will help address hydropower planning and implementation. Many resettlement and livelihood-restoration programs for developed HPPs have fallen short of expectations due to a short-term focus on resettlement-site facilities and land-acquisition compensation. Instead, these activities should only be the start of the resettlement process and should be followed by a long-term adjustment support program to restore livelihoods and living conditions[49], taking into consideration the diverse needs of women and men.

Strengthening the capacity of responsible government agencies, such as the Department of Hydropower Implementation and district/township authorities, to plan and implement resettlement is recommended, as is a review of the institutional framework to broaden the responsibilities of Land Committees and to engage other agencies in resettlement and livelihood restoration. The existing policy and legal framework should also be assessed in relation to the National Land Use Policy and the 1984 Land Acquisition Act (currently under review by parliament). *One Map Myanmar*, an eight-year national mapping project that commenced in 2016, will provide spatial data on land use and tenure that can be used to inform project resettlement planning.

10.5.5 Hydropower Benefit-Sharing Framework

A benefit-sharing guideline should be developed following the outcomes of an IFC white paper on hydropower benefit sharing in contested states. Benefit-sharing mechanisms provide options for project proponents to share benefits with locally affected people, communities, and states/regions that are host to and affected by hydropower projects. Examples of monetary and non-monetary mechanisms include:

- **Monetary mechanisms:** sharing a percentage of the power-generation revenue with local communities by: (i) direct payments to project affected people; (ii) lump-sum payments into a community development fund; and (iii) equity sharing, where communities receive an equity share in the project and subsequent returns over the life of the project;
- **Non-monetary mechanisms**: (i) the right to use reservoir for fisheries/aquaculture, irrigation, water supply, and tourism; (ii) employment of local people in project construction and operation; and (iii) provision of (or subsidized) electricity supply and other services.

Further analysis on benefit-sharing options and related legislative and policy implications specific to Myanmar is recommended. This would involve consultation and capacity building with a broad range of stakeholders, including Union and State/Regional governments, district/township authorities, local communities (including inclusive procedures for both women and men), ethno-political parties, EAOs, and hydropower companies. The benefit-sharing guideline should link with the resettlement procedure, as benefit-sharing can supplement resettlement and livelihood-restoration programs.

10.5.6 Watershed-Protection Mechanisms

Watershed protection can help to maintain hydropower project performance over time by maintaining or improving seasonal runoff distribution across the year and by minimizing erosion and sedimentation. Catchment runoff held in a denuded catchment, held in either the spoil profile or as groundwater, tends to be lower than that retained in a well vegetated catchment due to infiltration from the combined effects of acts more like a sponge, holding some water (recharging groundwater) in the monsoon and releasing it as a low flow throughout the year. Sedimentation can cause the loss of reservoir live storage, while suspended sediment can cause turbine runner wear. Watershed-protection mechanisms in Myanmar could include: (i) developer-sponsored watershed management activities, and/or (ii) payment for ecosystem services (PES). PES is delivered by local communities to assist in the provision of an ecosystem service (i.e. watershed) to obtain any payment. The main environmental service local communities can offer hydropower plants is watershed protection.

10.6 Data Collection and Research

Baseline monitoring and studies are recommended to provide data and information for basin, natural resource and hydropower planning, commencing early in the initial three-year SDF implementation plan. This information would help fill data gaps for system and sub-basin planning, including on hydrology, sediment movement, aquatic ecology and livelihoods.

[49] IFC Performance Standard 5 (PS5) advises that resettlement should "minimize its impact on those displaced through mitigation measures such as fair compensation and improvements to living conditions."

The focus basins for this work are the Ayeyarwady and Thanlwin, covering a combined total of three-quarters of the country and being the location of 69% of proposed and identified HPP capacity in Medium and Low zone sub-basins. A secondary focus area are the Mekong sub-basins where 11.4% of proposed/identified HPP capacity in Medium and Low zone sub-basins is located. Monitoring and research is also required across the other five basins to obtain long-term data required for detailed basin planning. Spatial focus areas within these basins where baseline information is required to enable more detailed planning, are:

- basin mainstem rivers - monitoring of key system features at selected points along these rivers (primarily the Ayeyarwady, Chindwin and Thanlwin) to understand system processes and values;
- Low and Medium zone sub-basins where multiple projects are proposed; and
- Low and Medium zone sub-basins without proposed projects but similar biophysical conditions to sub-basins being investigated for multiple HPPs, that could form trade-offs or set-asides for developed catchments to be developed.

10.6.1 Basin Baseline Data

Understanding the long-term hydrological and geomorphological characteristics of each basin is essential in understanding basin dynamics and effectively planning the sustainable development of major rivers. However, limited data is available on these features. Similarly, little is known about freshwater ecology and fish migration in Myanmar's rivers. More detailed baseline information is starting to be obtained through studies such as the AIRBMP, but long-term monitoring of river flows, sediment movement, and water quality is required, while aquatic ecology studies are also essential.

The Ayeyarwady State of the Basin Assessment (SOBA)[50] under the AIRBMP is the most comprehensive integrated environmental, social, and economic baseline for the Ayeyarwady and any river basin in Myanmar to date providing a 'first edition' understanding of complex basin-wide processes. A SOBA or similar analysis is recommended for the Thanlwin basin due to the significance of this major catchment in Myanmar, covering just under one-fifth of the country, as well as the scale of proposed hydropower development (14 proposed/identified projects totaling 16,000 MW) and the limited understanding of basin processes and values.

The following studies should be prioritized at the basin level for hydrology, sediment transport, biodiversity, and socio-economic studies.

10.6.1.1 Hydrology

River gauging across Myanmar's eight basins is limited. Just nine gauging stations exit in the Ayeyarwady basin, although there is some uncertainly over the reliability of some of this data[51]. Eight gauging stations are located on the Sittaung mainstem and one gauging station is located on the Thanlwin mainstem within Myanmar. Additionally, project discharge is monitored by Yeywa HPP on the Myitnge and at other existing HPPs, but the full extent of project flow gauging (including on major irrigation dams) is unknown. The network of meteorological stations across the country is also limited. In the Ayeyarwady basin stations exist, while in the Thanlwin basin some stations are operational.

Prior to the Ayeyarwady SOBA, no hydrological modelling or integrated surface water assessment had been conducted for the Ayeyarwady basin. SOBA established a model using the SOURCE water system planning software based on climate data from 1981 to 2016, from 18 rainfall stations. No surface water modelling has been conducted for any other basins in Myanmar.

Actions needed for baseline hydrological information include:

- reviewing the adequacy and reliability of hydrological data from all existing river gauging stations in Myanmar;

[50] SOBA, 2017.
[51] HIC, 2017. *Ayeyarwady State of the Basin Assessment (SOBA) 2017: Synthesis Report, Volume 1*. Yangon, December 2017.

- assessing the priorities of the Hydro-Informatics Centre (HIC) for enhancing hydro-met systems for the Ayeyarwady basin over the next three years;
- developing a plan for a hydro-met system for the Thanlwin and other basins;
- require all HPP owners/operators of projects of 10 MW capacity or greater to provide flow gauging data to MOEE every six months; and
- consolidating water quality data in a single database, which is currently collected and analysed by various government agencies.

10.6.1.2 Sediment Transport

There is limited understanding of sediment production and transport in major Myanmar basins. Sediment transport is not currently monitored and existing historical data is unusable. WWF conducted limited sediment sampling in the Ayeyarwady as part of the SOBA and recommended that an initial two-year sediment monitoring program be established for the Ayeyarwady integrating discharge monitoring and collecting physical samples; uniform methods and protocols, together with a suitable data-management system, should be established and then such protocols should be implemented on a permanent basis. A similar approach could be developed for the Thanlwin River to: (i) undertake baseline sampling for sediment and remote-sensing analysis, and (ii) develop monitoring framework for sediment and discharge.

10.6.1.3 Fisheries and Biodiversity

Assessments of aquatic biodiversity, freshwater habitats, and river health are needed along target river reaches in all major basins in Myanmar. These assessments should be integrated with socio-economic surveys to determine the importance of local fisheries for fish consumption and livelihoods. Currently, the national statistics are "guestimates," focusing on commercial fish production, and do not fully consider the contribution of capture freshwater fisheries to small-scale and part-time fisher livelihoods.

Migration studies for the Hilsa and other fish and aquatic animal species, although limited, are being conducted on the Ayeyarwady River using local surveys, and this approach can be used to identify sites along the mainstem for further monitoring of fish migration. Scientific studies should be combined with local knowledge to understand fish-migration routes in the Thanlwin and other basins. An initial assessment is needed to determine the target river reaches, and surveys should be carried out over the next three years. The upper reaches of many Myanmar rivers have not been assessed at all. Even though these reaches may not support significant fisheries, they may be critical to biodiversity and host numerous endemic species.

During SEA preparation a biodiversity technical working session identified areas for potential expansion of the KBA network. Aquatic biodiversity surveys should be prioritised in areas identified as new KBAs or for expansion, to enhance understanding of the KBA values so that boundaries can be refined as a basis for improved management and potential expansion of the official PAs system which only comprise 6% of total land area.

10.6.1.4 Socio-Economic

Socio-economic conditions and livelihood studies are better conducted at a project or cascade level. However, understanding vulnerability (e.g. flood and drought) and dependence on natural resources at the sub-basin or basin level could help inform basin-wide planning. The Social Impact Monitoring Vulnerability Assessment carried out by the Mekong River Commission (MRC) or a similar approach can provide a useful framework for assessing the vulnerability of local communities (with disaggregated data) within a 5 km area of influence of major rivers and tributaries in Myanmar. More information is needed at the sub-basin level regarding the dependency on rivers that may be affected by hydropower development, including:

- **River bank, islands gardens, and fields** –location, area, productivity, use pattern, number of households that farm on them, and their role in the household and community economies;

- **Dependency on capture fisheries** – in rivers and connected wetlands/floodplains the number of households and the intensity with which they are engaged in fishing, and the utilization of catches (consumption and selling) is needed; and
- **Livelihoods dependent on river navigation** – similar data on use patterns and role in household and local economies is required.

The priorities for gap-filling are the Ayeyarwady and the Thanlwin due to their overall size and scale of planned hydropower. Smaller river-basin assessments could also be carried out in the smaller Sittaung, Mekong, Bago, and Bilin basins. Studies in the Tanintharyi and Rakhine coastal basins could focus more on sediment transport, fish migration, and connectivity between freshwater and coastal ecosystems.

10.6.2 Data Management System

A centralized data management system could support the management of all relevant natural resource and hydropower project data and related information, making information available to end users. The SDF zoning and the data and GIS layers generated by the SEA could be shared via a website or online platform to inform hydropower, river basin planning and further research. MOEE and MONREC could then also consider establishing national databases of key natural resources and HPP information, including:

- a natural resource and biodiversity database (e.g. KBA, PAs) to be established by MONREC;
- the HPP database developed as part of the SEA and maintained by MOEE; and
- public disclosure process for all existing and future hydropower CIAs, EIA/IEEs established by MONREC.

Once the information on natural resources and hydropower is consolidated, then a review of other planned water data management systems is needed to promote data sharing and avoid duplication. As DWIR and other agencies are consolidating hydro-meteorological and other data into the HIC over the next three years the information generated by the SEA could feed into this to support the development of the Decision Support System (DSS). Collaboration on data management would also be needed with MOALI (irrigation reservoirs and land use), Department of Fisheries (fisheries production trends, leaseholds), DWIR (navigation) and other sectors.

It is recommended that MONREC request that private owners of existing HPPs provide river gauging data to the Ministry every six months, and for new projects this is included as an approval condition.

10.6.3 Basin Planning

Basin-wide hydropower planning is a component of integrated river-basin planning that coordinates the conservation, management, and development of water, land, and related resources across sectors within a given river basin. This aims to optimize the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring ecosystems.[52]

In Myanmar integrated river basin planning has commenced with the three-year AIRBMP that is developing a "*basin master plan*" and decision support system for the Ayeyarwady basin, covering 55% of Myanmar. Building on this process, it is recommended that the government develop basin master plan for the Thanlwin basin as a priority, covering an additional 19% of Myanmar, and prepare similar plans for the other basins.

[52] Adapted from: Abell, R., M. Thieme, E. Dinerstein, and D. Olson. 2002. *A Sourcebook for Conducting Biological Assessments and Developing Biodiversity Visions for Ecoregion Conservation. Volume II: Freshwater Ecoregions*. WWF, Washington DC, USA.

A review of the legal and institutional framework for river-basin management and the need for river-basin organizations should be carried out. An Ayeyarwady River Basin Commission has been proposed in the past; however, the focus of the AIRBMP in the short term appears to be establishing the river-basin plan and setting up the Hydro-Informatics Centre (HIC). The Stockholm Environment Institute is setting up a framework for a Chindwin River Basin Organization. In December 2017, the DWIR proposed a Thanlwin Basin Commission to be established among Myanmar, Thailand, and China. The Commission was first initiated by the Joint Committee for Coordination on Commercial Navigation on the Lancang-Mekong River, so the objectives may be focused around navigation and trade.

Further studies on the transboundary impacts of hydropower development should be carried out, particularly in the Thanlwin River basin and tributaries entering the Ayeyarwady River basin.

10.6.4 Sub-Basins

More targeted biophysical and socio-economic survey assessments should be prioritized for the 12 Medium-zone sub-basins with planned hydropower development (**Error! Reference source not found.**). Further information is needed for these sub-basins to determine whether significant impacts are likely to occur and identify the unique environmental and social values, river health status, and important basin-wide processes. These studies should connect river health with the existing levels of human disturbance (or pressures) to determine what the drivers of change are and how they can be managed. Further research could include fisheries and aquatic-ecology assessments and socio-economic surveys of people living within 5 km of the major tributaries with planned hydropower development, as well as biodiversity surveys for potentially expanding the KBA network. A CIA or similar integrated approach can provide a framework for identifying the valued environmental and social components at a sub-basin level.

Table 10-1: Medium-Zone Sub-Basins with Planned Hydropower

Basin	Sub-basins with Proposed / Identified Hydropower Projects
Ayeyarwady	Ngaw Chang Hka, Myitnge Upper, Manipur
Thanlwin	Nam Hka, Nam Pawn, Baluchaung, Yunzalin
Sittaung	Sittaung Other
Mekong	Nam Hkoke
Tanintharyi	Glohong Kra
Rakhine	Lemro, Thahtay

10.6.5 Cascade Planning

Coordinated planning of cascade hydropower developments is recommended. This enables the cumulative impacts of multiple projects to be identified and appropriate management measures to be developed, and that projects are optimized for power generation. Key recommended studies could include:

- **Cascade opportunity identification:** assessing the potential for new cascade development in selected Low and possibly Medium zone sub-basins, and additional projects in partly developed sub-basins.
- **CIA for cascade with existing hydropower:** CIAs go beyond individual project assessments and consider cumulative impacts resulting from the development of multiple HPPs in a sub-basin or watershed. A CIA should be prioritized as a pilot study in a Low- or Medium-zone sub-basin with existing hydropower, as the EIAs for existing HPPs did not assess cumulative or basin-wide impacts. Priority sub-basins for a CIA in Year 1 are Myitnge Upper and Lower (Ayeyarwady), Nam Teng (Thanlwin), and Paung Laung (Sittaung).
- **System-scale planning for proposed cascades:** System-scale planning (or Hydropower by Design) is an approach to assess both the impacts and benefits of hydropower cascades, and to

identify optimal solutions at sub-basin and basin levels. WWF, The Nature Conservancy (TNC), and The University of Manchester demonstrated system-scale planning in the Myitnge sub-basin. Priorities in Year 1 are Medium-zone sub-basins with proposed cascades, including Lemro in the Rakhine coastal basin, Nam Pawn in Thanlwin, and Ngaw Chang Hka in Ayeyarwady.

- **Hydropower feasibility study in sub-basins with existing cascades:** Feasibility for additional medium/large HPPs in sub-basins zoned Low or Medium with existing cascade development needs to be reviewed. Depending on how extensive past hydropower feasibility surveys of these sub-basins were, further investigation is recommended as a priority to assess if there are additional sites that could be developed in preference to developing projects in undeveloped sub-basins.
- **CIA for proposed cascade:** Following the system-scale planning in Year 1, a second CIA should be conducted in one of the three largest sub-basins proposed for hydropower cascade development: Ngaw Chang Hka, Nam Pawn, and Lemro. These cascades appear to be prime candidates for CIAs to determine if medium/large-scale hydropower development is appropriate; if so, project siting, design, and operation should be optimized to avoid and minimize major environmental and social impacts.
- **Trial the basin-wide hydropower Rapid Sustainability Assessment Tool (RSAT):** RSAT assessments have been completed for about nine hydropower sub-basins in the Lower Mekong region since 2010. RSAT, as a multi-stakeholder tool, could be trialed in Myanmar sub-basins with proposed hydropower cascades and high ethnic diversity, e.g. Myitnge Upper or Dapein (Ayeyarwady), Nam Pawn (Thanlwin), and Nam Lwe (Mekong). RSAT Topic 5 (social issues and stakeholder consultation) could also be used to inform CIAs, system-scale planning, and ESIAs.

10.7 SDF Implementation Program

10.7.1 Policies, Procedures, and Guidelines

The three-year SDF implementation program is presented as two sub-programs:

(i) policies, procedures and guidelines; and
(ii) data collection, research and basin planning.

The initial three-year program for the development and introduction of key policies, procedures and guidelines (Table 10-2) focuses on core material needed to implement the SDF as soon as possible, providing clear guidance to GoM and all stakeholders on the direction and planning requirements for hydropower development

Table 10-2: Three-Year Implementation Plan for Policies, Procedures, and Guidelines

Policy, procedures and guidelines						
Policy	***Year 1***		***Year 2***		***Year 3***	
Sustainable hydropower policy	■					
Procedures						
SDF screening procedure	■	■				
Resettlement procedure		■	■			
CIA procedure for hydropower cascade development			■	■		
SEA procedure			■	■		
Review existing environmental assessment framework	■					
Guidelines						
Sustainable design guidelines and mitigation options		■	■			
Guidelines for optimizing hydropower cascades		■	■			
Benefit sharing mechanisms for hydropower			■	■		
Watershed protection mechanisms					■	■
Guideline for conflict sensitivity analysis		■				

10.7.2 Data Collection and Research

The SEA prioritizes further research and studies to fill critical data gaps and improve understanding of hydropower cascades and various issues at the basin and sub-basin levels over the next three years (**Error! Reference source not found.**). The initial stages of the program focus on commencing the long-term monitoring of basin hydrology and sediment movement as early as possible.

Table 10-3: Three-Year Implementation Plan for Priority Studies

Priorities for futher research/studies						
Basin	**Year 1**		**Year 2**		**Year 3**	
SOBA for Thanlwin River Basin	■	■				
***Hydrology** - Consolidate existing water data (all basins)*		■	■			
***Hydrology** - Review existing hydro-met systems*			■	■		
***Hydrology** - Propose hydro-met system for Thanlwin and other basins (based on HIC)*					■	■
***Sediment transport** - Initial sediment sampling (Thanlwin)*	■	■				
***Sediment transport** - 2 year sediment monitoring (Ayeyarwady)*	■	■	■	■		
***Sediment transport** - 2 year sediment monitoring (Thanlwin)*			■	■	■	■
***Sediment transport** - Sediment monitoring proposal for other basins*						■
***Fisheries-** Determine target river reaches for assessment (Ayeyarwady, Thanlwin)*	■					
***Fisheries-** Aquatic biodiversity, habitat, river health assessment (target river reaches in Ayeyarwady and Thanlwin)*		■	■	■	■	■
***Fisheries-** Determine target river reaches for assessment (other basins)*						■
***Biodiversity** : Review new KBA proposed under SEA*	■					
***Biodiversity** : Conduct biodiversity surveys in proposed KBA/PAs*		■	■	■	■	
Socio-economic : Define survey sites/approach for assessment (Ayeyarwady and Thanlwin mainstem)		■				
Socio-economic: Conduct socio-economic surveys (Ayeyarwady)			■	■		
Socio-economic: Conduct socio-economic surveys (Thanlwin)					■	■
***River basin planning** : Review of legal freamework for river basin planning*	■	■				
***River basin planning** : Develop river basin master plan (Thanlwin)*					■	■
Sub-basin						
Integrated assessment of Ayeyarwady medium zone sub-basins	■	■				
Integrated assessment of Thanlwin medium zone sub-basins	■	■				
Integrated assessment of Sittaung medium zone sub-basins			■	■		
Integrated assessment of Rakhine medium zone sub-basins			■	■		
Integrated assessment of Mekong medium zone sub-basins					■	■
Integrated assessment of Tanintharyi medium zone sub-basins					■	■
Hydropower cascades						
CIA for cascade with existing hydropower	■	■				
System-Scale Planning for proposed cascades		■	■			
Hydropower feasibility study in sub-basins with existing cascades			■	■		
CIA for proposed cascade:				■	■	
Trial the RSAT in medium zone sub-basin with high ethnic diveristy			■	■		
Water data management systems						
Develop natural resouce and hydropower databases	■	■				
Integrate with water data management systems (ie HIC)			■	■	■	■

10.7.3 SDF Revision

The SDF should be periodically revised to keep pace with increasingly detailed baseline information, water- and land-use trends, other basin planning, and the developing hydropower sector. Finding balance in hydropower utilization and natural-resource protection in Low- and Medium-zone sub-basins will occur over time as the GoM permits some of these sub-basins to be developed for hydropower, while deciding to set aside other sub-basins to maintain system processes and unique values. The initial revision of the SDF is recommended three years after the release of this SEA

11 REFERENCES

ADB, 2015. *Report and Recommendations of the President to the Board of Directors: Proposed Loan to the Republic of the Union on Myanmar: Power Transmission Improvement Project*. October 2015.

Anthony, E.J., Besset, M. and Dussouillez, P., 2017. *Recent shoreline changes and morpho-sedimentary dynamics of the Ayeyarwady River Delta*. Aix Marseille Universite & WWF

Brakenridge, G.R., Syvitski, J.P.M., Niebuhr, E., Overeema I., Higgins, S.A., Kettner, A.J., and Prades, L., 2017. *Design with nature: Causation and avoidance of catastrophic flooding, Myanmar*. Earth-Science Reviews 165 (2017) 81-109.

Gupta, H., Kao, H-J., Dai, M., 2012. *The role of mega dams in reducing sediment fluxes: A case study of large Asian rivers*. Journal of Hydrology, 464-465 (2012) 447-458.

Lehner, B. and Oullet Dallaire, C., 2014. *River reach classification for the Greater Mekong Region*. Final report on behalf of WWF Greater Mekong Program.

MOEE and JICA, 2018. *Updating the National Electricity Master Plan PowerPoint Presentation.* Nay Pyi Taw Workshop. February 28, 2018.

MOEE and JICA, 2017. *Power Development Opportunities in Myanmar*. Myanmar Investment Forum 2017. June 6-7, 2017.

MRC, 2005. *Overview of the Hydrology of the Mekong Basin*. Mekong River Commission, Vientiane, November 2005. 73pp.

MRC, 2016a. *Development of Guidelines for Hydropower Environmental Impact Mitigation and Risk Management in the Lower Mekong Mainstream and Tributaries – Volume 1 the Guidelines*. Report prepared for the Mekong River Commission.

MRC, 2016b. *Development of Guidelines for Hydropower Environmental Impact Mitigation and Risk Management in the Lower Mekong Mainstream and Tributaries – Volume 2 the Manual*. Report prepared for the Mekong River Commission.

Pegram, C., Li, Y., Le, T., Quesne, R. Speed, J. Li, and Shen, F. 2013. *River Basin Planning: Principles, Procedures and Approaches for Strategic Basin Planning*. Paris, UNESCO.

Schmitt, R.J.P., Castelletti, A., Bizzi, S., Kondolf, G.M., 2017. *CASCADE – Enabling strategic portfolio optimization of dam sediment trapping and hydropower production*. Presentation to the World Hydropower Congress, May 9-11, 2017, Addis Ababa.

UNDP, 2013. *Accelerating Energy Access for All in Myanmar*. United Nations Development Programme, Yangon, Myanmar.

United States Bureau of Reclamation (USBR), 2014. *Glen Canyon Adaptive Management Program*. March 2014.

Walling, D.E. 2008. *The changing sediment loads of the world's rivers*, Ann. Warsaw Univ. of Life Sci. – SGGW, *Land Reclaim*. 39.

Wild T. and D.P. Loucks, 2015. *Mitigating Dam Conflicts in the Mekong River Basin*, In Hipel K.W. et al. (eds.), Conflict Resolution in Water Resources and Environmental Management, Springer International Publishing, Switzerland.

World Bank, 2014. *Ending Poverty and Boosting Shared Prosperity in a Time of Transition*. Yangon, Myanmar.

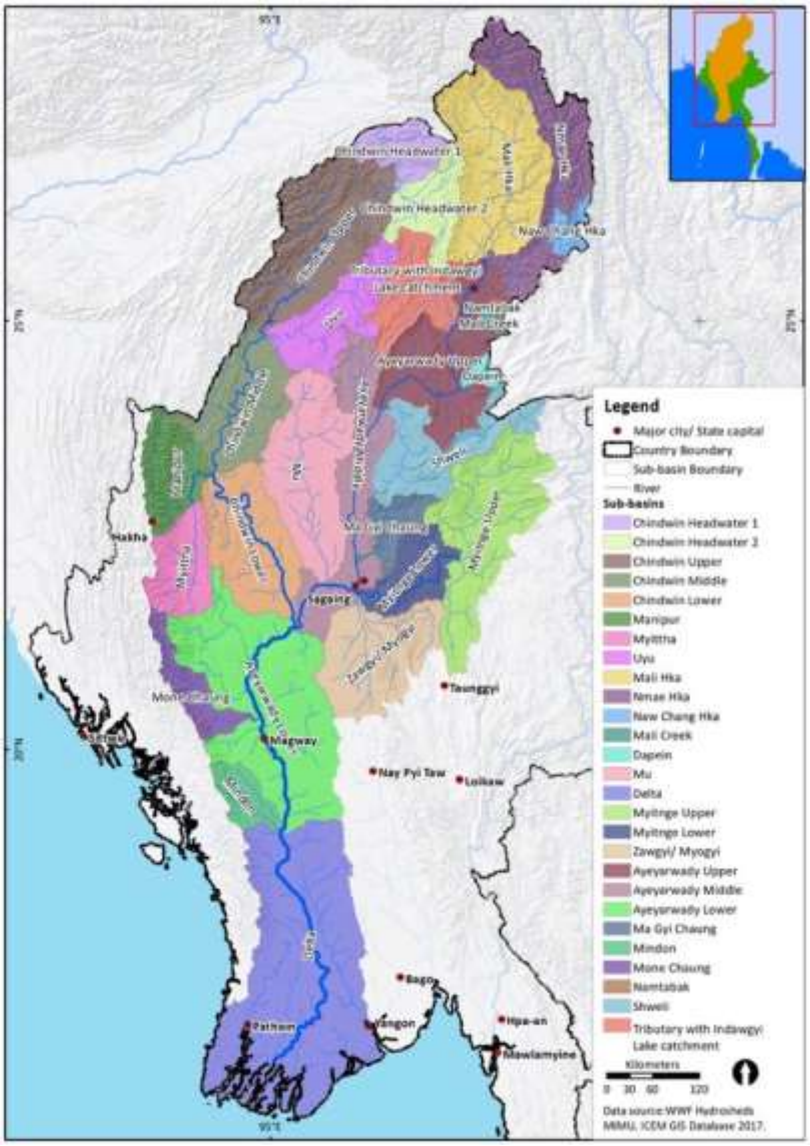
WWF, 2017. *C1.13 – State of the Basin Report Package 3 – Sediments and Geomorphology, Final Report*. Prepared for DWIR, PMU.

12 APPENDIX A: MYANMAR SUB-BASINS

1. Ayeyarwady Basin

Twenty-seven sub-basins are in the Ayeyarwady basin, consisting of 19 along the Ayeyarwady River and eight along the Chindwin River (Figure 13-1).

Figure 12-1: Sub-Basins of the Ayeyarwady Basin



Sub-basin	Area		Population[53]	State/Region
	km²	% of basin		
Ayeyarwady Lower	37,114	13.5	3,563,016	Bago, Chin, Magway, Mandalay, Nay Pyi Taw, Rakhine, Sagaing

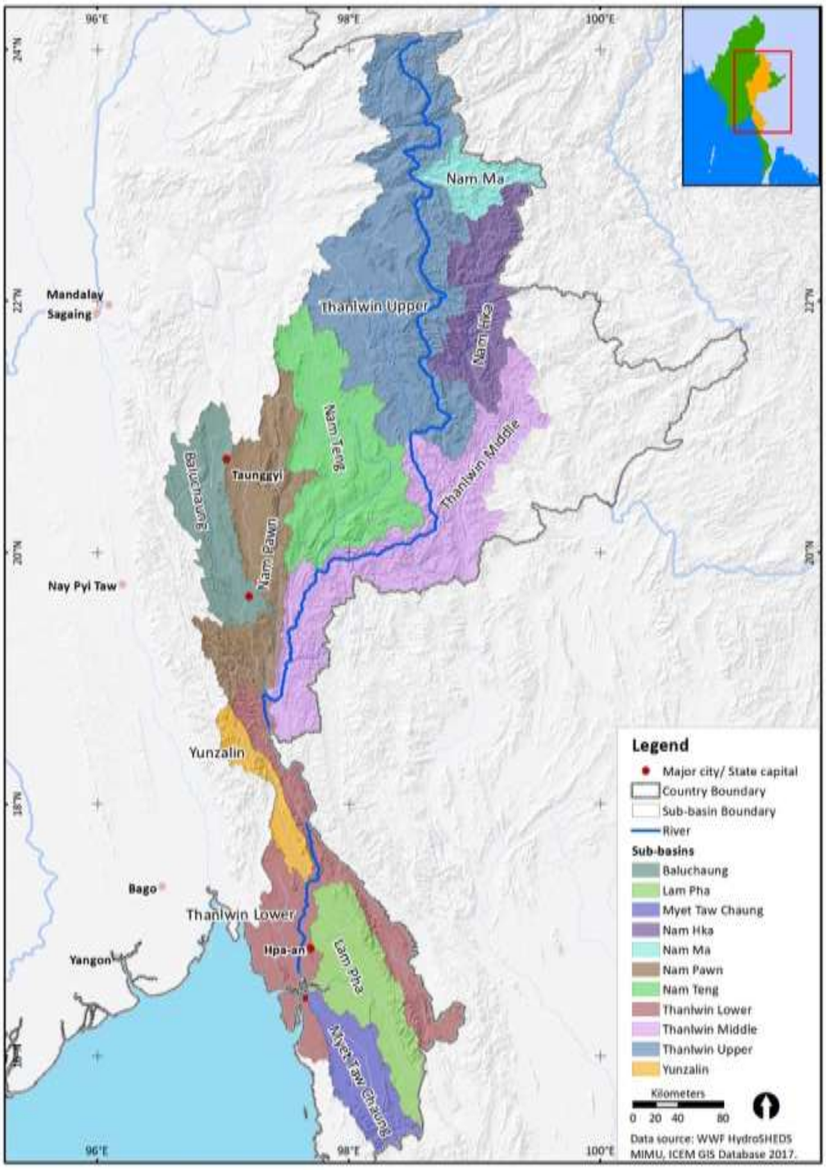
[53] Census, 2014.

Ayeyarwady Middle	17,940	6.5	3,344,726	Kachin, Magway, Mandalay, Sagaing, Shan
Ayeyarwady Upper	17,939	6.5	894,488	Kachin, Sagaing, Shan
Dapein	1,235	0.5	62,914	Kachin
Delta	53,084	19.3	11,815,891	Ayeyarwady, Bago, Magway, Rakhine
Ma Gyi Chaung	4,341	1.6	167,149	Mandalay, Shan
Mali Creek	719	0.3	N/A	Kachin
Mali Hka	23,287	8.4	74,211	Kachin
Mindon	4,445	1.6	205,439	Magway, Rakhine
Mone Chaung	5,974	2.2	232,711	Chin, Magway, Rakhine
Mu	19,708	7.1	1,953,363	Mandalay, Sagaing
Myitnge Upper	22,447	8.1	718,996	Shan
Myitnge Lower	8,070	2.9	1,221,902	Mandalay, Shan
Nam Tampak	718	0.3	N/A	Kachin
Ngaw Chang Hka	2,401	0.9	20,039	Kachin
N’mai Hka	17,501	6.3	25,296	Kachin
Shweli	13,141	4.8	328,567	Kachin, Mandalay, Sagaing, Shan
Tributary of Indawgyi Lake catchment	9,357	3.3	673,608	Kachin, Sagaing]
Zawgyi/Myogyi	16,327	5.9	2,099,186	Magway, Mandalay, Sagaing
TOTAL	**275,748**	**100**	**22,461,179**	

Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Chindwin Headwater 1	5,977	6.2	51,980	Kachin, Sagaing
Chindwin Headwater 2	7,813	8.0	60,019	Kachin, Sagaing
Chindwin Lower	16,621	17.1	3,563,016	Magway, Mandalay, Sagaing
Chindwin Middle	14,376	14.8	278,877	Chin, Sagaing
Chindwin Upper	23,314	24.0	112,506	Kachin, Sagaing
Manipur	8,972	9.2	516,151	Chin, Sagaing
Myittha	8,644	8.9	230,513	Chin, Magway, Sagaing
Uyu	11,440	11.8	370,874	Kachin, Sagaing
TOTAL	**97,157**	**100**	**5,183,936**	

2. Thanlwin Basin

Figure 12-2: Sub-Basins of the Thanlwin Basin

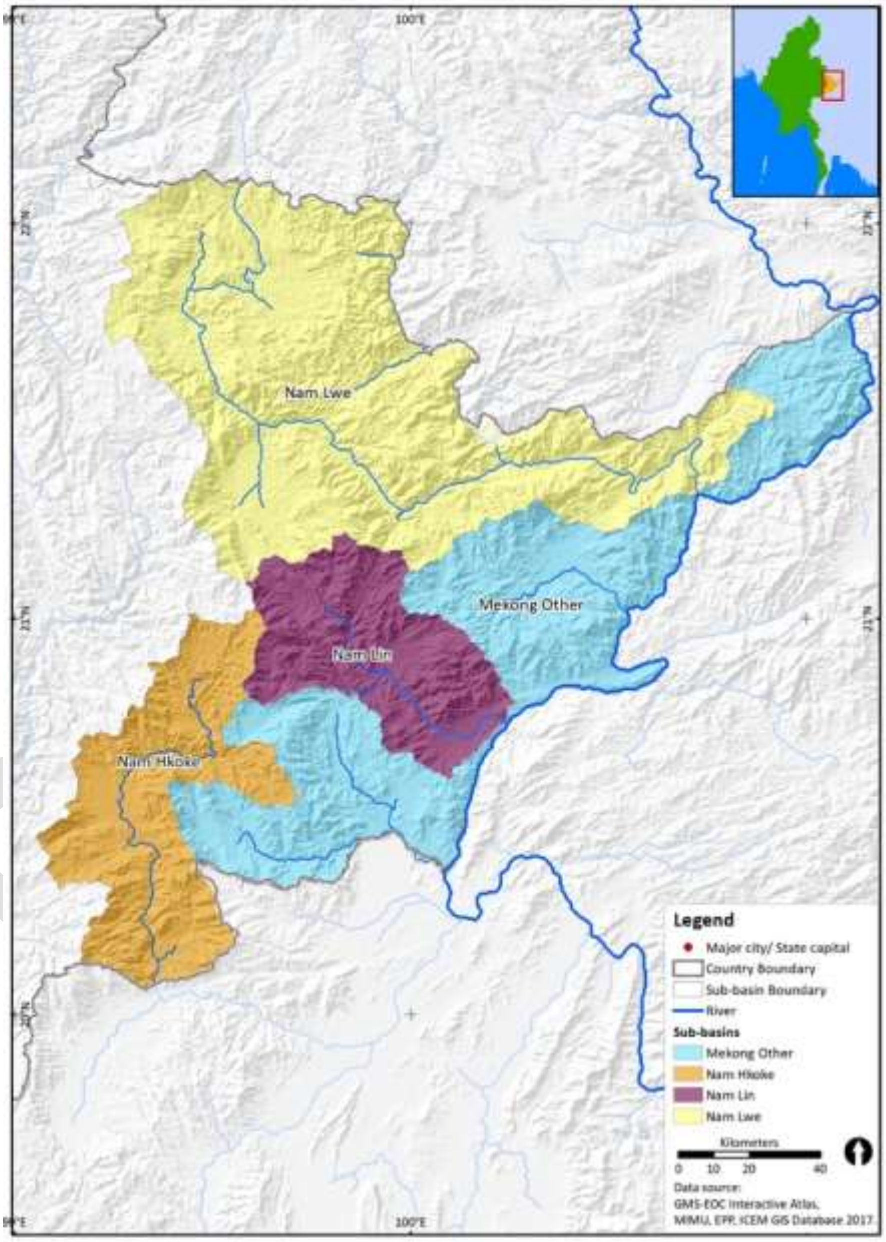


Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Baluchaung	7,837	6.1%	892,747	Kayah, Mandalay, Shan
Lam Pha	8,910	7.0%	486,225	Kayin, Mon
Myet Taw Chaung	5,665	4.4%	450,659	Kayin, Mon
Nam Hka	8,074	6.3%	19,732	Shan
Nam Ma	3,425	2.7%	24,479	Shan
Nam Pawn	11,572	9.1%	435,364	Kayah. Kayin, Shan
Nam Teng	15,386	12.1%	339,258	Kayah, Shan
Thanlwin Lower	13,972	11.0%	1,716,525	Kayah, Kayin, Mon
Thanlwin Middle	20,264	15.9%	134,457	Kayah, Shan
Thanlwin Upper	29,352	23.0%	1,122,780	Shan

Yunzalin	3,036	2.4%	8,076	Bago, Kayah, Kayin, Mon
TOTAL	**127,493**	**100**	**5,630,302**	

3. Mekong Basin

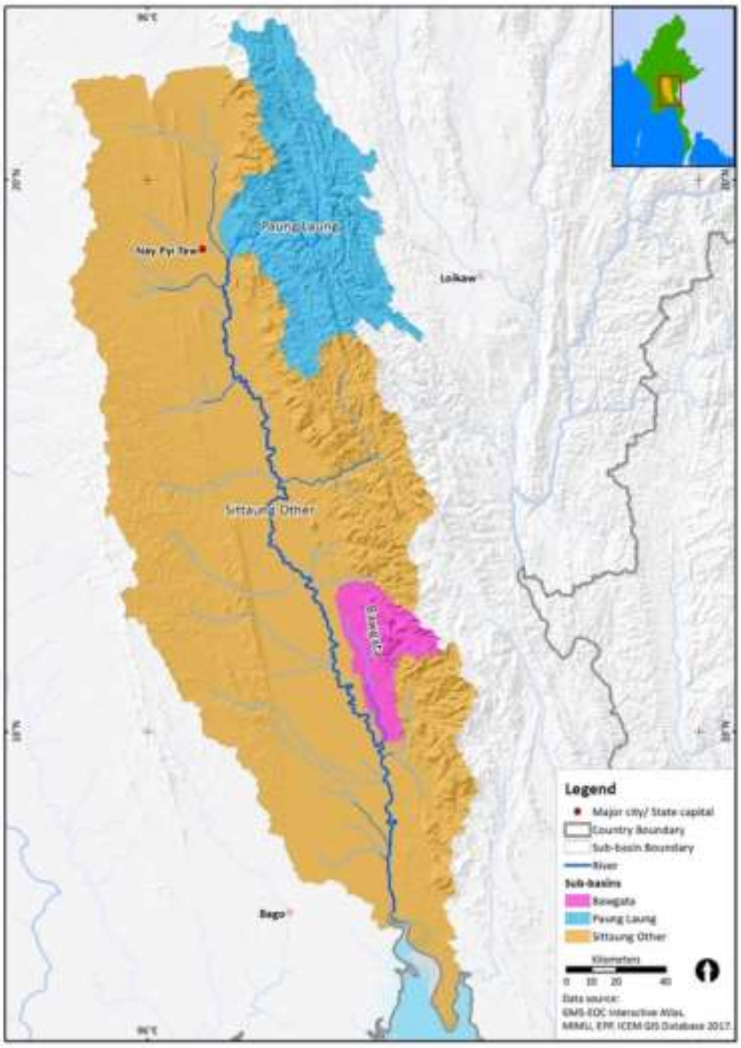
Figure 12-3: Sub-Basins of the Mekong Basin



Sub-basin	Area		Population	State/Region
	km²	% of basin		
Mekong Other	6,534	29.8	79,890	Shan
Nam Hkoke	3,411	15.5	104,649	Shan
Nam Lin	2,638	12.0	207,869	Shan
Nam Lwe	9,364	42.7	366,861	Shan
TOTAL	**21,947**	**100**	**759,269**	

4. Sittaung Basin

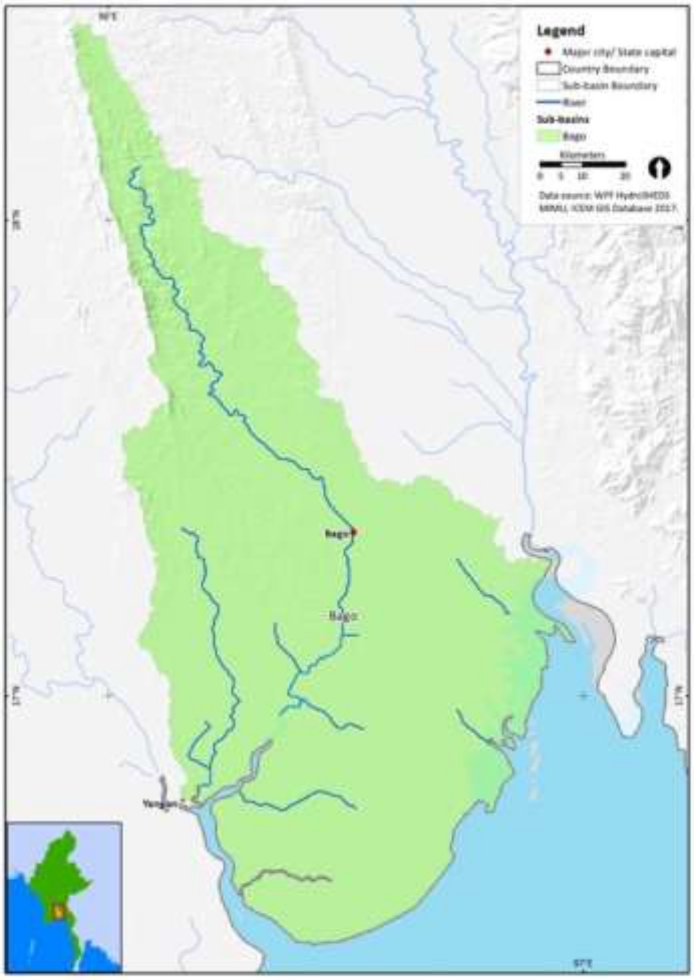
Figure 12-4: Sub-Basins of the Sittaung Basin



Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Bawgata	1,229	3.5	892,747	Bago, Kayin
Paung Laung	4,986	14.3	594,705	Kayah, Kayin, Mandalay, Nay Pyi Taw, Shan
Sittaung Other	28,698	82.2	3,088,695	Bago, Kayah, Kayin, Magway, Mandalay, Mon, Nay Pyi Taw, Shan
TOTAL	**34,913**	**100**	**4,576,147**	

5. Bago Basin

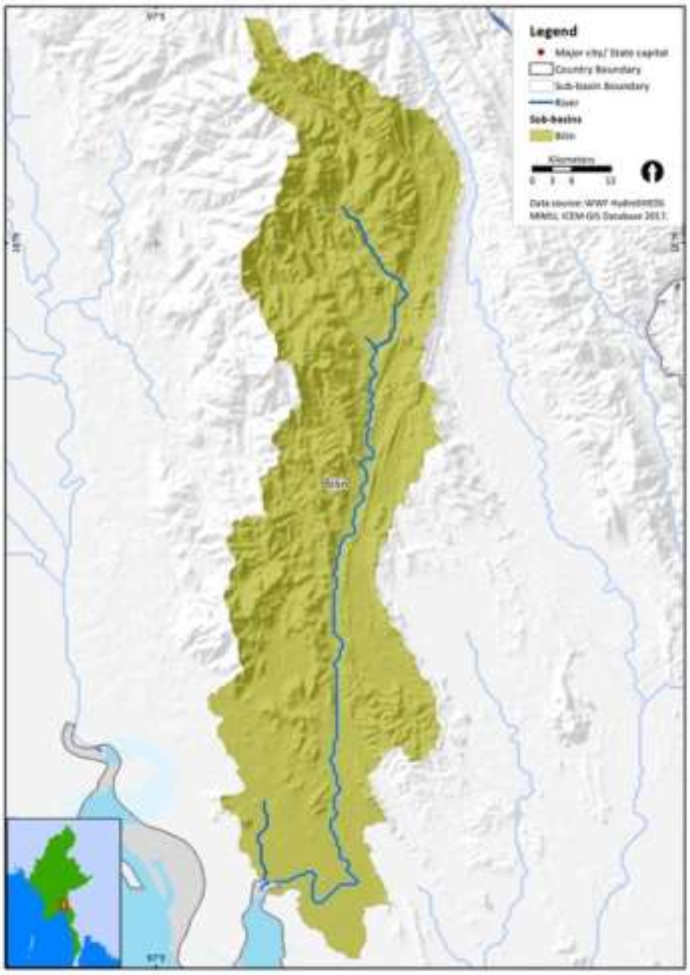
Figure 12-5: Bago Basin



Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Bago	10,261	100	4,610,213	Bago, Yangon

6. Bilin Basin

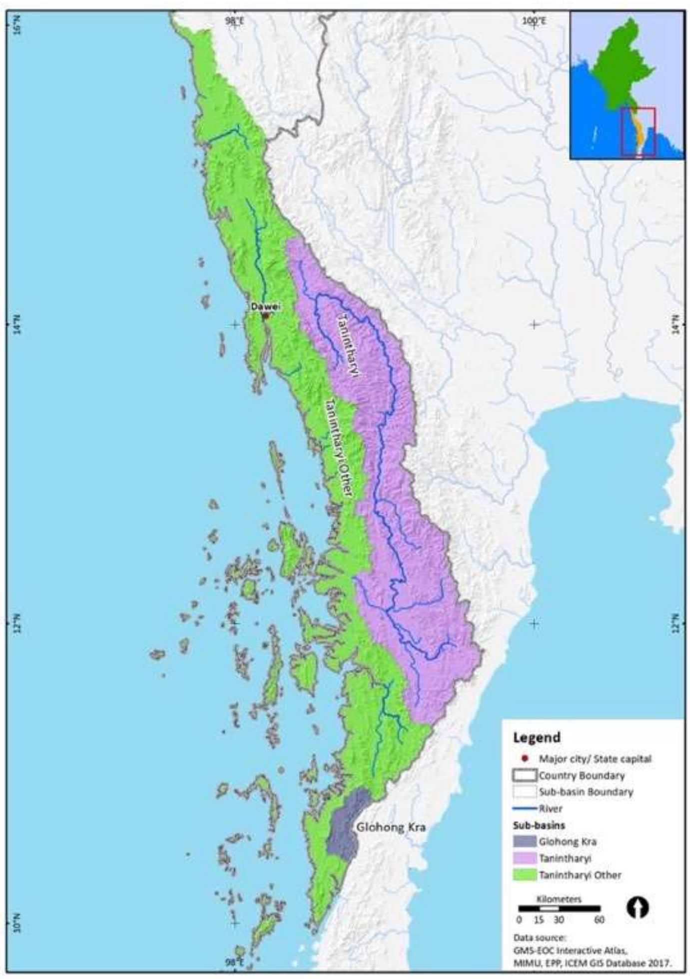
Figure 12-6: Bilin Basin



Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Bilin	3,056	100	216,160	Bago, Kayin, Mon

7. Tanintharyi Basin

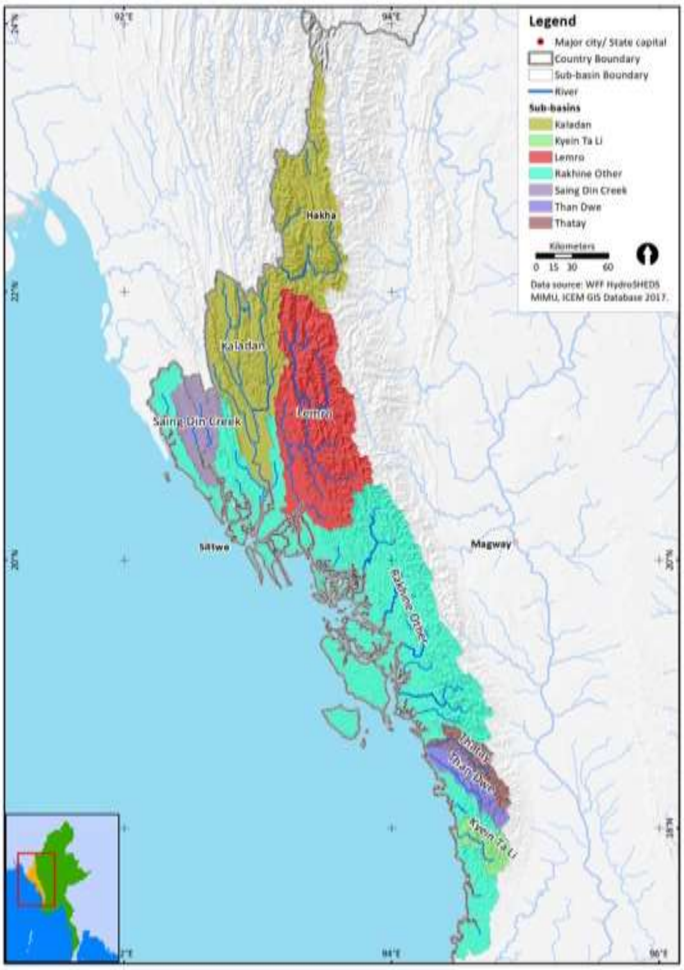
Figure 12-7: Sub-Basins of the Tanintharyi Basin



Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Glohong Kra	992	2.2	140,020	Tanintharyi
Tanintharyi	17,865	39.8	253,817	Tanintharyi
Tanintharyi Other	26,019	58.0	1,448,724	Kayin, Mon, Tanintharyi
TOTAL	**44,876**	**100**	**1,842,561**	

8. Rakhine Basin

Figure 13-8: Sub-Basins of the Rakhine Basin



Sub-basin	Area		Population	State/Region
	km^2	% of basin		
Kaladan	13,618	24.5	320,527	Chin, Rakhine
Kyein Ta Li	1,061	1.9	9,842	Ayeyarwady, Rakhine
Lemro	9,955	17.9	410,189	Chin, Magway, Rakhine
Rakhine Other	25,796	46.5	1,377,840	Ayeyarwady, Bago, Chin, Magway, Rakhine
Saing Din	2,331	4.2	55,545	Chin, Rakhine
Than Dwe	1,359	2.3	38,349	Ayeyarwady, Rakhine
Thahtay	1,289	2.3	10,943	Ayeyarwady, Bago, Rakhine
TOTAL	**55,409**	**100**	**2,327,884**	

13 APPENDIX B: SUB-BASIN ZONE DISTRIBUTION BY BASIN AREA

Basin	Myanmar Basin Area (km^2)			Total
	High	Medium	Low	
Ayeyarwady	77,892	106,825	188,188	**372,905**
Thanlwin	20,264	73,843	33,386	**127,493**
Sittaung	-	28,698	6,215	**34,913**
Mekong	6,534	3,411	12,002	**21,947**
Bilin	-	-	3,056	**3,056**
Bago	-	-	10,261	**10,261**
Tanintharyi	43,884	992	-	**44,876**
Rakhine	13,618	37,040	4,751	**55,409**
Surma-Meghna	-	-	792	**792**
Total	**162,192**	**250,809**	**258,651**	**671,652**

14 APPENDIX C: SUB-BASIN EVALUATION RATINGS

Figure 14-1: Geomorphology Sub-Basin Ratings

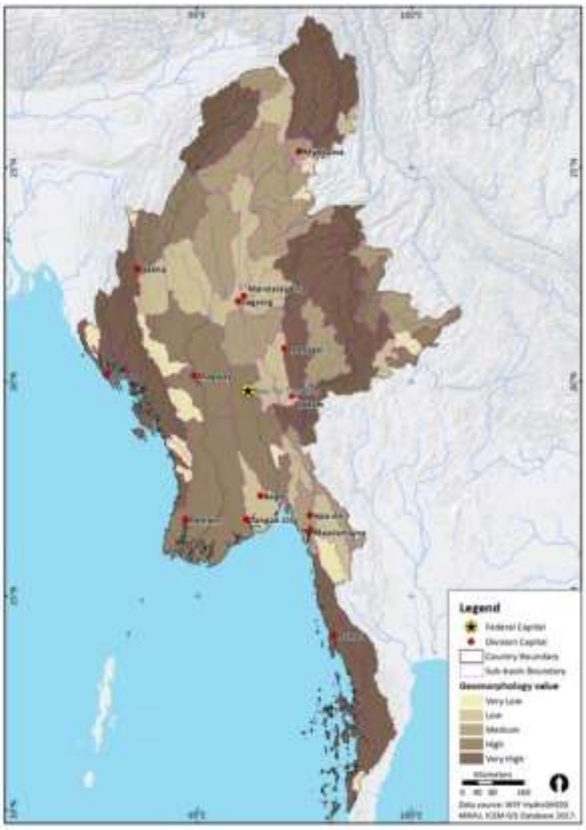


Figure 14-2: Aquatic Ecology Sub-Basin Ratings

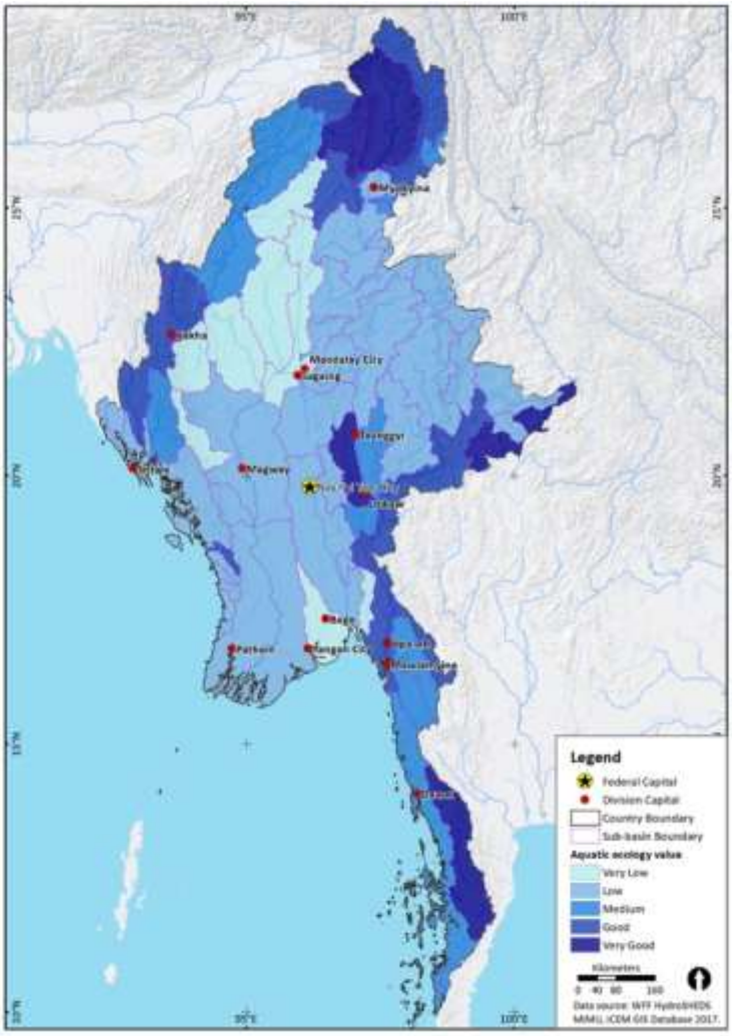


Figure 14-3: Terrestrial Ecology Sub-Basin Ratings

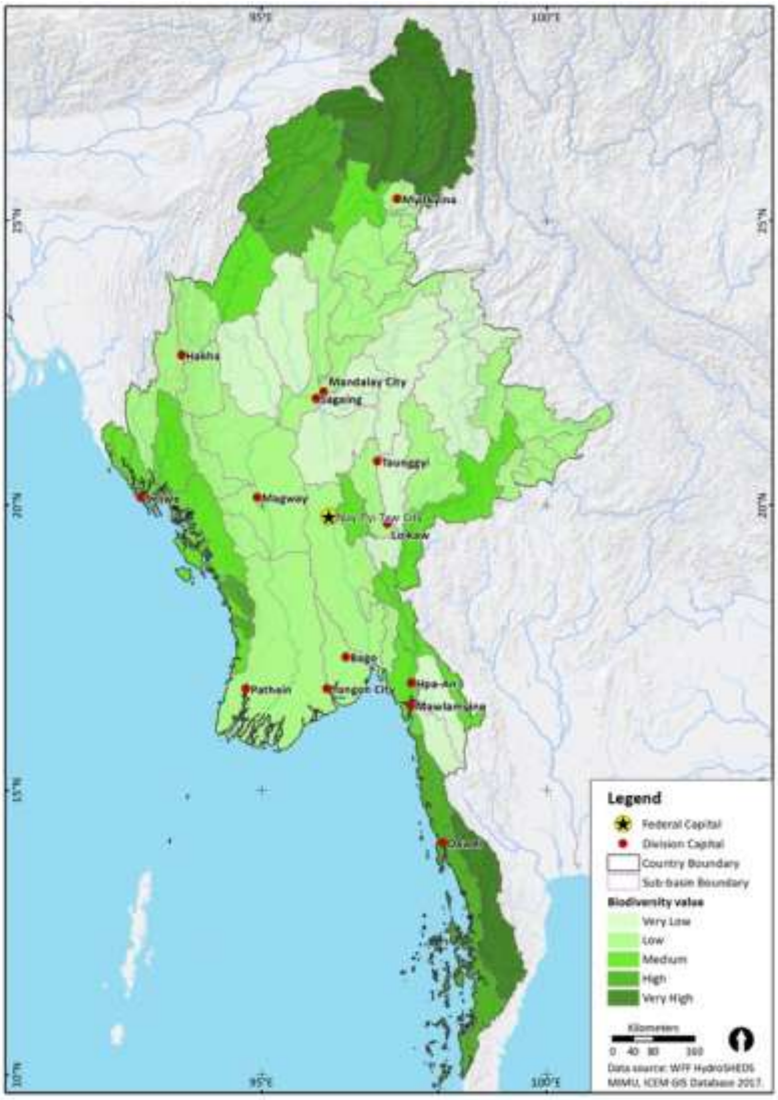


Figure 14-4: Social and Livelihoods Sub-Basin Ratings

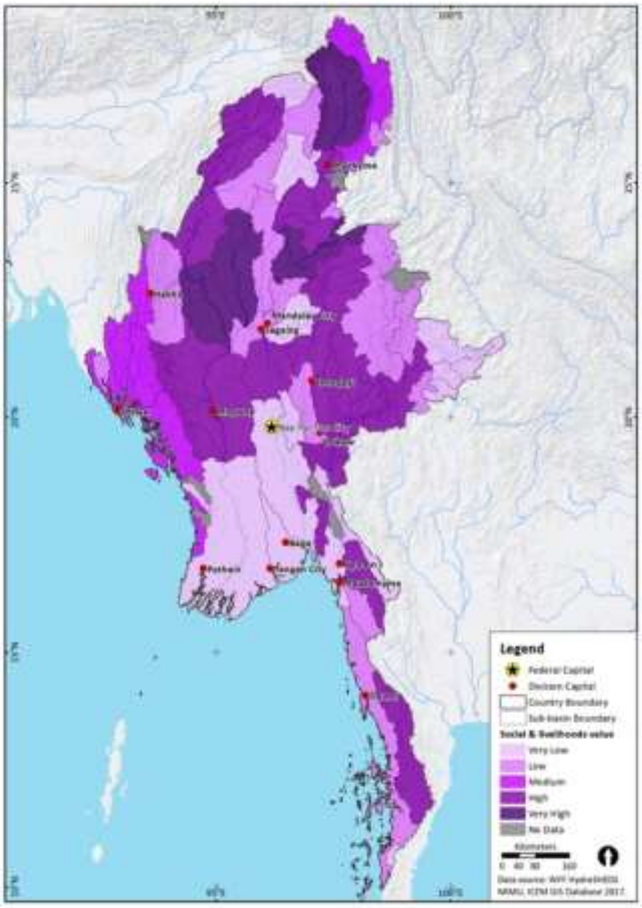
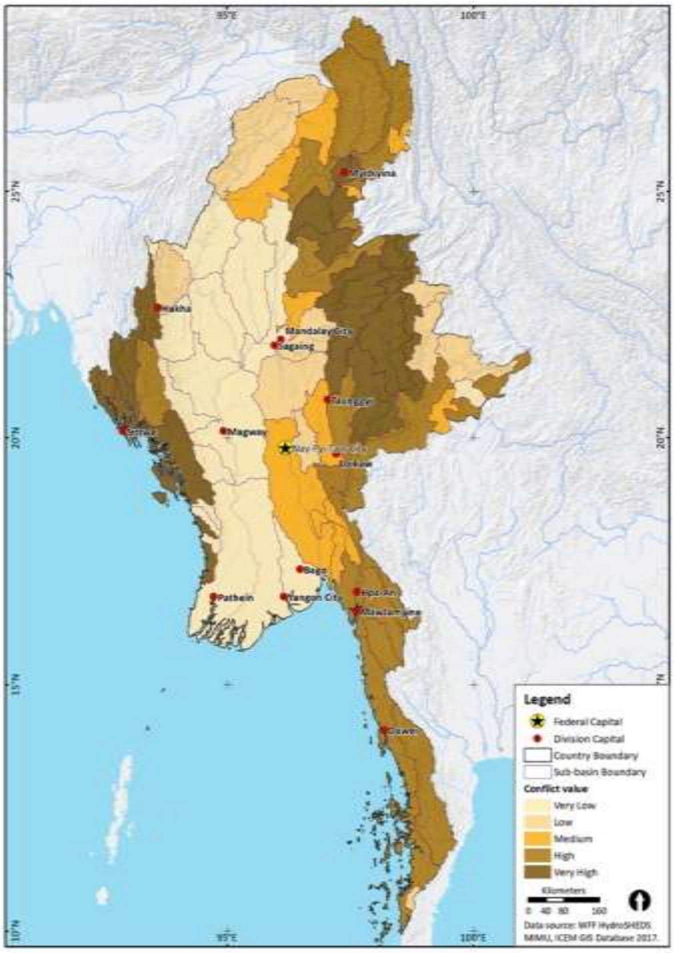


Figure 14-5: Conflict Sub-Basin Ratings



15 APPENDIX D: PROPOSED AND IDENTIFIED HYDROPOWER PROJECTS IN MYANMAR

Table 15-1: High-Zone – Proposed and Identified Projects

Sub-Basin	Sub-Basin	Total MW	Proposed		Identified	
			Name	MW	Name	MW
Ayeyarwady	Chindwin Headwater 1	**150**			Ta Rung Hka	150
	Chindwin Headwater 2	**65**			Ta Nai Hka Tawog Hka	15 50
	Chindwin Upper	**-**				
	Mali Hka	**1,900**	Laza	1,900		
	N'mai Hka	**11,395**	Chipwe (JVA) Dum Ban (MoU) Khaunglanphu (MoA) Nam Li (MoU) Pisa (MoA) Renan (MoA) Wutsok (MoA)	3,400 130 2,700 165 2,000 1,200 1,800		
Thanlwin	Thanlwin Middle	**-**				
Mekong	Mekong Other	**-**				
Tanintharyi	Tanintharyi	**656**	Tanintharyi (no agreement)	600	Sa Ra Wa Chaung Tha Gyet Chaung Thein Kun Chaung	11 20 25
	Tanintharyi Other	**-**				
Rakhine	Kaladan	**200**				200
Total		**14,366**		**13,895**		**471**

Note:

- The Thanlwin Middle (excluding mainstem) and Mekong Other have no proposed projects.
- Some middle-scale HPPs (10-100 MW) may be permitted in High zone sub-basins where the net impact is deemed to be acceptable.

Table 15-2: Medium-Zone – Proposed and Identified Projects

Sub-Basin	Sub-Basin	Total MW	Proposed		Identified	
			Name	MW	Name	MW
Ayeyarwady	Manipur	**380**	Manipur (MoU)	380		
	Myitnge Upper	**340**	Nam Hsim (MoU) Nam Lang (MoU) Nam Tu (Loc MoU)	30 210 100		
	Namtabak	**285**	Nam Tabak 1 Nam Tabak 2	141 144		
	Ngaw Chang Hka	**1,200**	Gaw Lan (JVA) Hkankawn (MoA) Lawngdin (MoA) Tongxinqiao (JVA)	120 140 600 340		
	Uyu	**12**			U Yu Chaung	12
Thanlwin	Nam Hka	**210**	Nam Hka (MoU)	210		
	Nam Pawn	**585**	Hawkham Upper (MoU) Hpak Nam (MoU) Hpi Hseng (MoU) Nam Pawn Lower (MoU) Nam Pawn Upper (MoU)	180 105 45 105 150		

	Yunzalin	**100**			Yunzalin	100
Mekong	Nam Hkoke	**60**	Mong Hsat (local MoU)	30	Nam Hkok	30
Sittaung	Sittaung Other	**150**			Thauk Ye Khat	150
Tanintharyi	Glohong Kra	**40**			Glohong Kra	40
Rakhine	Lemro	**690**	Lemro 1 (MoU) Lemro 2 (MoU)	600 90		
Total	**Total**	**4,052**		**3,720**		**332**

Note:

- 12 medium-risk zone sub-basins have proposed and identified projects; four of these sub-basins have only identified projects.
- Nine medium-risk zone sub-basins have no proposed or identified projects (Ayeyarwady basin – Ayeyarwady Lower, Chindwin Middle, Delta, and Indawgyi Lake tributary; Thanlwin basin – Baluchaung, Thanlwin Lower, and Thanlwin Upper; Rakhine basin – Rakhine Other and Thahtay).

Table 15-3: Low-Zone – Proposed and Identified Projects

Basin	**Sub-Basin**	**Total MW**	**Proposed**		**Identified**	
			Name	**MW**	**Name**	**MW**
Ayeyarwady	Dapein	140	Dapein 2	140		
	Ma Gyi Chaung	64	Sedawgyi Upper (GoM)	64		
	Mindon	18			Mindon	18
	Mone Chaung	150	Buywa Upper (GoM)	150		
	Myitnge Lower	766	Deedoke (MoU) Middle Yeywa (MoU)	66 700		
	Shweli	540	Nam Paw (Covenant) Shweli 2 (MoU)	20 520		
Thanlwin	Lam Pha	20			Lam Pha	20
	Myet Taw Chaung	10			Myet Taw Chaung	10
	Nam Ma	225	Mantong (MoA)	225		
Sittaung	Bawgata	160	Bawgata (MoU)	160		
	Paung Laung	100	Paung Laung Mid. (MoU)	100		
Mekong	Nam Lin	36	Nam Lin (local MoU)	36		
	Nam Lwe	618	He Kou (MoU) Keng Tong (MoU) Keng Yang (MoU) Suo Lwe (MoU)	138 170 70 240		
Bilin	Bilin	280	Bilin (local MoU)	280		
Rakhine	Kyein Ta Li	28			Kyein Ta Li	28
	Than Dwe	39			Than Dwe	39
	Saing Din Creek	77			Saing Din	77
Total		**3,271**		**3,079**		**192**

Note:

- 17 low-risk zone sub-basins have proposed and identified projects; six of these sub-basins only have identified projects.
- 10 low-risk zone sub-basins have no proposed or identified projects (**Ayeyarwady basin** – Ayeyarwady Middle, Ayeyarwady Upper, Chindwin Lower, Mali Creek, Mu, Myittha, and Zawgyi/Myogyi; **Thanlwin basin** – Nam Teng; **Bago basin** – Bago; and **Surma-Meghna basin** – Barak).