Strategic Environmental Assessment of the Myanmar Hydropower Sector

Final Report

IN PARTNERSHIP WITH

Australian Aid

MOEE

MONREC

IFC International Finance Corporation
WORLD BANK GROUP

Creating Markets, Creating Opportunities

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FOREWORD

The Union Minister

Ministry of Electricity and Energy

MOEE welcomes another study on hydropower resources and development to add to the list of references for decision makers to make informed decisions. Myanmar is amply endowed with hydropower resources of which less than 4% had been utilized. There is a huge scope for expanding this resource utilization. Myanmar's electricity demand and needs are growing significantly year by year and hydropower generated electricity will have to be a significant part of the future generation mix. The country celebrated its achievement of electrifying fifty percent of its households from the national grid in December 2019. It is planned to reach 75% of households by 2025.

While the environmental and social requirements will be upheld according to the law and regulations of the country, development of hydropower cannot be limited and must be open to broader perspectives and options that can be exercised by a sovereign nation for its development and prosperity. Other studies and viewpoints that support the sustainable development concept will be reviewed and considered for incorporating into any decision that must be made on hydropower development.

Having major cities and industrial - commercial centers along the main rivers are a fact and where most of the country's economic activities, livelihoods and jobs are generated. Flood management, water supply and riverine transportation are of major consideration also for these economic hubs along the rivers. The main criteria will be for the clear benefit of the country and people by utilizing the full potential of the river systems blessed to our country and people.

We recognize the effort and work that was put into this report by the team at IFC with the assistance of the Australian Government and the coordinating members from MOEE and MONREC. This report will surely have valuable input for the future sustainable hydropower development in Myanmar.

H.E U Win Khaing

The Union Minister

Ministry of Electricity and Energy

The Republic of the Union of Myanmar

FOREWORD

The Union Minister

Ministry of Natural Resources and Environmental Conservation

Myanmar's extensive hydropower potential can provide a critical source of electricity for the national grid and to contribute to economic growth. However, hydropower could have significant environmental and social impacts on natural hydrological flows, fish migration, biodiversity, water quality and navigation. Hydropower could also have adverse impacts on local people living near the project in terms of relocation and loss of livelihoods.

In collaboration with the Ministry of Electricity and Energy (MOEE) and International Finance Corporation (IFC), and with support from Australian Aid, MONREC conducted the Strategic Environmental Assessment (SEA) for Hydropower sector in Myanmar. The general objectives of the SEA were to assess environmental and social risks and impacts through a basin wide approach covering all eight river basins in Myanmar and to promote sustainable development by contributing to the integration of environmental considerations into the preparation and adoption of specified plans and programs.

The SEA sets a joint vision for the sector of 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.

The SEA is a systematic process to incorporate environmental and social considerations into hydropower policies, plans or programs to ensure these aspects are addressed at the earliest stage of decision-making. The SEA was conducted with a participatory process that included a Advisory Group, six Expert Groups, Government technical focal points and over 55 multi-stakeholder activities. MONREC views the SEA as an important tool for improving the strategic action, promoting the participation of relevant stakeholders in the decision-making process, focusing on key environmental sustainability constraints, and ensuring that actions do not exceed limits beyond which irreversible damage from impacts may occur. This important document will serve as the basis for the development of a sustainable hydropower sector for Myanmar for the benefit of both people and planet.

This SEA report is a milestone of sustainable hydropower development in Myanmar and MONREC would like to express thanks to all stakeholders who participated in its implementation, to IFC for providing the technical assistance and to Australian Government for financial support to improve environmental and social standards of the hydropower sector in Myanmar.

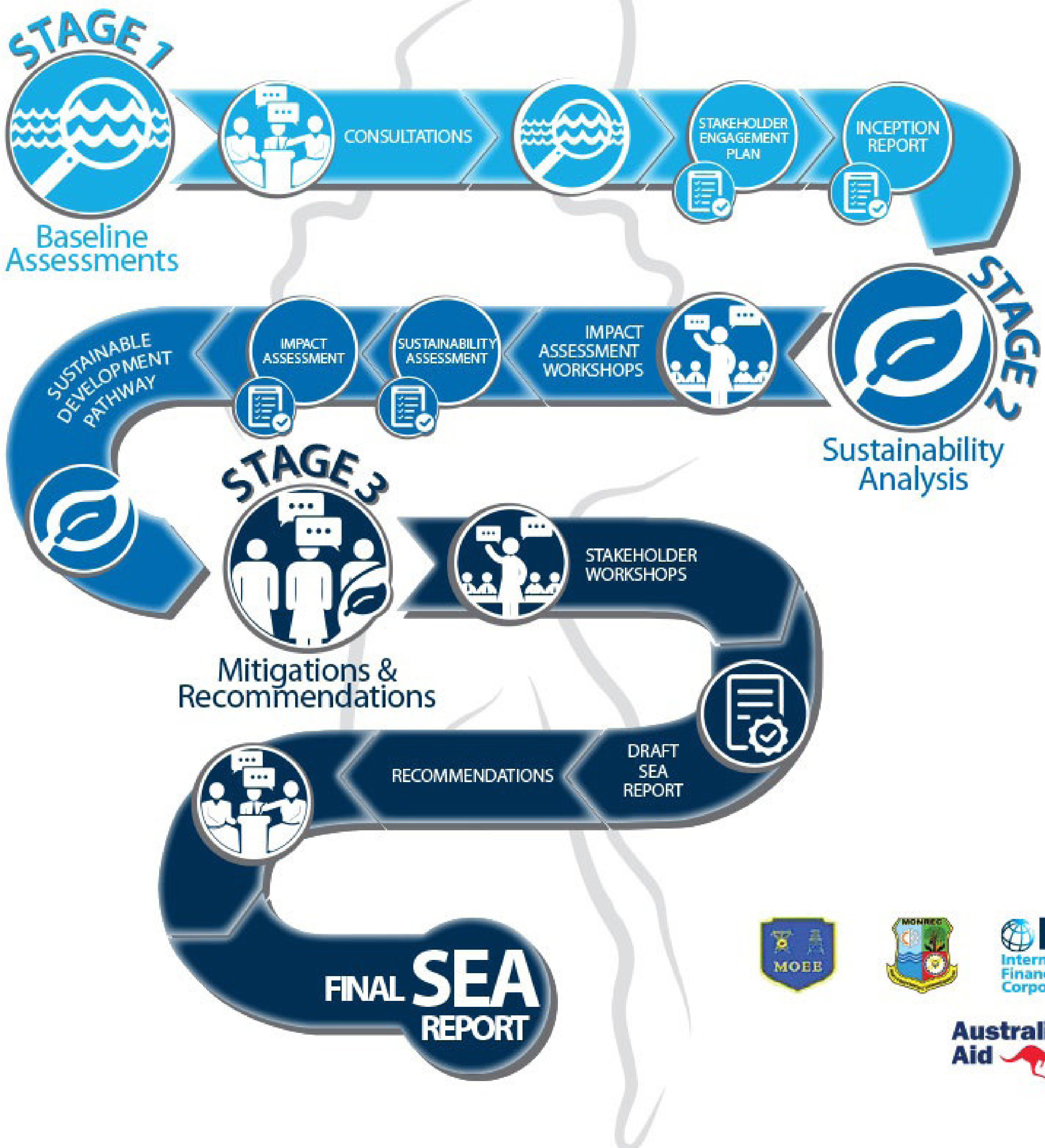
H.E. U Ohn Winn

The Union Minister

Ministry of Natural Resources and Environmental Conservation

The Republic of the Union of Myanmar

ROADMAP TO MYANMAR'S STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE HYDROPOWER SECTOR



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ACKNOWLEDGEMENTS

The Strategic Environmental Assessment (SEA) of the Myanmar Hydropower Sector would not have been possible without the leadership of Ministry of Natural Resources and Environmental Conservation (MONREC) and Ministry of Electricity and Energy (MOEE), with support from the Australian Government. Myanmar government focal points for this study including U Sein Aung Min and Daw Thandar Hlaing from Environmental Conservation Department, U Htoo Aung Zaw and U Nay Lin Soe from Department of Electric Power Planning played a critical role at all stages of the SEA process. Director General U Hla Maung Thein, Deputy Director General Dr. San Oo and Deputy Director General (Retire) U Sein Htoon Linn from Environmental Conservation Department, Director General Daw Mi Mi Khaing from Department of Electric Power Planning, Director General U Hein Htet from Department of Hydropower Implementation and Director U Tint Lwin Oo from Department of Electric Power Planning guided the work of the SEA and the focal points. These individuals provided technical inputs and facilitated working relations.

ICEM - International Centre for Environmental Management and the Myanmar Institute for Integrated Development prepared the overall SEA, with this final report prepared by IFC. ICEM's technical team included Jeremy Carew-Reid, Rory Hunter, Edvard Baardsen, Jens Grue Sjørslev, John Sawdon, Lois Koehnken, Lwin Lwin Wai, Mai Ky Vinh, Peter-John Meynell, Rick Gregory, Stephen Gray, Vuong Thu Huong, Win Myint, Yinn Mar Swe Hlaing, Yan Min Aung and Lina Sein Myint.

The IFC team leading and guiding the SEA included Kate Lazarus, Matt Corbett, Pablo Cardinale, Naung San Lin, and Tiffany Noeske. Vikram Kumar, IFC Country Manager for Myanmar and Daw Khin Thida Maw, Country Officer for Myanmar, provided valuable inputs. We also recognize the ongoing support of IFC's Environmental and Social Governance Department and Infrastructure Department, as well as the feedback and collaboration received from colleagues at the World Bank.

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ABBREVIATIONS

ADB	Asian Development Bank
AG	Advisory Group
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
DEPP	Department of Electric Power Planning
DWIR	Directorate of Water Resources and Improvement of River Systems
EAOs	Ethnic Armed Organizations
ECC	Environmental Compliance Certificate
ECD	Environmental Conservation Department
EFlow	Environmental Flow
EG	Expert Group
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EITI-MSG	Extractive Industries Transparency Initiative Multi-Stakeholder Group
ENAC	Ethnic Nationalities Affairs Council
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 Agreement
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	Liquefied Petroleum Gas
masl	Meters 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
MPLCS	Myanmar Poverty and Living Conditions Survey
MRC	Mekong River Commission
Mtoe	Million tons of oil equivalent
MW	Megawatt
NCA	Nationwide Ceasefire Agreement
NEMP	National Electricity Master Plan
NGO	Non-governmental organization
NTFP	Non-Timber Forest Product
NTP	Notice to Proceed
PES	Payment for Ecosystem Services
PPA	Power Purchase Agreement
SDF	Sustainable Development Framework
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SOBA	State of the Basin Assessment
TWh	Terawatt hour
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural Organization
VEC	Valued Environmental and social Component
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 catchment to a larger 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 each drain 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 MOEE.

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

Project size: the convention used in the SEA is: Small = 1 MW to <10 MW; Medium = 10 MW to 100 MW; Large = >100 MW. This differs from the definition contained in the Electricity Law 2014: small-scale electric power projects = up to 10 MW capacity; mid-sized projects = larger than 10 MW to less than or equal to 30 MW.

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

Regulated area: the catchment area regulated by a dam.

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

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

Watershed: a discrete natural drainage area within a sub-basin.

EXECUTIVE SUMMARY

The Myanmar hydropower sector, in the early stages of development, has the opportunity to develop sustainably by balancing electricity generation with environmental and social outcomes. The country is currently following a conventional hydropower development process, with individual projects identified and approved without due consideration of the overall cumulative impacts that multiple projects and other pressures have on the river basin. In many countries this process has resulted in most major rivers and tributaries suitable for hydropower being developed, regulating these watercourses for 50-100 years and beyond. Significant cumulative impacts on basin health and related ecosystem services have resulted, with minimal opportunity available to lessen these impacts.

This Strategic Environmental Assessment (SEA) of the Myanmar hydropower sector considers environmental and social values at the river basin level, recommending an approach to achieve sustainable hydropower development. The SEA recommends moving the initial planning focus away from individual projects to basin health to plan a sustainable sector development.

1. Background

Myanmar has a substantial need for power. The country has the lowest grid connected electrification rate in Southeast Asia, with only 40% of the population supplied. It is estimated that at least 500 MW of additional generation capacity is required to come on line annually up to 2030 to meet domestic demand. Additionally, Myanmar's electricity transmission grid requires considerable expansion and upgrading to meet demand.

The energy mix proposed in Myanmar is under review, with conventional and renewable power sources being analyzed in a national power sector strategy. Hydropower is likely to play an important role in the energy mix as it can generate large scale affordable renewable energy and help stabilize the grid, particularly intermittent power generation from other renewable sources.

Hydropower in Myanmar has experienced relatively limited development compared to the country's identified potential total capacity. The total installed capacity of projects of 10 MW and greater (29 projects) is 3,298 MW, accounting for 58% of national energy supply in early 2018. A further 1,564 MW capacity is under construction in six projects, but several of these are stalled or taking far longer to complete than scheduled. Currently, a total of 43,848 MW capacity is proposed in 69 projects nationally. These projects include six over 2,000 MW capacity each and seven between 1,000-2,000 MW capacity. To date, 80% of hydropower projects have been developed in cascade arrangements in sub-basins, with this geographic distribution driven by load center locations and the limited transmission grid, coupled with suitable sub-basin hydrology, topography and geology. Most development has occurred in the Ayeyarwady river basin where 64% of total installed capacity exists, with the Sittaung river basin accounting for 25%.

Myanmar, covering 671,700 km^2, has abundant freshwater resources. The main river basins are the Ayeyarwady, covering 55% of the country (with 90% of the basin lying within Myanmar), and the Thanlwin, covering 19% of the country (with 45% of the basin within Myanmar). An estimated 70% of Myanmar's population lives in rural areas, with a large proportion having a high livelihood dependency on riverine and other natural resources.

The health of Myanmar's river systems is reliant upon maintaining natural processes. Freshwater ecosystem services include:

- **Provisioning**: fish production, irrigation, and domestic water supply;
- **Regulating:** flow regulation, water purification, natural hazard (flood) regulation, maintenance of coastal landforms, and marine nutrient supply; and
- **Cultural:** cultural landscapes, recreation, and tourism.

The importance of Myanmar's aquatic resources is illustrated by fish production. An estimated 3.2 million people are employed in the freshwater and marine fisheries sector, consisting of 800,000 full-time and 2.4 million part-time (www.worldfishcenter.org/country-pages/myanmar). This sector is the fourth largest contributor to Myanmar's gross domestic product (GDP) and the fourth largest source of foreign exchange income, while providing an important source of dietary protein (estimated at 30 kg per person per annum).

Despite the potential for hydropower to make a substantial contribution to national socio-economic development, the sector has recently experienced challenges due to public opposition to large projects. Opposition has at least partly resulted from insufficient project transparency and stakeholder engagement and inclusion, as well as political shifts. Projects proposed on major rivers have received the most objections, leading the government to suspend the Myitsone, Tamanthi and Tanintharyi hydropower projects, totaling 7,800 MW capacity. Hydropower planning in Myanmar also has to contend with conflict affected areas, limited natural resource data and information (on river hydrology, geomorphology, aquatic ecology, social and livelihoods), and limited government capacity and resources.

2. Business-as-usual Development Limitations

Myanmar's current hydropower development process ('business-as-usual') is similar to conventional hydropower planning in most countries – focused on individual projects rather than basin- and sub-basin level planning. Feasibility analysis to select a project site is primarily founded on engineering and economic factors, which leads to project proposals with little consideration of the cumulative environmental and social impacts on the sub-basin or basin.

Business-as-usual hydropower development in Myanmar, assumed to be the installation of all currently proposed projects over the next 30 years, will not deliver basin sustainability. The development of large scale projects on the Ayeyarwady, Chindwin and Thanlwin mainstem rivers will cause significant impacts on system connectivity, basin processes and ecosystem services. These mainstem projects plus business-as-usual development in sub-basins will increase the total catchment area within Myanmar regulated by hydropower from 14% at present to 45%, regulating most hill and mountain catchments. This would result in the progressive degradation of basin health and the loss of important natural and social values across much of the country.

3. SEA Vision, Scope and Methodology

Ministry of Electricity and Energy (MOEE) and Ministry of Natural Resources and Environmental Conservation (MONREC) recognized the need to develop a sustainable hydropower sector, to balance development with natural resource maintenance. The ministries partnered with the International Finance Corporation (IFC) to prepare the SEA, setting the joint vision of:

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 is supported by six objectives:

- maintain natural river basin processes and functions that regulate and maintain river health and ecosystem services;
- retain unique and important biophysical and cultural sites and values, as well as representative environmental values;
- avoid unacceptable social, livelihood and economic impacts;
- recognize, understand and avoid or manage conflict risks;
- provide development benefits to project affected people, communities and regions; and
- generate adequate, reliable and affordable hydropower energy for domestic consumption.

The scope of the SEA covers all projects of 10 MW capacity or greater in Myanmar. The main planning principles applied include:

i) **Whole-of-basin planning:** focusing on system health at a hydrological scale to guide project site identification;
ii) **Balanced natural resource utilization:** retaining the full functions and values of a number of intact rivers and sub-basins to offset hydropower development impacts in other rivers/sub-basins, thereby maintaining basin health; and
iii) **Natural resource capacity-based development:** hydropower developed within the capacity of the natural system (or, carrying capacity) without unduly degrading natural values or creating significant impacts on the communities who use these resources.

Issue scoping was undertaken to understand the current hydropower development process and environmental and social values of importance to different stakeholders. An SEA Advisory Group and six technical Expert Groups were convened to guide the SEA, identify the best available information, review draft findings and help engender broad understanding of and commitment to the SEA vision. These groups consisted of local and international specialists covering different technical fields, from government, non-governmental organizations, the private sector, development partners, multi-lateral agencies, academic institutions, ex-government officers and independent researchers.

Broad stakeholder engagement was undertaken to canvass views on the direction of the sector and issues of importance, involving over 55 consultation activities across Myanmar. Activities included regional river basin workshops with civil society organizations and state/region governments, multi-stakeholder workshops, direct consultation with local communities, political parties, ethnic armed organizations, and discussions with the Myanmar Hydropower Developers' Working Group.

A hydropower geographic information system (GIS) database was prepared, mapping existing, under construction and proposed projects of 10 MW capacity or greater. Eight basins were defined covering the country, consisting of six river basins: Ayeyarwady, Thanlwin, Mekong, Sittaung, Bago and Belin; and two coastal basins where coastal watersheds were grouped: Tanintharyi and Rakhine. Basin complexity was handled by identifying and analyzing two natural management units with related, but discernably different, primary functions:

i) **Mainstem rivers:** providing basin connectivity; and
ii) **Sub-basins:** providing the primary land/water interface, where physical, chemical and biological processes influence the ecological functioning of the basin.

A total of 58 sub-basins were defined and evaluated, covering the entire country. The business-as-usual development impact was then assessed to determine the likely outcomes of this development pathway, then a 'sustainable development framework' was prepared to guide future development.

4. Sustainable Development Framework

The sustainable development framework (SDF) for future hydropower sector development was formulated based on an evaluation of basin processes and values and likely hydropower impacts. This 'first edition' plan recommends balanced development over the long term, providing the initial planning framework for project siting. The SDF focuses on basin health and the retention of important natural and social values. This is supported by two subsequent levels of integrated hydropower planning necessary to deliver sustainable development:

- Cumulative Impact Assessment (CIA) - for a sub-basin or watershed where multiple projects or a single notable hydropower project is proposed; and
- Project environmental and social assessment (either an Environmental Impact Assessment or Initial Environmental Examination) - for each hydropower project of ≥1 MW, as required under Myanmar law as part of the project approval process.

The main component of the SDF is the Basin Zoning Plans that recommend: (i) mainstem river stretches to be retained to maintain basin connectivity; and (ii) sub-basins zoned for either potential development or protection. Mainstem rivers provide basin connectivity: an unimpeded pathway for water, sediment, fish and other aquatic organisms to move between sub-basins and the sea, maintaining essential ecosystem services. Connectivity-related basin functions include water cycling and river flow characteristics (seasonality, water levels), river channel maintenance, aquatic ecology cues and processes (e.g. for fish migration), riverine habitat maintenance, flushing of land derived nutrients into the sea, sediment replenishment in marine areas that maintains coastal landforms, natural hazard regulation (floods and coastal protection), and the prevention of saltwater intrusion in delta regions. Sub-basins provide the primary land/water interface in basins, where physical, chemical and biological processes influence basin ecological functioning.

Mainstem rivers in five basins have been identified to maintain critical basin processes. Each mainstem is a Strahler Order 4 or greater and has a very large average annual flow rate of greater than 1,000 m^3/s (except for the Sittaung mainstem). Approximately 4,100 km of mainstem river reaches are recommended to be reserved for their connectivity value, consisting of sections of the Ayeyarwady (1,500 km), Chindwin (900 km), Thanlwin (1,200 km), Mekong (200 km) and Sittaung (300 km) rivers.

Sub-Basins were zoned either for potential development or for protection, based on the evaluation of the baseline values of three biophysical factors:

i) **Geomorphology:** river connectivity and delta/coastline stability; potential sediment production; river flow;
ii) **Aquatic ecology and fisheries:** river reach rarity (WWF, 2014); and the presence of endemic species, key biodiversity areas, Ramsar sites and important wetland areas, confluences, karst geology, and the presence of threatened fish and aquatic organisms; and
iii) **Terrestrial biodiversity:** percentage of protected area / key biodiversity areas; and percentage of intact forest (≥80% crown cover).

Social and livelihood features were also evaluated, incorporating social vulnerability, dependence on natural resources, and poverty. Information was restricted to 2014 census data at the township level, with proxy indicators used for social vulnerability and poverty. The intention was to include this evaluation to help to determine sub-basin zoning, but this was not possible as the data did not provide a good indicator of likely social impacts that are usually highly location-specific within sub-basins.

The status of conflict between state and non-state armed groups was also evaluated for each sub-basin, identifying conflict risks that may pose significant or insurmountable obstacles for project development, or may be exacerbated by project development. The evaluation was based on the current and historic status of armed conflict, considering the presence of armed groups, historic population displacement, recent conflict incidents and estimated battle deaths. It provides an additional screening layer for proposed projects, to be applied by developers early in the project feasibility analysis to determine if the project should proceed. As conflict risk is dynamic over time and the level of risk can vary across a sub-basin, project planning in conflict-prone areas should include conflict sensitivity analysis that incorporates broad stakeholder engagement with directly affected people, historically displaced populations, ethnic armed organisations and ethnic political parties.

Ratings were given to each biophysical factor then totalled and scaled to determine one of three sub-basin ‘zones’:

- **High** - provides an important contribution to basin processes (such as high flows or a large sediment load), and/or has unique natural values for at least two biophysical factors;
- **Medium** - no high conservation value features over a notable area for two biophysical factors, although may contain notable values for a single factor or pockets of such values;

- **Low -** no high conservation value features over a notable area for any biophysical factor, although may contain pockets of high value.

The ten High zone sub-basins identified, covering 24% of Myanmar, are recommended for protection to maintain critical biophysical processes and values in these catchments. Hydropower development in these sub-basins is recommended to be restricted to smaller scale projects with low environmental and social risks that cumulatively will not unduly degrade significant sub-basin values. Five of the High zone sub-basins form a contiguous block in the headwaters of the Ayeyarwady basin, covering a combined area of 78,900 km^2 (21% of the basin in Myanmar). Important values in this area include the contribution of around 47% of total basin discharge and a substantial volume of sediment. This area also contains high value aquatic habitat and notable terrestrial ecosystems in Hkakaborazi National Park, four Wildlife Sanctuaries, numerous key biodiversity areas and 35% of all remaining intact forest (>80% crown cover) in Myanmar. Two other High zone sub-basins are located in the Tanintharyi basin, while one each is located in the Thanlwin, Mekong, and Rakhine basins.

Twenty-one Medium zone and 27 Low zone sub-basins were identified as being potentially suitable for hydropower development, covering 37% and 39% of Myanmar respectively. These sub-basins are recommended to be considered by government for potential hydropower development in the initial stages of zoning implementation. Over time, as new information is obtained on natural resources and social features, as basin modelling is refined and projects are approved, it is recommended that the government consider utilization trade-offs in this group of sub-basins to achieve a balance between developed catchments and catchments reserved to maintain system health, ecosystem services and other important values.

Sustainable hydropower development is recommended to incorporate cascade projects instead of similar generation capacity dispersed across many sub-basins. The advantages multiple projects in a sub-basin or watershed versus dispersed projects can include a lower overall magnitude of impact per unit of energy generated, and increased power generation per unit of water regulated as stored water is run through multiple powerhouses. This allows intact rivers to be retained while generating similar or greater hydropower within a basin. The development of Low and Medium zone sub-basins, assuming all business-as-usual projects are installed, would raise the total Myanmar catchment area regulated by hydropower from 14.4% to 23.5%, considerably less than 45% that would be regulated under business-as-usual.

The total capacity of the future hydropower sector developed in accordance with the sustainable development framework cannot be accurately predicted due to the range of natural resource, social and market variables that will have an influence. However, the approximate scale is estimated to be around 13,000 MW or greater installed capacity. This estimate is based on existing projects (3,300 MW), plus new generation from projects under construction (1,600 MW), currently proposed projects in Medium and Low zones (7,300 MW), some capacity from low impact hydropower projects in High zone sub-basins, as refurbishment of existing power stations and the installation of turbines on irrigation projects, not to mention small hydropower projects of less than 10 MW capacity. But as hydropower investigations proceed in priority sub-basins, additional overall capacity may well be developed.

The Basin Zoning Plans provide an initial planning tool for project siting, supported by the hydropower GIS database, sub-basin evaluations and a three-year framework implementation plan that includes:

- establishing of a Joint Planning Committee with the Government of Myanmar (MOEE and MONREC);
- developing a national Sustainable Hydropower Policy;
- developing a Basin Zoning procedure for Government of Myanmar implementation;
- recommending sustainable project design criteria;
- recommending improvements to environmental and social impact assessment and management planning; and

- collecting baseline data and conducting research.

As a first edition plan, it is recommended that the framework be reviewed after three years after the commencement of implementation, and revised as needed based on more detailed information and implementation findings and results.

5. Outcomes

The SEA seeks to provide a balanced pathway for sustainable hydropower development in Myanmar, based on important biophysical processes and values, the range of views of different stakeholders, and the power needs of the country that could be serviced by hydropower generation. It has promoted an important conversation among stakeholders on sustainability and the long-term direction of hydropower, and provides the first basin-wide view of hydropower development and related natural resource values in Myanmar.

The sustainable development framework serves as the planning nexus between hydropower development and natural resource protection, with both being achievable through basin-level planning. By shifting the initial planning focus away from individual projects towards long-term basin health and the maintenance of system-dependent ecosystem services, the environmental and social risks of hydropower to natural resources and river-dependent communities are substantially reduced. The framework recommends a development framework whilst recognizing current planning constraints, allowing the sector to move towards sustainable development before business-as-usual development plays out and results in significant basin regulation and degradation.

Application of the framework for hydropower sector planning is expected to:

- help maintain healthy basins over the next 100 years and beyond by avoiding significant natural resource degradation from the loss of mainstem connectivity and important sub-basin environmental and social values;
- preserve essential river-based ecosystem services;
- provide clear direction to decision makers and developers on the appropriate siting and design of projects;
- initiate meaningful stakeholder engagement, thereby improving project design and stakeholder acceptance of well planned projects;
- improve access to international financing by avoiding and reducing basin-wide cumulative impacts; and
- promote local and national development through the provision of affordable and reliable renewable electricity generation, to supply households, businesses and industry.

1. INTRODUCTION

Myanmar, the largest country in mainland Southeast Asia, has one of the least developed economies in the region[1] despite some abundant natural resources and relatively low population density. The power system in Myanmar is illustrative of the country's underdevelopment, with 40% of households electrified.[2]

The Government of Myanmar (GoM) recognizes that access to electricity is important to improve livelihoods and achieve 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 potential to increase 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, with 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 45.0% 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 degraded or lost 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) of 10 MW capacity or greater 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.

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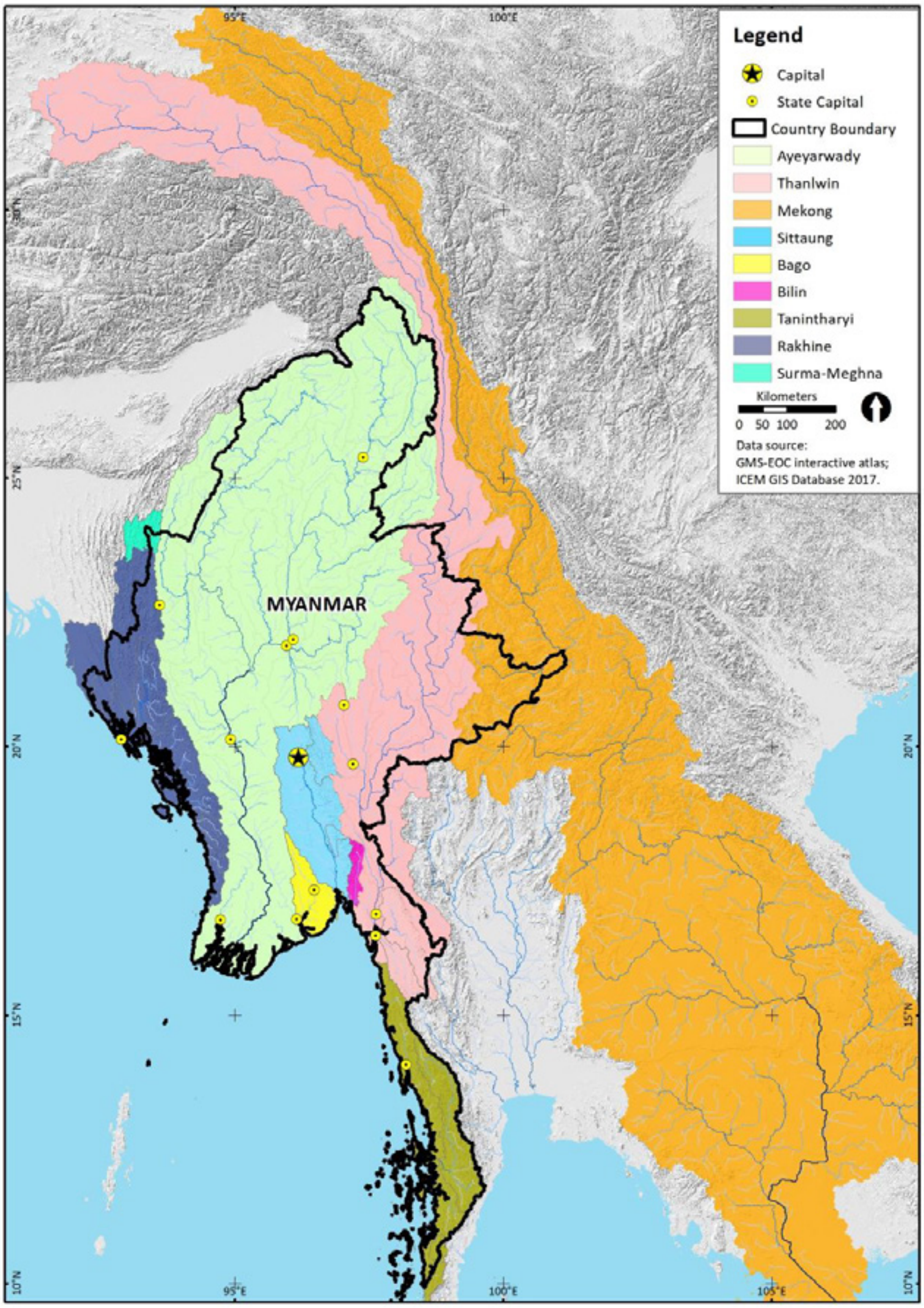
[1] United Nations Development Program (UNDP), 2013. Accelerating Energy Access for All in Myanmar. UNDP, Yangon, Myanmar.

[2] MOEE, 2018. MOEE presentation to: The Third Meeting of Energy and Electric Power Sector Coordination Group – 8 August 2018.

[3] 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.

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 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 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 rivers and major tributaries, creating substantial changes to river processes and functions, and the loss of unique environmental and social values. Stakeholders have recognized these adverse impacts and vocally opposed some large scale projects, causing the government to suspend three major HPPs[4] on environmental and social grounds.

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. This project-centric planning approach locks in the project site at the pre-feasibility stage, with little to no consideration of environmental and social impacts, particularly cumulative impacts of multiple projects on 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, with few major tributaries remaining free-flowing.

In response to the increasing challenges of hydropower planning in Myanmar and recognising the opportunity to develop a sustainable hydropower sector, GoM instigated this Strategic Environmental Assessment (SEA) as the first stage in basin-wide hydropower planning. The SEA was developed through a partnership between Ministry of Electricity and Energy (MOEE) and Ministry of Natural Resources and Environmental Conservation (MONREC), with support from the International Finance Corporation (IFC) and the Australian Government. The SEA brings environmental and social considerations into preliminary hydropower planning to ensure that project siting, design and management incorporate sustainable development principles.

[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.

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 deliver the dual outcomes of 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, under construction, proposed, and identified hydropower projects of at least 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 in 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- low regime of 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, including 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 is required to maintain wetland health or 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 and largescale 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, aiming 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 and 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 catchments. This includes further developing sub-basins with substantially modified river conditions from existing HPPs. Additional projects in a cascade arrangement in these sub-basins may only raise existing cumulative environmental and social impacts by a small increment when compared to initiating projects in a number of undeveloped sub-basins.

Recognize and manage conflict risks for more informed decision making. The risk that conflict poses to hydropower development, and vice versa, requires the implementation of robust safeguards to identify and manage these risks. 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 projects in areas of risk 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[5] 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"[6] 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-basins with the sea; and sub-basins - areas that either drain into the mainstem river, or directly into the sea, providing the primary land/water interface where physical, chemical, and biological processes influence the ecological functioning of the basin.

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.

[5] The upper limit of the United Nations Industrial Development Organization's definition of small hydropower (2016).
[6] 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."

Natural resource capacity-based development: Hydropower should be developed within threshold levels or 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 an 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 different aquatic habitat types, thereby contributing to the overall health of basin processes.

2.5 Information Limitations

The SEA has been prepared with limited available data in a number of 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 relied upon 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 the diverse views 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, building a broad understanding of the need for and direction of 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 the main information gaps and planning requirements, enabling key actions to commence as early as possible to fill these knowledge gaps and enable more detailed planning to commence in the short to medium term.

A consultative and transparent approach was adopted to garner broad views and to evaluate baseline conditions and trends. 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 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 (DEPP) of MOEE. The departments and ministries provided advice and assistance during SEA preparation that involved:

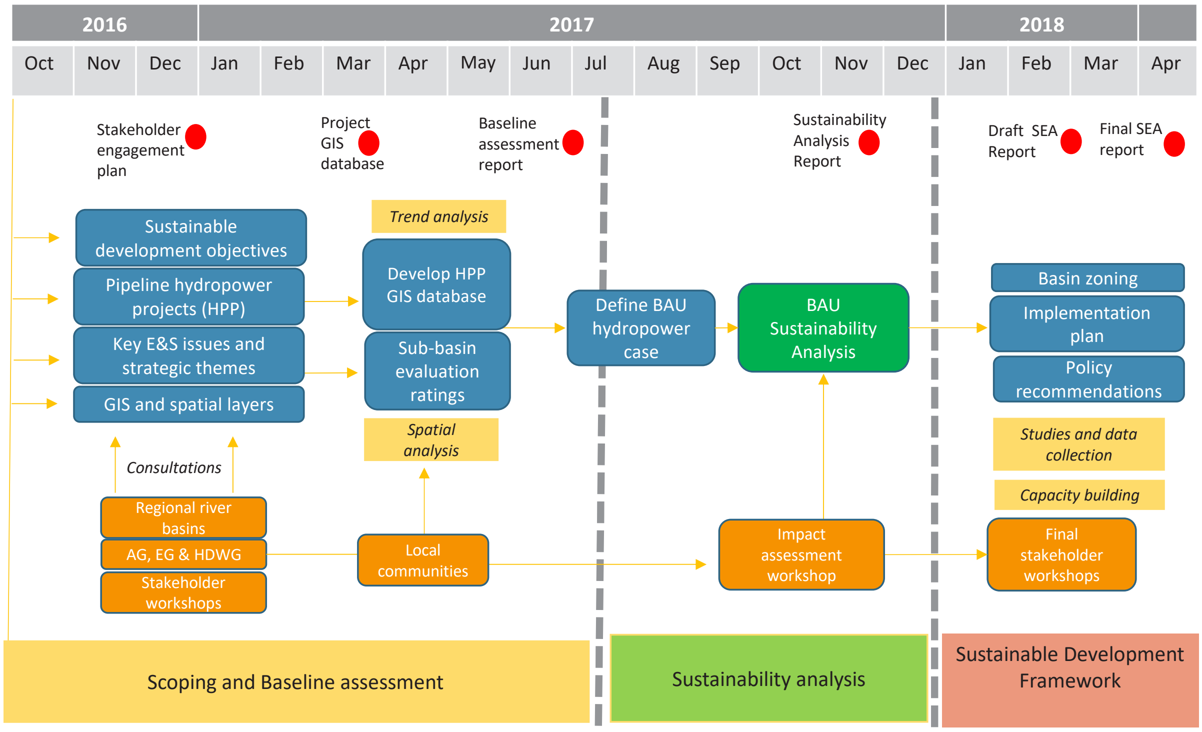
- participating in senior advisory committee meetings to review the SEA direction and progress;
- providing two technical advisors from each ministry to participate in all stakeholder engagement activities;
- providing key technical data for the compilation of the hydropower project database;
- reviewing 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 main SEA preparation tasks (Figure 3.1) were:

- issue scoping;
- formulation of and consultation with the SEA Advisory Group (AG) and technical Expert Groups (EG);
- hydropower project GIS database preparation;
- sub-basin environmental and socio-economic baseline evaluation;
- hydropower BAU sustainability analysis;
- SDF development; 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

A national GIS database of existing and proposed hydropower projects of 10 MW capacity or greater was developed to take stock of the status of hydropower development in each basin and sub-basin and inform sustainable development planning. The database provides the location of each project and a summary of key project information, 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. The Baseline Assessment report was prepared covering seven related features:

- Hydropower
- Geomorphology and sediment transport
- Terrestrial biodiversity
- Fisheries, aquatic ecology, and river health
- Economic development and land use
- Social and livelihoods
- Peace and conflict

Sub-basin evaluation was then undertaken for five strategic SEA themes: (i) geomorphology, (ii) aquatic ecology and fisheries, (iii) terrestrial biodiversity, (iv) social and livelihoods, and (v) peace and 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 1-5 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. This analysis was presented in a separate Sub-Basin Evaluation report, summarizing baseline values, key biophysical and socio-economic features, and presents the ratings for each of Myanmar's 58 sub-basins. The baseline ratings for each sub-basin were then 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 involved all currently proposed and identified HPPs being constructed over the next 30 years. Conducting this initial assessment identified major cumulative impacts and in doing so provided justification and direction for sustainable hydropower development.

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 mainstem and sub-basin analysis and ratings of identified values, aiming to achieve 100+ year outcomes. Critical mainstem rivers are recommended 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.

3.3.6 SDF Implementation Plan

A program of key actions was prepared to implement and periodically update the SDF. The program includes: recommended policies and procedures for government implementation of the SDF; critical baseline data gathering and research to fill gaps and improve planning at basin and target sub-basin levels; additional coordinated basin-wide planning; institutional capacity enhancement; and periodic SDF revision.

3.3.7 Stakeholder Engagement

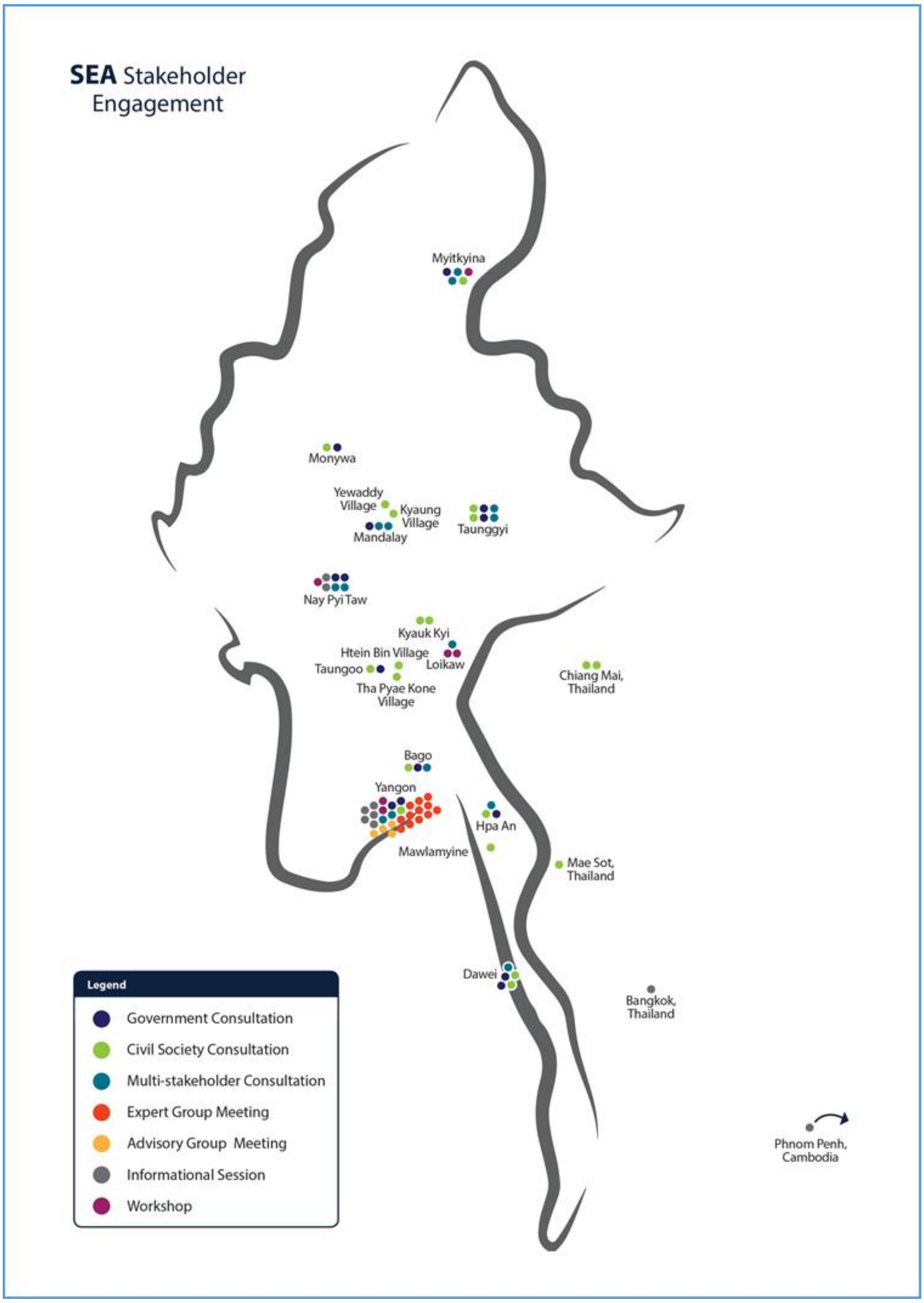
Stakeholder engagement was undertaken throughout the SEA process to help build broad awareness and enable decision-makers better understand the range of stakeholder values and interests that need to be considered in formulating the SDF and in improving dialogue between the public and private sectors. 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/region 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/region 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 Paunglaung, 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 Kyaukkyi 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 the SEA AG and six EGs. The AG 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 EGs 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 organized along the key strategic themes of the SEA.

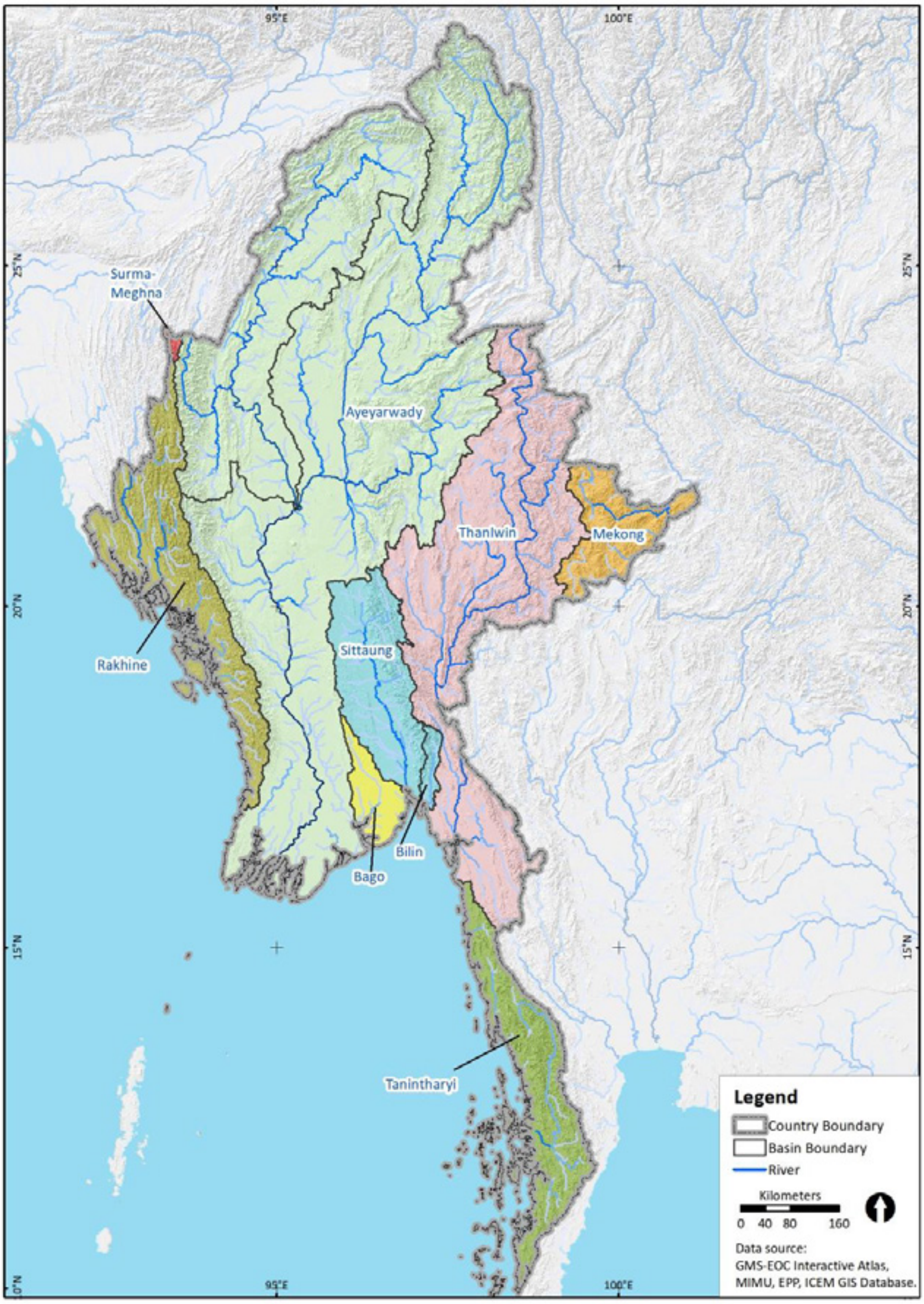
The Regional River Basin Consultations - Key Findings report provides additional information on stakeholder engagement at the river basin level.

4. BASINS AND SUB-BASINS

4.1 Basin and Sub-Basin Delineation

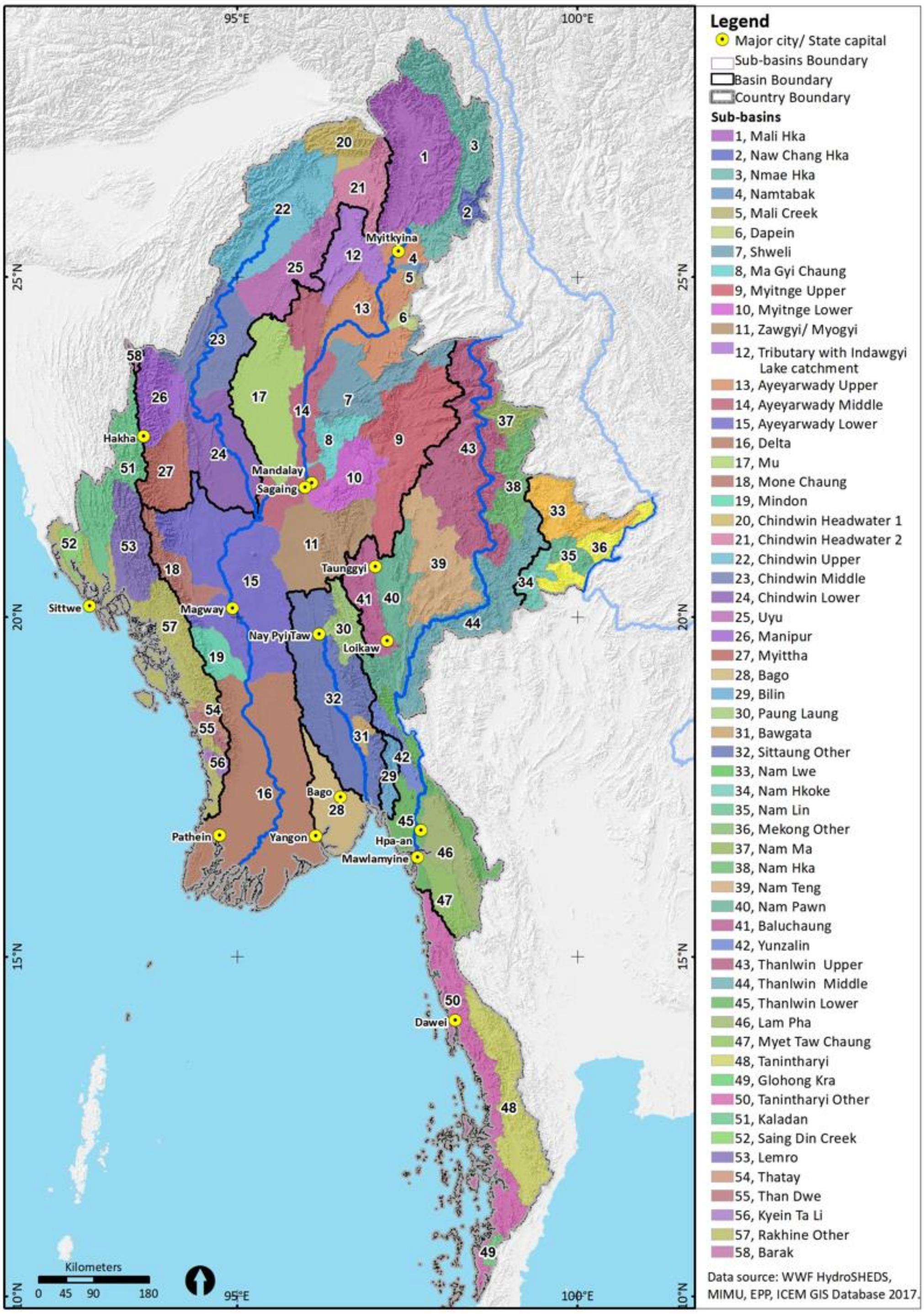
Six river basins were defined within Myanmar based on surface water hydrology, either extending from the sea up to the headwaters of the natural catchment area where it is wholly contained within Myanmar, or limited to the Myanmar area of basins that extend into neighboring countries: Ayeyarwady, Thanlwin, 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, planning 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 catchment area is too large and complex to analyze and manage as a single unit (Figure 4.2). The Bago and Bilin basins, being only 3,056 km^2 and 10,261 km^2 in area respectively, are relatively small and hence are each 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 siting and screening, as well as the key sustainable development principle of preserving intact tributaries/sub-basins while 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 allows for trade-offs to be made between areas with similar conditions. Fifty-eight sub-basins were identified using HydroSHED[7] 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 cascade projects 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 and middle Ayeyarwady. Sub-basin details by basin are summarized and illustrated in Appendix A.

Fifty-two sub-basins drain directly into a 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 the mainstem river 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 in these catchments 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: Nawchankha 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 Paunglaung and Bawgata, both discharging into the Sittaung Other. 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.

As more detailed information becomes available, disaggregation of some sub-basins down to watershed level is likely to occur to improve planning and management, thus completing a multi-scale approach to hydropower planning.[8] Sub-division to watershed level is likely to occur where sub-basins are large and/or have a distinct range of conditions, where different management regimes are desirable within a single sub-basin.

4.2 Basin Description

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 headwater area in Myanmar (792 km^2). The total basin area, river length, and states/regions crossed by the eight major basins are summarized in Table 4.1.

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

[8] 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).

Table 4.1: Major River and Coastal Basins in Myanmar

Basin	Total Basin Area[a] (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 – 48 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
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 taken from GIS HydroSHEDS/HYBAS LAKES data apart from the Thanlwin.
Note: Barak sub-basin 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. 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, Chaung Ma Gyi, 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 southwards 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 m 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, 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 283,335 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 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 out of Thailand. A 130 km long reach of the Thanlwin river 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 in Myanmar 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 lies within Myanmar, in Shan State (East), covering 3.3% (21,947 km^2) of Myanmar's land area.[9] With headwaters on the Tibetan Plateau, the Mekong River flows southeast through China, meeting the tripoint of China, Myanmar, and Lao People's Democratic Republic (Lao PDR). The river forms the Myanmar/Lao border for around 240 km before becoming the Lao-Thailand border, then entering Lao PDR. Tributaries within Myanmar contribute an estimated 558 m^3/s to the mean river discharge rate of 13,000 m^3/s (3.7% of total flow). Similar to the Ayeyarwady and Thanlwin basins, most runoff occurs during the monsoon season (mid-May to mid-November). The Mekong Basin within Myanmar 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 within Myanmar are Mong Yang, Mongkhet, Mongla, Kengtung, Mongyawng, Mongkhol, Monghast, and Tachileik.

4.2.4 Sittaung Basin

The Sittaung basin covers around 5.2% (34,913 km^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.[10] The

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

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 and cultivation 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 draining from the Pegu Range hills (known as the Yangon River further downstream where it joins the Myitmaka River), the smaller Myit Mo Hka catchment to the west, and a number of small watersheds to the east drain directly into the sea. The basin covers 1.5% (10,261 km^2) of Myanmar, and the Bago River is around 200 km long. Annual rainfall is 2,980 mm in the basin.

Around 4.6 million people reside in the basin, with 78% living in rural areas and the remaining 22% in urban areas. Bago City is the largest settlement with a population of 284,000 (2012). Bago District has a population density of 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 0.5% (3,056 km^2) of Myanmar and is therefore treated as a single sub-basin. The Bilin River flows from Papun Township, Kayin State, 210 km southwards 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, with Bilin town being the main settlement. 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 6.7% (44,876 km^2) of Myanmar. It 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), covering 40% of the basin. The upper basin boundary forms the national border with Thailand for around 450 km. Population density in the basin is 41 people per km^2, with the main cities/towns being Dawei and Myeik.

4.2.8 Rakhine Basin

The Rakhine coastal basin is situated 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 8.2% (55,409 km^2) of Myanmar. The distance from the mountains to the sea is relatively short, with many small rivers draining the coastal ranges directly 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, with the main settlements being the towns of Sittwe, Kyaukpyu, Thandwe, Gwa, and Maungdaw.

5. ENERGY AND HYDROPOWER DEVELOPMENT

5.1 Energy Security

Myanmar is both an exporter and importer of energy. Exports accounted for around 34% (6.3 Mtoe) of total domestic energy production in 2014, but increased to 44% (11.8 Mtoe) in 2015 according to International Energy Agency statistics.[11] The main energy export is gas sourced from offshore fields and piped to Thailand and China under long-term supply agreements that effectively preclude the domestic use of these resources. Myanmar also exports power generated by several hydropower plants to Yunnan Province, China.

At the same time, Myanmar is increasing its energy imports, particularly of oil products due to limited domestic oil supply and refining capacity. Growing domestic power demand is likely to increase the reliance on fossil fuel imports for power generation, with the sector facing several different scenarios. Recent 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 to develop domestic renewable energy resources, including solar and wind. But in the short to medium term up to 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 Myanmar's generation mix, accounting for 60.4% in early 2017. It is likely that hydropower will become more important in the short term as some sizeable generation projects are progressively commissioned, and if 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 national energy mix will probably decline as the country adopts other forms of generation such as coal, gas, and other renewables.

Current power demand projections indicate the need to add 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 is added to the generation mix apart from projects under construction, power demand will 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 the high level of technical and non-technical losses (currently at around 20% of production), while demand-side management measures (such as time-of-day pricing) could be introduced 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.

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[11] https://www.iea.org/statistics/statisticssearch/report/?country=Myanmar&product=balances.

[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 required if hydropower development is foregone. This could include coal, gas, other renewables, and increased imports. Although this could make power supply more expensive, diversification may increase energy security if stable supply chains are secured.

The 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. Gas and coal have the advantage of having plant construction close to load sources, however 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 a possibility by establishing international agreements and the construction of transmission lines. This option is likely to be more expensive than domestic hydropower generation and may pose security concerns.

Recent power supply announcements by MOEE include the proposed installation of four new LNG plants in Myanmar and the importation of 100 MW of power from Lao PDR. MOEE is also 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.

5.1.2 Energy Security in the Power Sector

Hydropower development may 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 leave supply 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. Increasing rainfall variability or changes 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, with these studies and more recent ones estimating 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 Lawpita Falls on the Baluchaung in the Thanlwin basin, completed in 1960. The second phase of this project adding 84 MW was completed in 1974. In the 1980s, an additional 25 MW capacity was built in other parts of the country, followed by three projects totaling 102

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

MW in the 1990s, 11 projects totaling 2,194 MW between 2000-2010, and 12 projects totaling 982 MW between 2011-2015.

Since the mid-1970s, hydropower has been the main source of electricity in Myanmar, but the industry is still in its relative infancy as the potential installed capacity is far greater than current capacity. Twenty-nine hydropower projects of 10 MW capacity or greater are operational, totaling 3,298 MW, versus an estimated 45,632 MW of potential countrywide capacity reported by MOEE in 2015.[14] In addition, 32 mini-hydropower plants (between 0.1 and 5.0 MW capacity each) totaling 33.3 MW have been installed on irrigation dams and as separate off-grid rural electrification projects.

Hydropower development is moving from government-driven projects toward private sector dominated projects. In the past, the majority of hydropower projects were exclusively developed by the GoM, either by MOEE or 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: Shweli 1 and Dapein 1 HPPs completed in 2009 and 2011, respectively. Seven domestic and foreign private sector hydropower projects are in operation, with a further 22 operational projects are owned by 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. Private sector development relied on companies proposing projects directly to the GoM. The location and type of project either came from previous hydropower studies or developer investigations. 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. Electricity consumption of 333 kilowatt hours (kWh) per capita (reported by MOEE in March 2018) is ranked as one of the lowest in the world, substantially lower than the 2014 world average of 3,128 kWh.[15] 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 is 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.[16]

In March 2018 total installed capacity was 5,642 MW, of which 3,255 MW (57.7%) was from hydropower, 2,175 MW (38.6%) from gas, 120 MW (2.1%) from coal, and 92 MW (1.6%) from

[14] Ministry of Electric Power, 2015. Development of Electric Power in Myanmar. PowerPoint presentation presented by H.E. U Maw Thar Htwe, Deputy Minister, May 2015.
[15] http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC
[16] 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.

diesel.[17,18] 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 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 Myanmar's distinct wet and dry seasonal pattern, the country experiences significant fluctuations in the supply of electricity. The existing base load generation mix dominated by hydropower reaches peak capacity towards the end of the wet season and tails off during the dry season, resulting in supply shortages. Available capacity is about 50% of total hydropower installed capacity due to poor maintenance and issues with power evacuation. Two hydropower plants totaling 53 MW (Baluchaung 1 and Sedawgyi) and a gas-fired power plant (57 MW Thaketa) are being rehabilitated, while seven older hydropower plants[19] 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. Annual hydropower electricity generation grew from about 2,000 GWh in 2000-01 to 11,190 GWh by early 2018. 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 8,344 GWh by early 2018. Meanwhile, generation from coal-fired power plants halved to 451 GWh by early 2018.

Myanmar's transmission system consists of 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 grid expansion: the Asian Development Bank (ADB) is financing the 230kV 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

[17] MOEE, 2018. MOEE presentation to: The Third Meeting of Energy and Electric Power Sector Coordination Group – 8 August 2018.

[18] There is a slight difference between MOEE's data in the presentation of June 6-7, 2017, and the HP Database, which includes some state/region projects and has used data provided by developers.

[19] Zaungtu (commissioned in 2000), Zawgyi II (2011), Ye Nwe (2007), Kinda (1990), Mone Chaung (2004), Thapenzeik (2002), and Kabaung (2008).

population to 75% by 2021/2022, and then to 100% by 2030. The GoM is preparing an update to the National Electricity Master Plan (NEMP) with assistance from the JICA. The NEMP includes a strategy for new electric power generation plants to be constructed by 2030 based on an energy mix of 53% hydropower (13,194 MW), 15% domestic gas (3,836 MW), 11% coal (2,621 MW), 11% LNG (2,866 MW), and 10% other renewable sources (other than hydropower) (2,420 MW).[20] 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

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 can identify and develop a potential project, with initial siting undertaken by either MOEE or the developer.

For hydropower projects larger than 30 MW capacity,[21] the GoM enters into a contractual arrangement with the developer, with the contract type determined by the source of project funding:

- Sole investment - financed by the GoM through either 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 MOEE on a BOT basis.

Project development involves four consecutive steps ending in the following agreements that progressively grant the developer the right to move the project to the next stage:

1. Memorandum of Understanding (MoU)[22];
2. Memorandum of Agreement (MoA);
3. Joint Venture Agreement (JVA); and
4. Project Development Permit.

Seeking a MoU for the right to investigate and develop a hydropower project involves a prospective developer preparing an expression of interest for a project on 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 MOEE, then both parties negotiate the scope and duration of the required study and fieldwork at the project site. 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, MOEE and the developer sign a MoU with an 18-month validity. Next, the developer prepares a feasibility study that includes determining the financial viability of the project, and prepares an EIA, which are subsequently reviewed and approved by MOEE and MONREC, respectively. If the EIA is acceptable, MONREC issues an Environmental Compliance Certificate (ECC).[23] MOEE and the developer then enter into preliminary negotiations on the power purchase agreement (PPA)[24] and agree on a draft PPA. MOEE and the developer next sign a MoA, followed by the developer negotiating a draft JVA with MOEE and other development partners. Once MOEE and the developer sign a JVA, the developer seeks all necessary permits from government agencies, including approval from the Myanmar Investment

[20] MOEE and JICA, 2018. The Project for Capacity Development of Power Sector Development Planning. Presentation on the Optional Studies of Generation Mix.

[21] State and region governments can approve projects up to 30 MW capacity if not connected to the grid.

[22] The GoM is issuing a Notice to Proceed (NTP) in lieu of a MoU for LNGs projects and is expected to also provide NTPs for some hydropower projects in future.

[23] To date, no ECCs have been issued by MONREC, with no-objection letters issued instead.

[24] The Hydropower Developers Working Group (HDWG), with support from IFC, has drafted a model CA/PPA template for hydropower projects which is under final review by MOEE.

Commission, agreement on the final PPA following results from procurement, and financial close.[25]

HPPs with an installed capacity of up to 30 MW and not connected to the national power grid can be developed by a state/region 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, 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 and large 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. An EIA is usually prepared after the feasibility study has been submitted to MOEE, therefore it does not contribute to project siting and design improvement to avoid and reduce negative impacts. This process is out of line with good international industry practice that involves the concurrent preparation of the project design and EIA, 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 conducting limited monitoring to date 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

5.7.1 Operational and Under Construction Projects

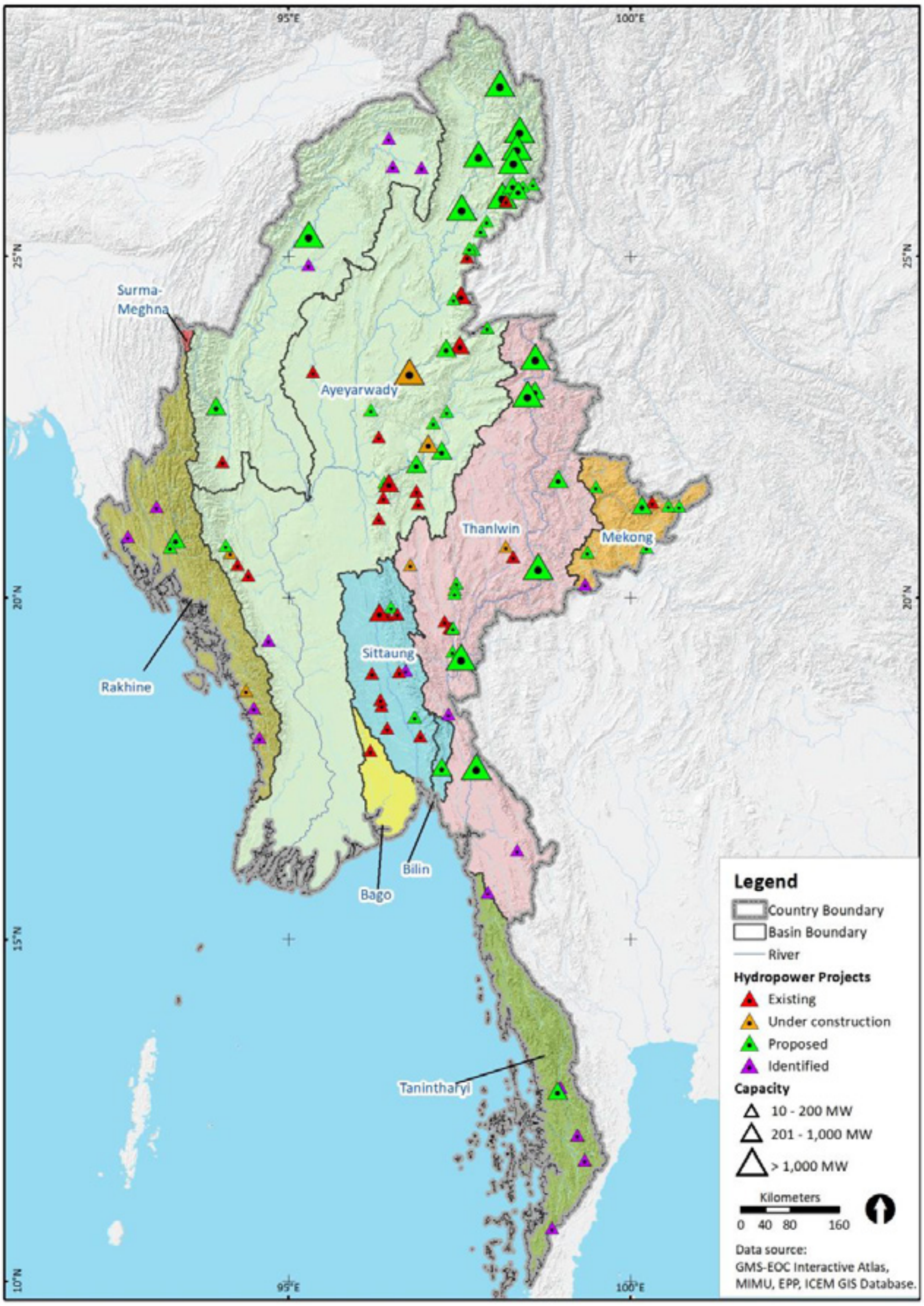
There are 29 operational hydropower plants of 10 MW capacity or greater in Myanmar, totaling 3,298 MW installed capacity (Table 5.1 and Appendix B). Six additional projects are under construction with total installed capacity of 1,564 MW. Basin distribution of existing projects is dominated by the Ayeyarwady, with 13 operational (2,060 MW) and three under construction (1,372 MW)[26]. The Sittaung basin, with an area of only 34,900 km^2 (5.2% of the country) is the most intensively developed basin in terms of MW capacity/km^2, with nine projects in operation totaling 810 MW, representing 24.6% of Myanmar's operational hydropower capacity. The Thanlwin basin follows with four projects in operation (302 MW) and two under construction (81 MW)[27]. In the remaining five basins there are only two operational projects of 10 MW capacity or greater: Mongwa HPP (66 MW) in the Mekong basin, and Zaungtu HPP (20 MW) in the Bago basin; and only one project under construction: Thahtay HPP (110 MW) in Rakhine basin.

[25] The procurement process for HPPs is under review.
[26] Buywa HPP (47 MW), Yeywa HPP (280 MW), and Shweli 3 HPP (1,050 MW).
[27] Keng Taung Upper HPP (51 MW) and Baluchaung Upper HPP (30 MW).

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**

Figure 5.1: Status of Hydropower Development in Myanmar



5.7.2 Proposed and Identified Projects

Proposed and identified HPPs of 10 MW capacity or greater in Myanmar total 43,848 MW (Table 5.2 and Table 5.3), consisting of 22,760 MW on mainstem rivers (51.9%) and 21,088 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 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**

Note: excludes identified projects.

The 51 proposed projects have been notified to MOEE and are in various stages of pre-construction development. These projects are all proposed by the private sector. Eight of these projects, ranging between 600-7,000 MW capacity, are proposed on identified mainstems or the main basin tributary. Five of these HPPs are proposed on the Thanlwin River, totaling 14,960 MW or 66% of all proposed mainstem projects. The remaining three proposed mainstem projects - 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 by the GoM.

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 Nawchankha (1,200 MW) are the next largest sub-basins in terms of total proposed MW.

A further 18 HPPs with a combined total capacity of 994 MW have been identified at state/region level, for which no feasibility studies have been prepared (Table 5.3). The majority of identified projects have an installed capacity of 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	394
Total	**18**	**994**

6. SIGNIFICANT ENVIRONMENTAL AND SOCIAL ISSUES

The SEA focuses on significant environmental and socio-economic issues directly related to medium and large HPPs to reduce negative impacts during project siting and design. These issues were considered in terms of both science supported issues and stakeholder concerns, most of which are common issues.

6.1 Major Potential Hydropower Environmental and Social Issues

While hydropower development delivers renewable energy, jobs, tax contributions, and improvements to local infrastructure such as roads, and can promote local development, it can create adverse environmental and social impacts at the 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 riverbank and river bed erosion due to reduced sediment load and “sediment-hungry water” • Changes to grain size 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 retention 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

Factor	Potential Impact	Cause/Effect
		• 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 cultural/religious practices	• 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
	Loss of important natural/cultural heritage/religious sites	• Inundation or removal of unique sites
	Access/transport restrictions	• Curtailing of or reduction in 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 huge 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 is to enhance decision makers' understanding of the range of stakeholder environmental and social values that should be considered in formulating the SDF, improving the dialogue among stakeholders. Ongoing consultations were important in identifying environmental and social issues associated with hydropower development at all levels to define 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 Stakeholder River Basin Issues and Opportunities

Regional river basin consultations conducted early in the SEA process engaged local CSOs, EAOs, government officials, and other stakeholders at the basin and state/region levels. Many planned medium and large hydropower projects are in conflict-prone areas, while the legacy issues of a number of existing hydropower projects have not been resolved, resulting in widespread concern on the links to armed conflict and historical displacement. 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.

Environmental governance was also highlighted as a major concern, related to the lack of local voices and public participation in decision-making. For example, poor coordination between central, region, and local governments, and the limited authority of local governments were raised. Governance was complicated by parallel administrative systems and poor enforcement of existing laws. In the Tanintharyi basin, local people were reportedly forced to agree to development projects but experienced no benefits from gas exports, continuing to suffer from lack of access to electricity and high prices. Stakeholders also complained about a lack of transparency and accountability, project misinformation disseminated by developers, low local acceptance of projects, and lack of compensation payments to people affected. EIAs were viewed as weak and often omitting information on negative impacts.

Security was also raised as a concern as local people said they felt that foreign investment 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.

The frequency of issues of concern and opportunities raised by stakeholders are shown in Figure 6.1 and Figure 6.2 respectively. The graphs indicate the percentage of stakeholders raising each issue/opportunity in four basins, based on the frequency of listing, excluding similar issues to avoid overlap. In the case of identified opportunities, selecting the most important one was difficult due to the broad range of suggestions made.

Figure 6.1: Frequency of Issues of Concern Raised by River Basin

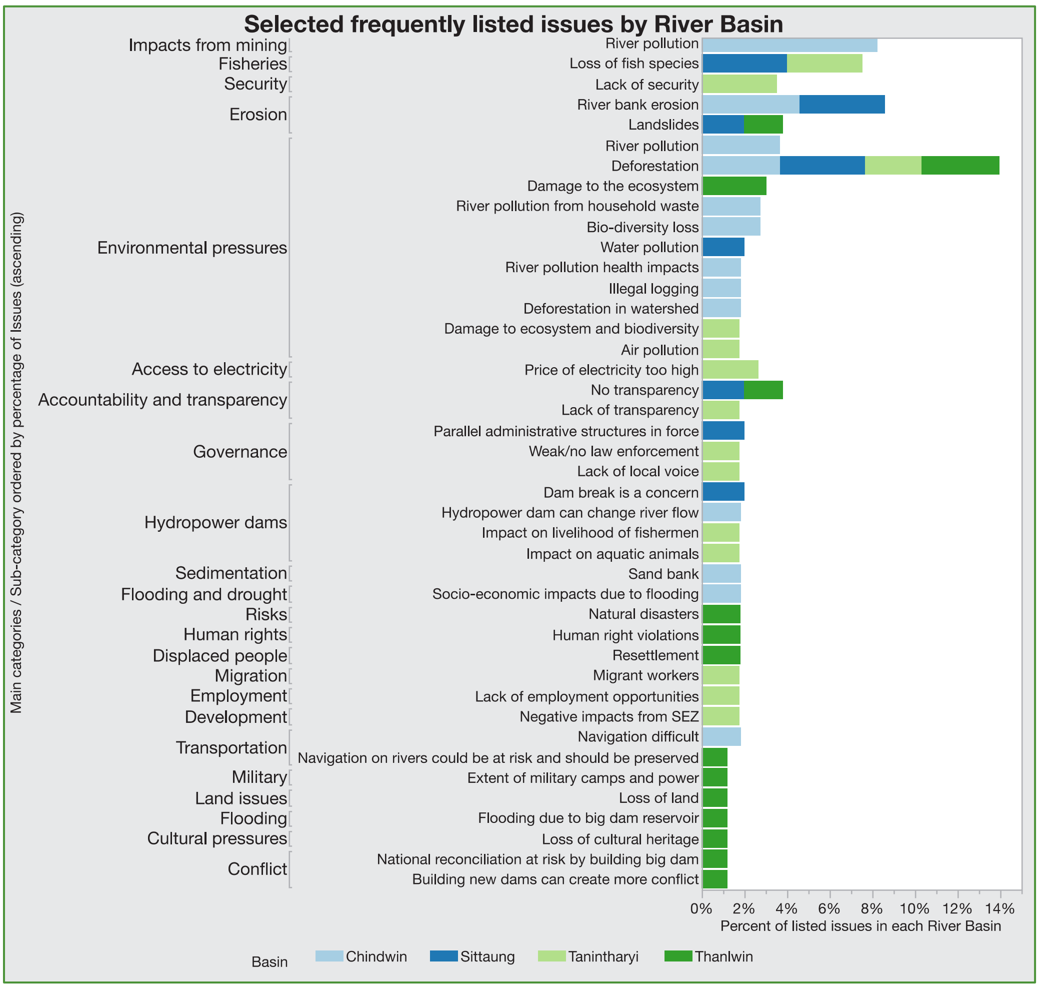
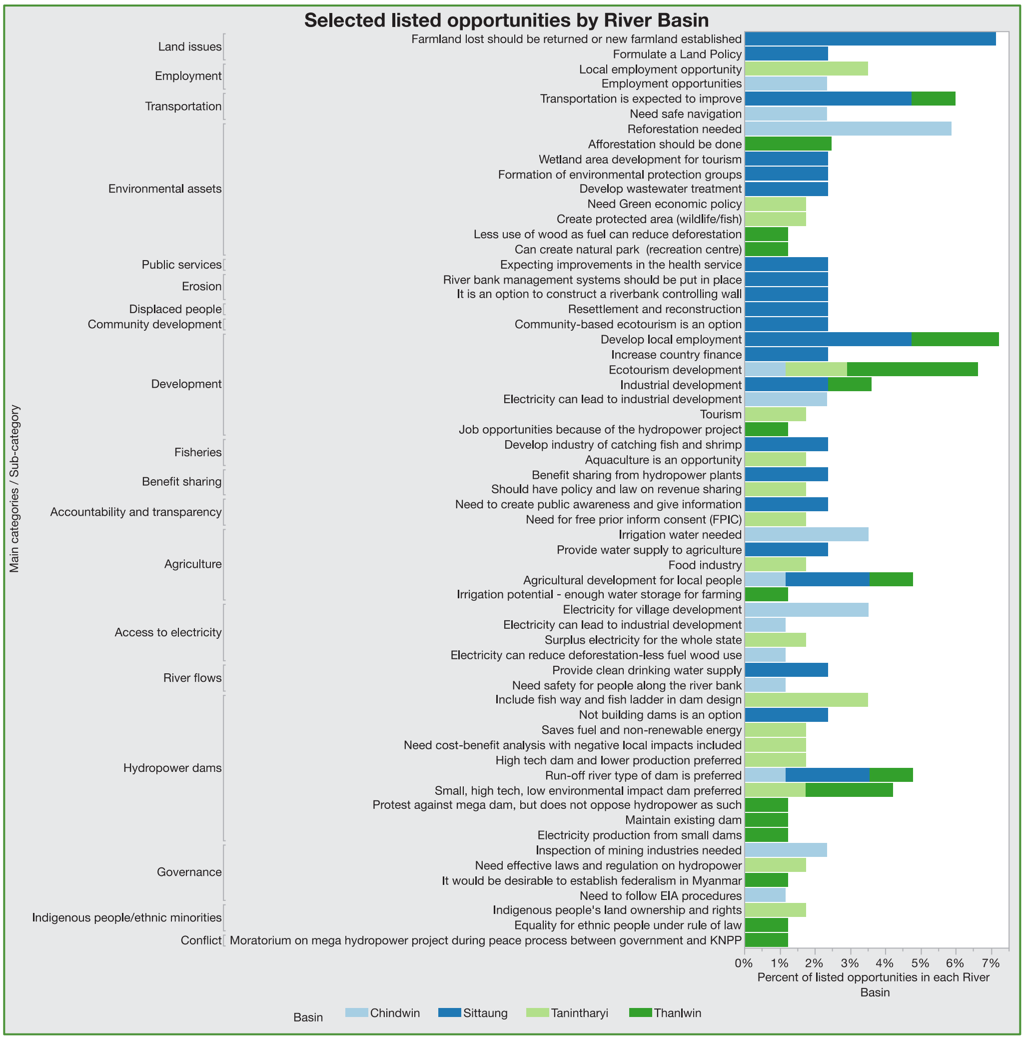


Figure 6.2: Frequency of Opportunities Raised by River Basin



Stakeholders in the Sittaung basin, the most intensively developed basin for hydropower to date in terms of MW/km², reported changes in flow, sedimentation and riverbank erosion, loss of fisheries, and social issues associated with existing projects. Understanding the impacts, benefits, and cumulative effects of the nine existing HPPs in the Sittaung basin was important in considering sustainable hydropower development in the other basins. For example, during consultations with local communities near the Upper Paunglaung140 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. This loss of agricultural land encouraged shifting cultivation and the harvesting of fuelwood in the project catchment, resulting in deforestation. Information on the resettlement and compensation process were reported as not being clear and opportunities for public participation were limited.

Mining was raised as a significant issue in the Upper Ayeyarwady and Chindwin catchments as it has 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 navigation, were identified as the key economic sectors having impacts on or being affected by basin-wide processes. Consultations held with villages affected by the Lower Yeywa 790 MW HPP, commissioned in 2010 on the Myitnge River in the Ayeyarwady basin, validated the perceived environmental and social impacts of existing projects. 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 project construction and operation.

Stakeholders listed hydropower development, governance, transparency, accountability, and benefit sharing as both issues and opportunities. They agreed that existing and planned hydropower projects bring both environmental and social impacts as well as 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, it was recognised that a starting point for dialogue on HPPs exists regarding the potential benefits to local communities and the generation of revenue for state/regions.

6.2.2 River Basin Recommendations

Toward the end of the SEA process, a final round of regional river basin consultations was conducted with CSOs and state/region government officials to share and discuss the draft key findings of the SEA. The main recommendations made during this process are presented below, grouped by project, sub-basin and basin, and at state/region 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 made to strengthen the EIA process by:

- Consulting with local communities before project siting and design are finalized to select projects with the least environmental and social impacts;
- Incorporating local knowledge, community concerns and livelihood issues into the EIA process and decision making;
- Assessing impacts and developing mitigation plans and livelihood restoration programs in consultation with affected communities;
- Assessing the potential for fish passage and other mitigation options to reduce impacts;
- Conducting social baseline research, covering health, education, gender, ethnic minority groups, and social welfare;
- Developing communication mechanisms between government, hydropower developers, and local communities, improving capacity, and allocating budget for environmental monitoring and management; and
- Providing local employment opportunities rather than relying on migrant labor.

Sub-basin and basin: Stakeholders highlighted the need to conduct more research on river hydrology, sediment transport, water quality and pollution, and dam safety, 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 were also raised as needing to be considered in future sub-basin evaluations. Cumulative Impact Assessment (CIA) was recommended in sub-basins where more than one HPP is proposed, or where mining or a large-scale irrigation project is planned.

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

Capacity building and coordination between Union and state/region governments, and among regional departments, was 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 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/region governments to ensure local communities 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 resettlement compensation and suitable livelihood restoration for local communities. They indicated that the lack of formal land tenure made it difficult to calculate compensation for the loss of agricultural land. It was recommended that a policy recognizing the cultural and traditional values of ethnic areas and respecting customary law be developed, as well as a green or renewable energy policy framework to guide future development.

A representative of groups protesting the suspended Myitsone HPP 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 requesting that hydropower and other developments:

- 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, and provide related training to 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 little to no consideration of 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 and large storage and run-of-river HPPs located on most mainstem rivers and major tributaries 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%) total hydropower capacity, consisting of existing, under construction, proposed and identified projects. 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, Chaung Ma Gyi, Mali Creek, Mone Chaung, Mu, Myitnge Lower, Myittha, N'mai Hka, Shweli, and Zawgyi/Myogyi. The Ayeyarwady River mostly retains 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: The cumulative impacts of BAU hydropower development in this basin can fundamentally and irreversibly alter the nature of river flows, sediment transport and riverine aquatic ecosystems, and in turn affect coastal and marine ecosystems. BAU development would involve the construction of 30 projects, consisting of: eight very large projects with capacities ranging from 1,200 MW to 6,000 MW - two mainstem projects - (Myitsone and Tamanthi HPPs), five on the N'mai Hka, and one on the Mali Hka); and 22 smaller projects across the basin.

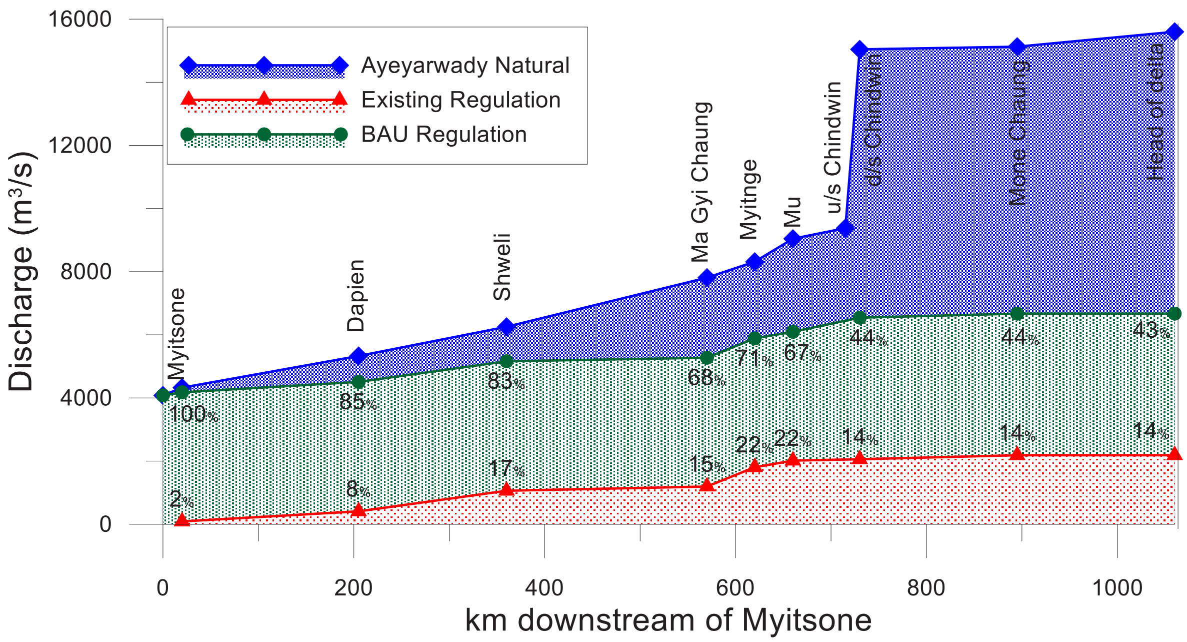
BAU development would more than double the basin area within Myanmar regulated by hydropower projects, raising it from 16.1% to 38.6%. Mainstem connectivity within the upper 19% of the basin would be cut off by the Myitsone and Tamanthi HPPs, trapping a substantial volume of sediment and seasonally altering the flow regime discharging from this area that contributes an estimated 47% of total basin discharge.[28]

Figure 7.1 compares (i) estimated pre-regulation flow rates in the Ayeyarwady with (ii) existing regulated flow rates and (iii) regulated flow rates under BAU development. The comparison

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

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 confluences before reducing to less than 15% with the inflow of the unregulated Chindwin River. The existing level of flow regulation in the middle Ayeyarwady, combined with increased sediment input due to mining, deforestation and other land use activities, may already be contributing to the navigation difficulties in this reach of the river due to increased sediment deposition.

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, that contributes 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, few large free-flowing tributaries would be retained and river connectivity would be substantially reduced. Sediment delivery from mountainous areas in the headwaters would be largely 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 replenishment 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.

[29] Ibid.

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 volume. 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.

Aquatic biodiversity: Aquatic ecology and fisheries in 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 development in the Dapein, Mali Creek, Chaung Ma Gyi, Myitnge, Namtabak, and Shweli sub-basins would be unlikely to significantly change aquatic ecology as these catchments as they are already substantially modified by existing hydropower projects.

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. Immediately upstream of the Chindwin-Ayeyarwady confluence, the combined degree of regulation of the Tamanthi, Manipur, and Myittha HPPs would be around 8.8%. This 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, and increasing flow velocity and water levels.

Terrestrial biodiversity: Development of the mainstem Ayeyarwady and Chindwin, and the N'mai Hka and Mali Hka, 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 KBA and 16,270 km^2 of intact forest, that incorporates 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. This area has 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 - habitat of the critically endangered white-rumped vulture (*Gyps bengalensis*); and (ii) Mehon (Doke-hta Wady River) KBA - habitat of 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 into forests and exploitation of non-timber forest products (NTFPs), and increase pressure on wildlife and fish stocks.

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

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[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.

Social: Resettlement and the loss and degradation of natural resources utilized to support livelihoods are the main direct social impacts expected from BAU development. A large number of people are likely be resettled to install 10 of the 14 BAU projects, 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 influence (AOI) of these projects may be 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 particular 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 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. Conflicts are still active in some Chindwin sub-basins, especially the Uyu where a very high number of conflict incidents were recorded between 2012 and 2017.

7.2.2 Thanlwin Basin BAU Impacts

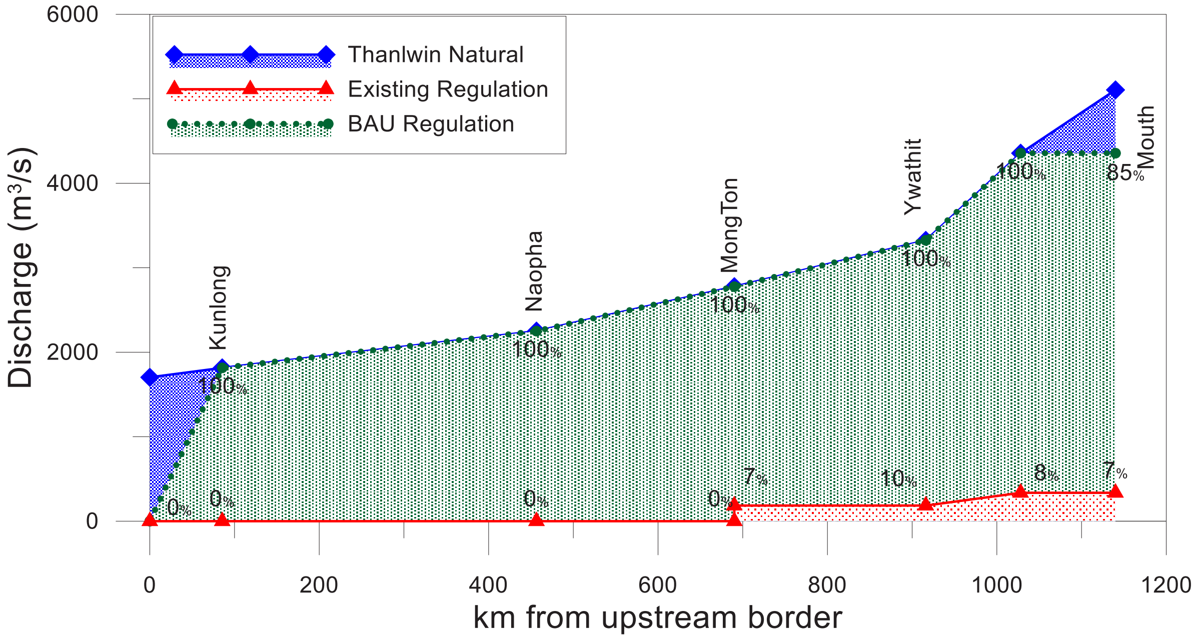
The Thanlwin is an undeveloped river with respect to hydropower. There is no mainstem development in Myanmar or China, with only four HPPs of 10 MW capacity or greater in two sub-basins in Myanmar - 248 MW in two operational projects and one under construction project in Baluchaung, and a 54 MW project in Nam Teng. The Thanlwin is one of the few remaining large rivers in Asia that retains 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.[31] The cumulative impacts of these projects would cut river connectivity, alter the flow regime and trap sediment at a basin scale, and affect regional coastal and marine ecosystems. Installing an additional 17 proposed and identified HPPs in eight sub-basins (six of which are unregulated) would also change natural features in these catchments, albeit primarily at a local scale.

Figure 7.2 compares (i) estimated pre-regulation flow rates in the Thanlwin with (ii) existing regulated flow rates and (iii) regulated flow rates under BAU development. The comparison shows that effectively 100% of the flow of the mainstem Thanlwin would be regulated from 100 km downstream of the Myanmar-China border (at the upstream end of the Kun Long HPP reservoir), to around 180 km upstream of where it flows into the sea (at the Hutgyi HPP dam). This scale of development would result in substantial loss of system connectivity, with little sediment entering the coastal zone or sea, and major 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 two very large reservoirs.

[31] The five mainstem projects proposed on the Thanlwin River are the Kunlong, Naopha, Mong Ton, Hutgyi and Ywathit. The Wei Gyi (4,540 MW) and Dagwin (792 MW) HPPs have been cancelled (MOEE – pers. comm.).

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 and 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 disconnect aquatic habitat in 91.0% of the entire basin and 80.6% of the basin area within Myanmar, from the sea. The five mainstem dams would convert the Thanlwin River to a series of deep-water, slow-moving reservoirs separated by some flowing sections of 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. These 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 basin 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 85% KBA and forms part of the Golden Triangle. This 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 into forests and exploitation of NTFPs, as well as increasing 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 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 fertilization of riverside vegetable gardens and adjacent farmland. But an estimated 45,000 people live in the extended downstream AOI that would be affected by river flow changes created 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 to aggravate grievances and conflict, particularly 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 incorporates areas of high ethnic diversity, where HPPs may have implications for cultural heritage, land rights, poverty, and the rights of displaced populations. Armed conflict has been directly linked to HPPs in this basin.

7.2.3 Mekong Basin BAU Impacts

The Mekong basin area within Myanmar is relatively small, consisting of four sub-basins that comprise just 2.7% (21,947 km^2) of the total Mekong basin area. The Mekong catchment within Myanmar 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 this sub-basin.

Hydrology and geomorphology: BAU development would involve seven proposed/identified projects being installed: four totaling 618 MW capacity in Nam Lwe sub-basin; two 30 MW projects in Nam Hkoke sub-basin; and a 36 MW project in Nam Lin sub-basin. The development of these tributaries in Myanmar would decrease catchment connectivity and sediment delivery, and 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, the proposed 170 MW run-of-river Keng Tong HPP, is estimated to have a low to moderate impact on river connectivity and sediment movement. The Suo Lwe HPP (240 MW), proposed 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 proposed downstream of the Mongwa HPP and would not substantially increase impacts on existing conditions. The Nam Hkoke sub-basin that flows into the major Nam Me Kok tributary in Thailand, has two planned/identified projects, but there is insufficient information available to evaluate potential impacts.

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

Aquatic biodiversity: Mekong River tributaries in Myanmar provide river connectivity values with the mainstem, supporting important fisheries even though they only contribute 2% of total Mekong basin flows. The under construction Mongwa HPP on the Nam Lwe will soon cut river connectivity into the Nam Lwe sub-basin. Of the four dams planned on the Nam Lwe, the Suo Lwe storage project is expected to significantly alter river flows by creating a high degree of regulation and will cut river connectivity with the dam.

The proposed Nam Lin HPP in the Nam Hka sub-basin is expected to cut aquatic ecosystem connectivity near the confluence with the Mekong. The two proposed HPPs on the Nam Hkoke may create transboundary impacts as this river flows into Thailand where it is known as the Nam Mae Kok and is recognized as an important tributary of the Upper Mekong. The Mong Hsat HPP is proposed relatively high up in the catchment and therefore may have a low impact on aquatic ecology, but the Nam Hkoke HPP is located closer to the Mekong mainstem and therefore 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, Nam 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. Four additional projects with AOIs covering a combined 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 km^2 (84%) of its KBAs. Although the Nam Lin sub-basin contains only a small area of KBA, the planned project may adversely impact this area.

Social: Resettlement would likely be the main social impact 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 around 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, may 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 are active in 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.

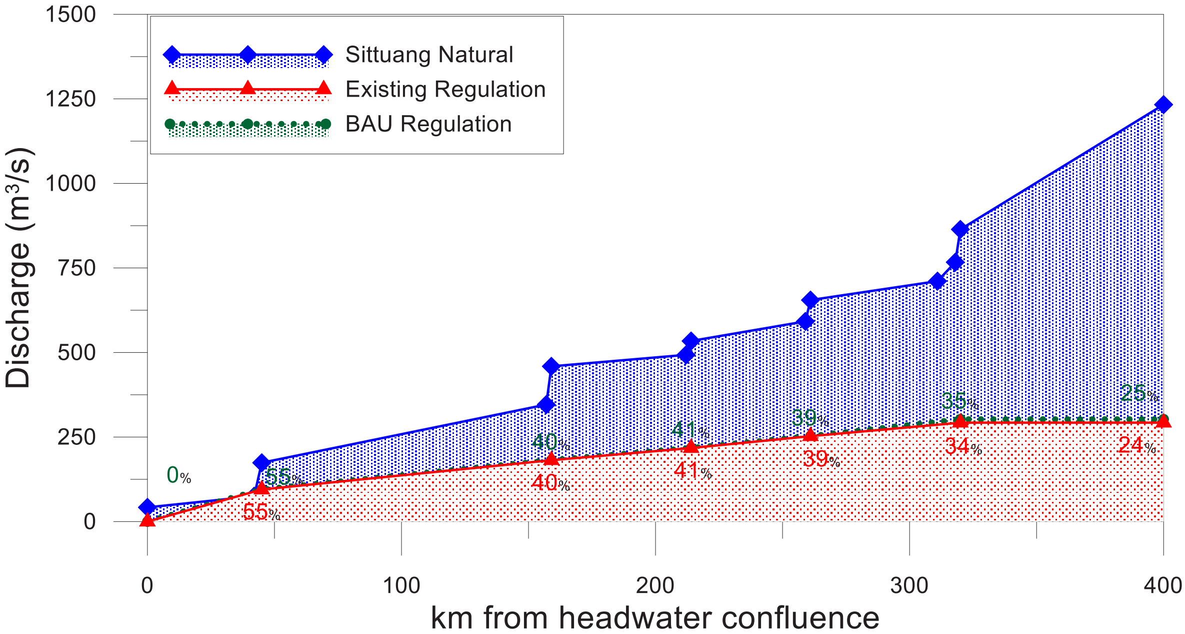
7.2.4 Sittaung Basin BAU Impacts

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 Sittaung Other sub-basin, three (460 MW) in Paunglaung sub-basin and one (120 MW) in Bawgata sub-basin. 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 from a reduction in sediment deposition.[32]

Hydrology and geomorphology: BAU development would involve two proposed projects and an identified project totaling 410 MW being installed, with one in each sub-basin: Bawgata HPP 160 MW, Paunglaung Middle 100 MW, and Thauk Ye Khat 1150 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 and thus creating a limited change to hydrology.

[32] 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 without 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, with the loss of basin connectivity already affecting fish movement in the lower Sittaung and coastal waters.

The Paunglaung 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/identified HPPs, the degree of flow regulation in the Sittaung estuary would be around 14.4%.

Terrestrial biodiversity: The three proposed projects in the Sittaung basin may indirectly further degrade intact forest in the region due to unauthorized forest encroachment, NTFP harvesting and poaching, 90% of which has already been lost. Deforestation is likely to increase in the undeveloped Bawgata sub-basin. The AOI of the Bawgata HPP contains 21 km² of intact forest and 158 km² of KBA that includes an important biodiversity corridor. The Paunglaung HPP AOI contains 162 km² of intact forest and 630 km² of KBA that provides 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 Paunglaung projects, while 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 active 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 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 projects of 10 MW capacity or greater. A single project is proposed in the basin, Bilin HPP (280 MW) on the Bilin River, that would regulate 74% of this catchment area. 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, with migratory fish species moving up river to spawn due to 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.

Although 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. The proposed Bilin HPP, having a large reservoir with multi-annual storage capacity, would block connection between the Gulf of Mottama and the higher reaches, affecting water quality and seasonal flows.

The Bilin HPP AOI incorporates 730 km^2 (57%) of KBA situated in the Bilin basin. This proposed project is expected to further degrade intact forest, with deforestation likely to expand during construction.

The KNU is active in the basin and 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 likely to have minimal conflict 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, a collection of coastal watersheds within the Tanintharyi Other sub-basin, and the small Glohong Kra sub-basin that flows eastwards into Thailand. This basin has no existing hydropower projects equal to or greater than 10 MW.

Hydrology and geomorphology: Five projects totaling 696 MW are 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 around 9,870 km^2 (55%) of the sub-basin area within Myanmar and inundate 585 km^2. This river provides high inflow to the coastal zone (averaging around 900 m^3s^{-1})[33]. 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.

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

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, and sediment transport characteristics of these sub-basins, they are in an area of high rainfall and likely play a vital role in providing nutrients and freshwater outflows to the coastal zone, which together support vegetation that provides 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. 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 due to their shorter and less diverse river reaches, with medium human pressure from populations living along the coastal plains.

The Tanintharyi HPP is estimated to create a 44% degree of regulation in the Tanintharyi River, therefore it is likely to have a significant impact on the river's unique aquatic ecology and fisheries. Longitudinal connectivity would be lost between the upper half of the catchment and the coast, while changes to seasonal flows and water quality are likely. 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 KBA, 53.2% intact forest, and 4.2% protected area. 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 project construction, encroachment into forests and exploitation of NTFPs likely to occur 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, although no people live in the immediate and extended downstream zones.

Conflict: The Tanintharyi and Tanintharyi Other sub-basins are considered to have high conflict vulnerability, while Glohong Kra is deemed moderate. While armed conflict has not occurred recently in the Tanintharyi and Tanintharyi Other sub-basins, there were high rates of 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 active across much of the 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 sub-basins drain into the sea via a main river, while Rakhine Other, the largest sub-basin at 25,796 km^2, drains directly into the sea via a series of small disconnected watersheds. 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 of 10 MW capacity or greater, but construction of the Thahtay HPP (111 MW) in the Thahtay sub-basin in underway (around half completed in 2017). Six HPPs are proposed/identified in the basin, including two proposed projects in the Lemro sub-basin – Lemro 1 (600 MW) and Lemro 2 (90 MW) - and four identified projects ranging between 28 MW and 200 MW in four different sub-basins. Apart from project capacity and siting, no other details are available on the identified projects.

Hydrology and geomorphology: The two Lemro HPPs are in the lower reaches of the main river (Strahler Order 3) and are likely to have a significant impact on river connectivity and sediment delivery. Lemro 1 HPP is a large storage project with a reservoir volume of 9.1 km^3 and surface area of 193 km^2. This project has the potential to trap virtually all inflowing sediment 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 would likely have a substantial impact 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 at a regional scale as each small river contributes to an important coastal plain environment. Altering the flow pattern and quantity of sediment outflowing to the coastal area can induce substantial changes.

Aquatic biodiversity: The small rivers emerging from the Chin Hills in the north and the Rakhine Yoma are likely to have low ecological value with low to medium human pressures, but they 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 the Thahtay 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 low ecological value.

Terrestrial biodiversity: The total AOI of the six planned and one under construction HPPs in the Rakhine basin contains 3,422 km^2 of KBA (13.2% of total KBA in the basin) and 1,846 km^2 of intact forest (12.3% of total intact forest in the basin). 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 wild Asian elephants, 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 in this catchment. The influx of construction workers and camp followers during the construction of the six BAU projects is likely to cause further forest encroachment and harvesting of NTFPs and wildlife. This increase in forest degradation may increase 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 would likely be resettled and/or 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 sub-basins are highly conflict-affected and vulnerable. The occurrence of armed conflict and presence of armed groups in these sub-basins has changed rapidly since 2012. The violence and displacement that has occurred since 2012 has distinct but overlapping causes compared to other parts of the country, involving wrestling with human rights, security, citizenship, and religious identity issues, in addition to ethno-political contests over governance and territory that also prevail elsewhere. In recent years, armed groups have increased activity in several sub-basins. The violent activities of an armed group in 2017 prompted very strong responses from security forces that resulted in the displacement of hundreds of thousands of people, in addition to those that were already displaced since communal violence commenced in 2012.

The 2012 violence spread throughout much of 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 the 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 where violence or displacement has not been confirmed.

The Lemro HPPs were initially given a low conflict rating due to their location among ethnic Chin populations, away from the Rakhine conflict, which should be treated with caution. Important social themes concerning hydropower development in Rakhine include poverty (the Rakhine sub-basins are among the poorest in Myanmar), human rights and citizenship issues.

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 when 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 caused by the seasonal retention 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.

In addition, large scale resettlement and the loss of livelihoods from reduced access to natural resources is expected to occur, while conflict may be exacerbated in some areas.

Major irreversible basin-scale changes would occur to river flows, geomorphic, and ecological processes and functions of the Ayeyarwady and Thanlwin basins that cover three-quarters (74.5%) of the country. BAU hydropower development across Myanmar would triple basin fragmentation, from 14.4% of the national land area at present to 45.0%. The effect of BAU development on basin fragmentation is illustrated by the different outcomes for the Thanlwin and Sittaung basins. BAU development would raise the percentage of the Thanlwin basin within Myanmar that is longitudinally disconnected from the sea from 12.9% to 80.6%, primarily due to the lowest mainstem HPP, Hutgyi. By comparison, in the highly developed Sittaung basin, 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%.

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 catchment areas: The Tamanthi HPP catchment area in the Chindwin Upper sub-basin is estimated to be 20,700 km^2; the Hutgyi HPP catchment area in Myanmar is estimated to be 102,736 km^2, with a further 24,758 km^2 of the basin located downstream within Myanmar.

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 by keeping development within the sustainable carrying capacity of each basin.

Hydropower projects are major capital investments typically 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 as more information is obtained and implementation undertaken periodic revision of the SDF is recommended.

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:

- **Site screening against the SDF Basin Zoning Plans** for all projects of 10 MW capacity or greater;
- **CIA** for new or additional projects in a sub-basin or watershed; and
- **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 the concept and feasibility stages 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 is recommended for screening against the relevant Basin Zoning Plan at project concept stage to ensure that it is sited in accordance with the Plan. The eight Basin Zoning Plans provide developers and others with clear information on (i) the recommended reserved mainstem rivers and sub-basins, and (ii) sub-basins potentially suitable for development. It is recommended that the project proponent submit the project concept design to MOEE for screening at the earliest possible stage. Projects that are sited in accordance with the Basin Zoning Plan are recommended to be considered for the granting of a project Memorandum of Understanding (MoU) by MOEE.

Larger scale projects proposed in high value sub-basins are recommended not to be granted a MoU. Smaller scale[34], lower impact projects in high value sub-basins that would supply rural and remote communities are recommended to be screened against additional criteria to determine if they should proceed.

[34] A capacity limit on "smaller scale" HPPs in High zone sub-basins is yet to be developed, but would need to consider the inclusion of small and medium scale HPPs.

Table 8.1: Hydropower 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 MONREC	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, or a single additional HPP, that may either impact or contribute to an adverse impact on important environmental or social attributes (valued environmental and social components - VECs). A CIA is designed to assess if the proposed development's cumulative impacts will exceed a threshold that could compromise the sustainability or viability of VECs. In effect, this can determine the level of hydropower development that is sustainable (carrying capacity) in relation to the number, type, scale, and location of new HPPs, taking into account existing and likely developments in the area over time, and to plan appropriate management measures for these combined impacts.

The need for a CIA should be identified by together by MOEE and MONREC, either when multiple projects are being considered in a sub-basin or watershed, or when a single project proposal is submitted. A CIA is ideally conducted for one or more proposed medium or large HPPs in a sub-basin/watershed which is either undeveloped or partially developed, where the project/s are expected to adversely affect VECs.

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).[35] 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 recommended areas for (i) reservation from hydropower development - high value areas where hydropower development is not consistent with sustainable development due to the undue degradation or loss of essential basin processes and high natural values from medium to large scale HPP development, and (ii) potential development - lower value areas that are potentially suitable for hydropower development.

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

[35] MOECAF, 2015. *Environmental Impact Assessment Procedure*. Notification No. 616/2015. 29 December 2015.

- **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, thereby maintaining these essential basin processes and functions;
- **sub-basin** - a discrete natural catchment area that either drains directly into the mainstem river/main basin tributary or 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 Plans set 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 Plans 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 to maintain basin processes and functions. Unimpeded mainstem connectivity provides the pathway for water, sediment, fish, and other aquatic organisms to move between sub-basins 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 creates barriers that cut connectivity, longitudinally fragmenting this trunk waterway into semi-connected parts. Dam operation usually results in system degradation due to:

- flow changes - daily and/or seasonal flow regulation from the retention of water in a reservoir;
- 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 a flowing river into a deep, slow flowing reservoir, creating a semi-connected and altered aquatic habitat.

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 5,048,000 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 per 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) would be excluded. By maintaining connectivity along this reach 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). 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).[36] Two exceptions were made to this classification, where Strahler Order of 4 river reaches were not classified as mainstems: (i) 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).[37] 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 recommended to be reserved to maintain the reach ecological conditions of this important river. Immediately upstream of this reach the Mensong HPP in China has been cancelled to maintain connectivity for fish migration. A mainstem river reach on the Sittaung River has also been recommended 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 unimpeded conduits 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 sub-basins, and to provide basin-wide fish migration routes.

The defined mainstems in Myanmar, illustrated in Figure 8.1, are:

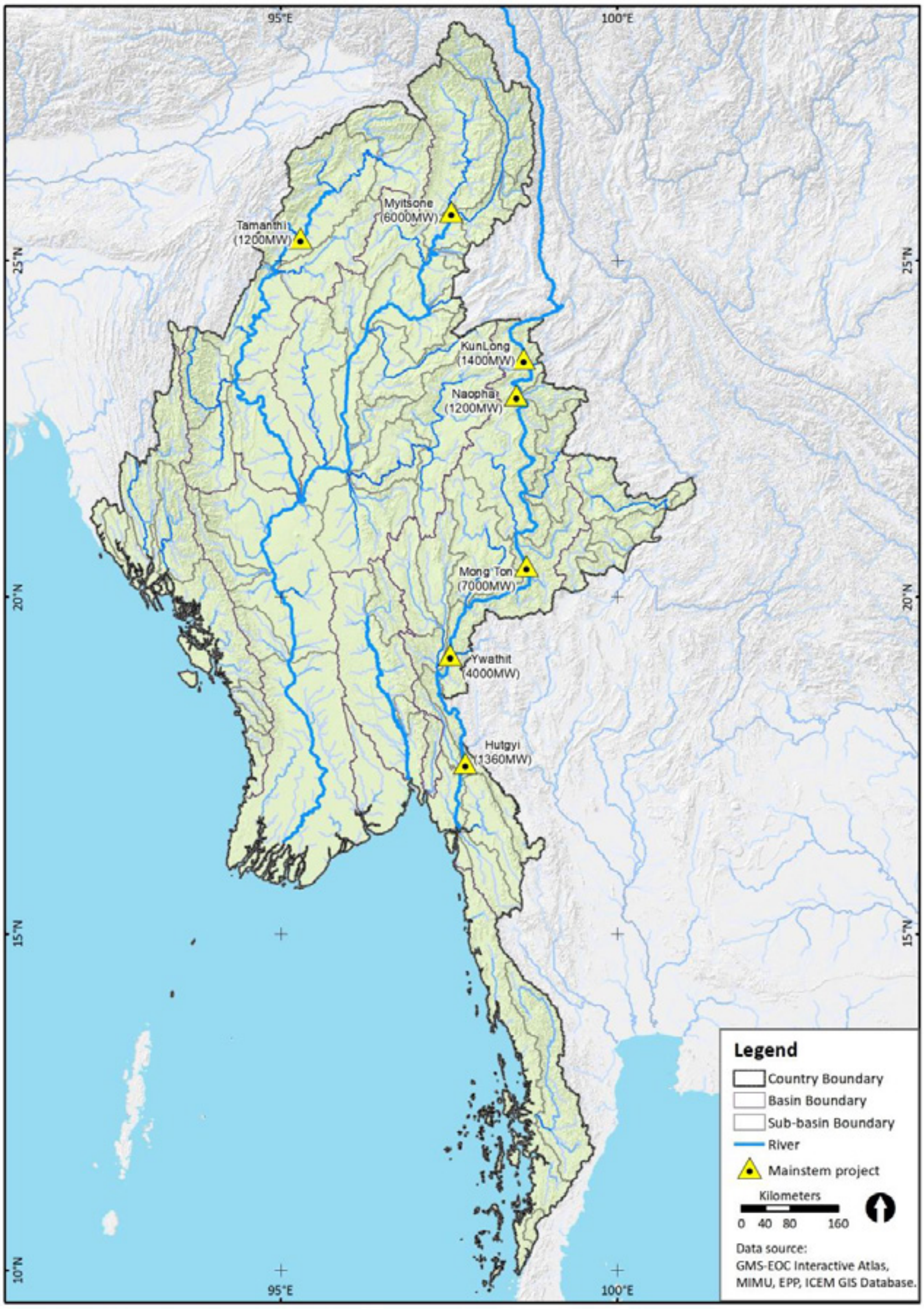
- Ayeyarwady - commencing at the Mali Hka-N'mai Hka confluence;

[36] The recommended reserved mainstem is recognized as a corridor that incorporates 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.

[37] Around 100 km of the Myitnge River and 30 km of the Manipur River classified as Strahler Order of 4 are not classed as mainstem rivers.

- 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 recommended in either the Tanintharyi and

Rakhine basins as they consist of multiple low Strahler Order rivers that flow to the sea, with 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 rivers to determine if any should be delineated as mainstems for reservation.

The seven proposed projects sited on mainstems, totaling 22,160 MW capacity (Table 8.2), are high impact projects and hence special consideration would be required to conduct systematic basin-level assessment on the adverse environmental impacts of hydropower development. These projects include the Myitsone and Tamanthi HPPs (totaling 7,200 MW) that were suspended by the GoM due to concerns about environmental and social impacts (pending further GoM review), and Mong Ton HPP as originally designed where redesign as two separate projects (Mong Ton and Wan Gan HPPs) 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[38]	Kun Long	1,400
	Naopha	1,200
	Mong Ton	7,000
	Ywathit	4,000
	Hutgyi	1,360
TOTAL		**22,160**

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[39], and would substantially reduce basin sediment load. The effect of Thanlwin mainstem development would be even more marked, with the proposed Hutgyi HPP disconnecting over 91.3% of the basin catchment area from the sea in terms of aquatic ecology, and preventing the delivery of a large sediment load to the coastline up until the reservoir is full of sediment and then passes all inflowing sediment downstream.

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	258,577	283,335	91.3

Two other impacts resulting from the 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 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,

[38] Wei Gyi and Dawgin HPPs on the Thanlwin mainstem have been cancelled (MOEE, pers. comm.).
[39] AIRBMP, 2017.

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, Mong Ton HPP on the Thanlwin River, originally proposed 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: Mong Ton HPP Mainstem Impact

The proposed Mong Ton HPP on the Thanlwin River, as per the original design as a single large project, 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 would 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.

The redesign of this project was requested by MOEE, and is being considered by the developer as two separate projects (pers. comm. - China Three Gorges), but no details are publicly available on the redesign.

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, aiming 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 are recommended to be zoned for reservation. Sub-basins with lesser values may be suitable for sustainable hydropower development, where the GoM may grant a MoU that permits detailed project investigations, but still imposes the formal project approval process requiring 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. Sub-basin geomorphology and aquatic ecosystems are directly affected by medium/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, project roads, and transmission line), as well as forest and wildlife harvesting by the project workforce and service businesses during construction and operation. The scoring methodology applied to each biophysical feature in each sub-basin is summarized in Appendix C, with a national map of the scores for each factor presented in Figure 8.2 to Figure 8.4 below.

Figure 8.2: Geomorphology Sub-Basin Ratings

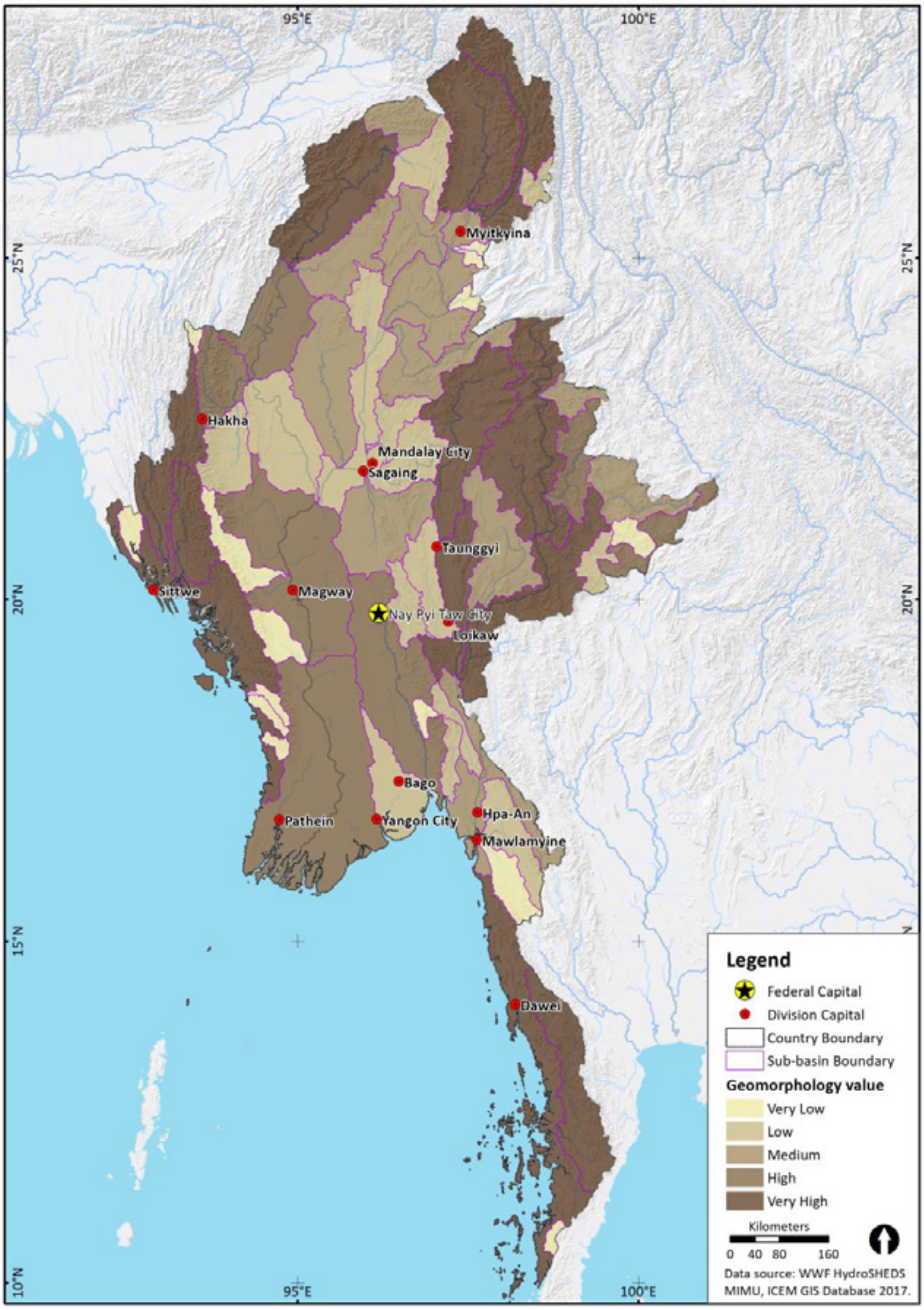


Figure 8.3: Aquatic Ecology Sub-Basin Ratings

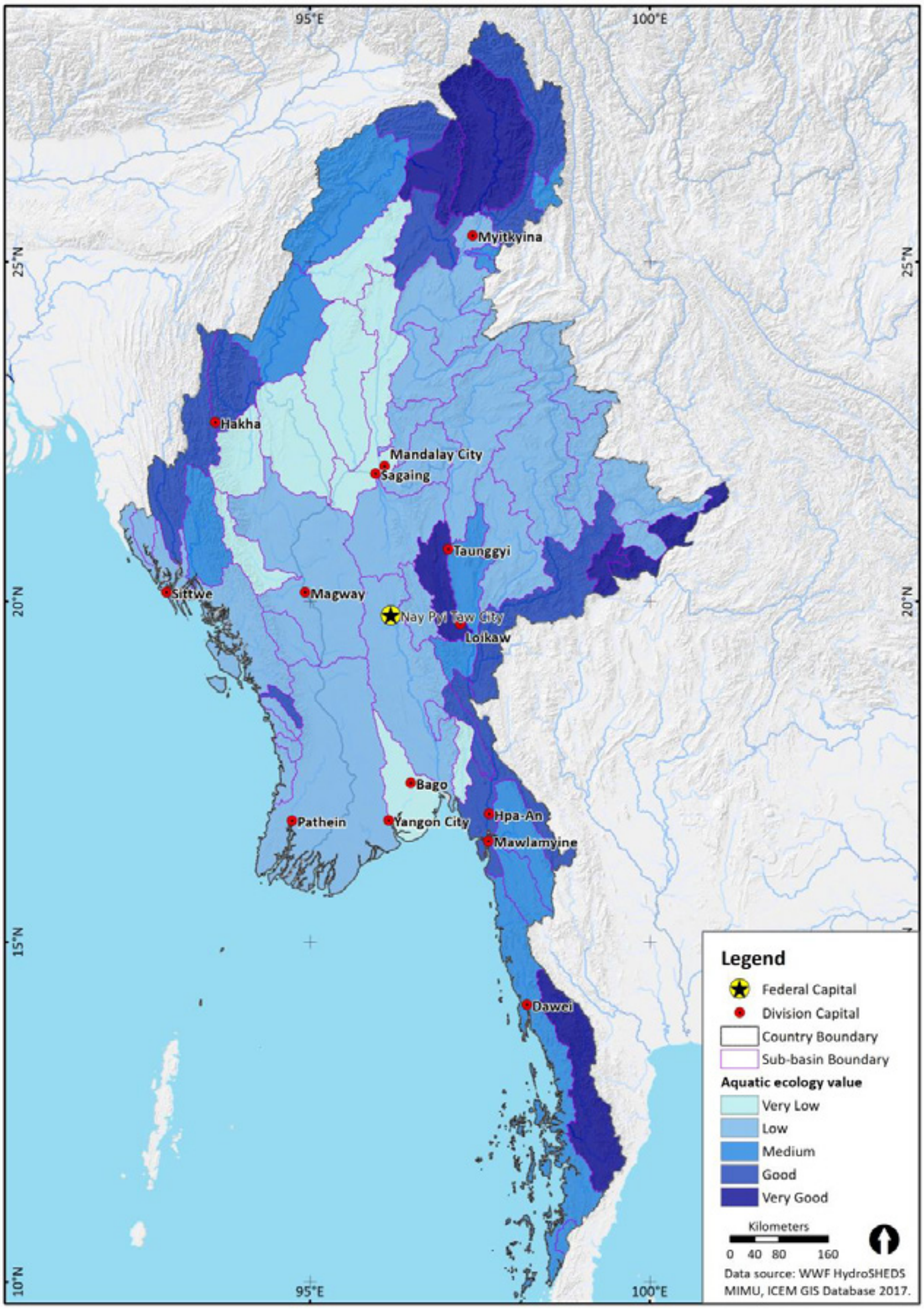
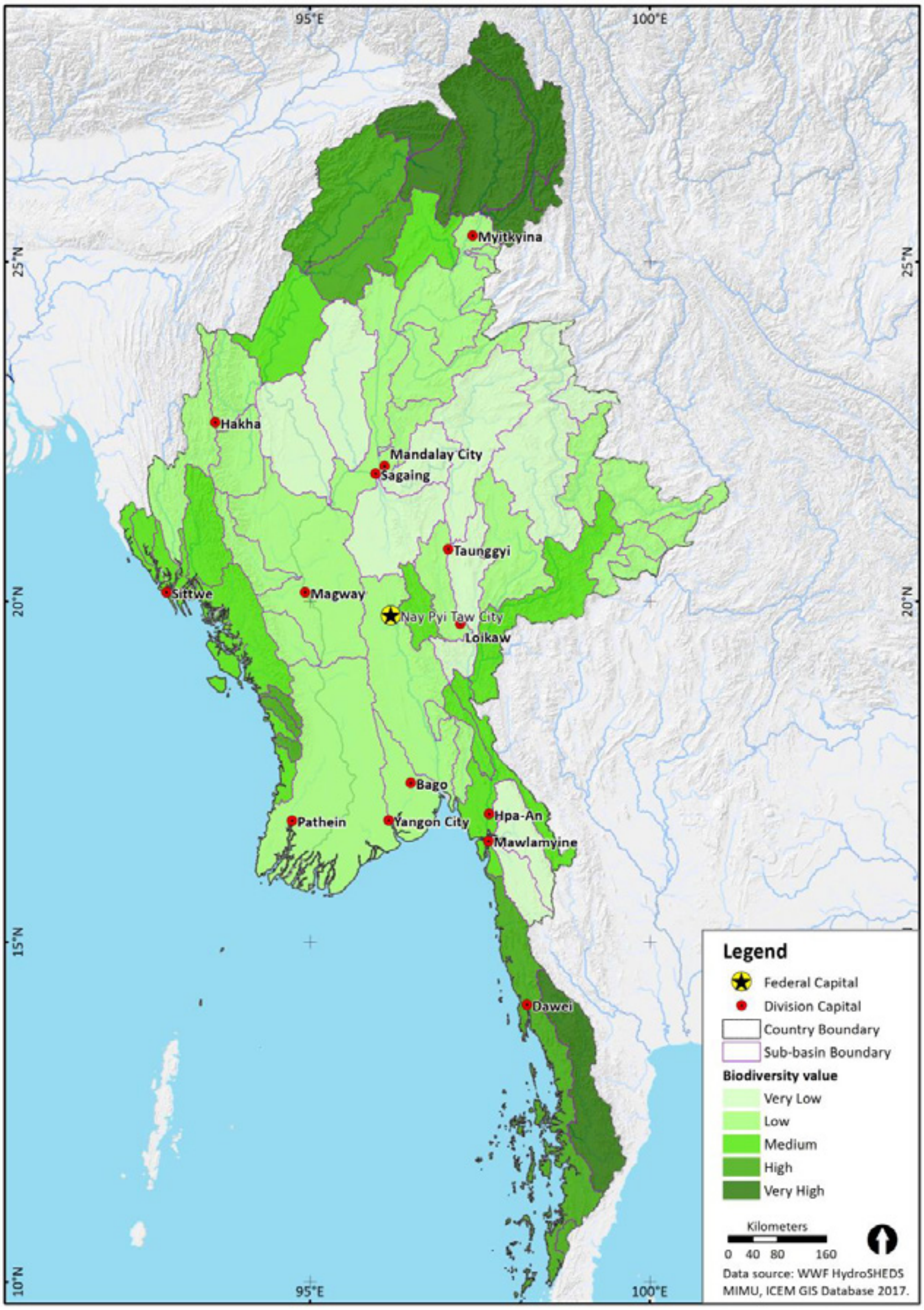


Figure 8.4: Terrestrial Ecology Sub-Basin Ratings



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.[40]

[40] High value terrestrial ecosystems such as Protected Areas, KBAs, and critical habitat can remain largely intact near medium to large hydropower projects if the project does not create a direct or indirect impact on the area from such aspects as new or improved access to or near the ecosystem, or illegal forest harvesting or poaching by the project workforce or people/businesses catering to the workforce.

Therefore, a socio-economic value for the entire sub-basin is a poor indicator of the specific features likely to be adversely affected. 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 that has some relationship to local livelihoods dependent on them. The Myanmar Poverty and Living Conditions Survey (MPLCS)[41] found that poverty rates are highest in the hilly and mountainous areas of Chin, Kachin, Kayah, Kayin, Shan states (MOPF, 2017). Similarly, the status of armed conflict was also evaluated but not applied to determine sub-basin zoning as conflict is a dynamic situation subject to rapid change, and, in some instances, may be resolved and managed over time.

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** - 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** - the sub-basin does not contain high ecological value features over a notable area for two biophysical factors, although it may contain high values for a single factor or such values in pockets.
- **"Low" value zone** - 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 and shown in Figure 8.5.

Table 8.4: Sustainable Hydropower Zoning Scale

Zone	Total Sub-Basin Rating	Additional Criteria	No. of Sub-Basins	Suitability
High	11 and above	At least two factors with a score of 4 or more	10	Recommended reservation to maintain high conservation values – HPPs excluded apart from smaller scale, lower impact 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

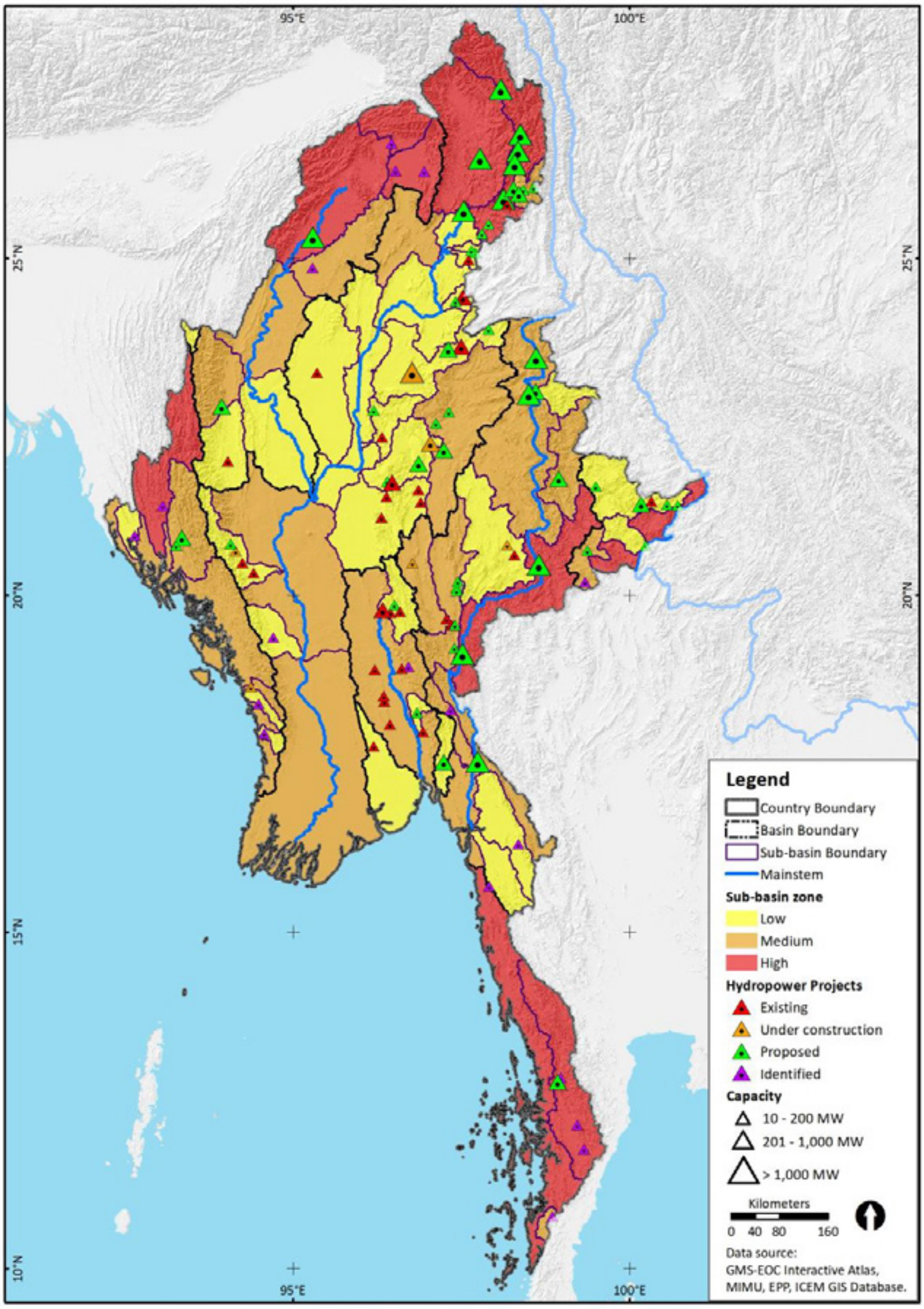
[41] MNPED, 2010. *Integrated Household Living Conditions Survey*. Ministry of National Planning and Economic Development and Central Statistical Organization.

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 8.5: 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 natural resource use. 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).[42] 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 located in the 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, with just two having 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.

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
	Delta	4	2	2	8
	Indawgyi Lake catch. trib.	3	4	3	10

[42] HMIS, 2011.

Basin	Sub-Basin	Geomorphology and Sediment	Aquatic Ecology	Terrestrial Ecology	Total Score
	Myitnge Upper	5	2	1	8
	Nawchankha	2	3	5	10
	Namtabak	3	3	2	8
(Chindwin)	Chindwin Middle	4	3	3	10
	Manipur	4	4	2	10
	Uyu	3	1	4	8
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
	Yunsalin	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
	Rakhine Coastal Other	5	2	3	10
	Thahtay	1	4	4	9

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 land and water resource use. 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 Middle	2	1	2	5
	Ayeyarwady Upper	3	2	2	7
	Dapein	1	2	2	5
	Chaung Ma Gyi	2	2	2	6
	Mali Creek	1	3	2	6
	Mindon	1	2	2	5
	Mone Chaung	1	1	2	4
	Mu	3	1	1	5
	Myitnge Lower	2	2	1	5
	Shweli	3	2	2	7

Basin	Sub-Basin	Geomorphology and Sediment	Aquatic Ecology	Terrestrial Ecology	Total Score
	Zawgyi/ Myogyi	3	2	1	6
(Chindwin)	Chindwin Lower	2	1	1	4
	Myittha	2	1	2	5
Thanlwin	Lam Pha	2	3	1	6
	Myet Taw Chaung	1	3	1	5
	Nam Ma	3	2	1	6
	Nam Teng	1	2	2	5
Sittaung	Bawgata	1	2	2	5
	Paunglaung	2	2	3	7
Mekong	Nam Lin	1	2	2	5
	Nam Lwe	3	2	2	7
Bago	Bago	2	1	2	5
Bilin	Bilin	2	1	2	5
Rakhine	Kyein Ta Li	1	2	4	7
	Saing Din Creek	1	2	3	6
	Than Dwe	1	2	4	7
Surma-Meghna	Barak	1	4	2	7

Development Restrictions for High Zone Sub-Basins

Strict hydropower development restrictions are recommended in High zone sub-basins to ensure that these catchments retain the identified natural values that drive basin processes and/or are unique to these areas or representative of values that are in decline and need protection. It is recommended that all larger scale and higher impact projects are not developed in High zone sub-basins, but smaller scale, lower impact projects are considered where 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.

Each project proposed in a High zone sub-basin is recommended to be screened by MOEE at concept stage, removing unsuitable projects from further consideration early in the planning process.

Defining specific development restrictions to achieve sustainable hydropower within High zone sub-basins should be based on setting threshold impact levels to account for the variability in local conditions that will 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. It is recommended that proposed projects be assessed against a screening framework jointly developed by MOEE and MONREC, 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 project size and impacts 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 the main river of any watershed over a specified area in sub-basins that discharge via a single river;
- maximum degree of sub-basin flow regulation - taken as a cumulative of all HPPs in the sub-basin;
- maximum project size - for example, dam height above river-bed level, reservoir volume, or MW capacity; 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 at key thresholds.

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, assuming that local conditions and features are similar.

Preference may 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 relative to flow.

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 on flow regulation and connectivity is confined to that catchment. But a cumulative limit for all combined coastal watersheds in that basin is recommended to ensure that these natural resources are not unduly degraded.

Special considerations may be appropriate 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 in High zone sub-basins are recommended to be subject to the standard development approval process where they are proposed to meet the needs of local communities, involving the preparation of an IEE (Table 8.1) to ensure that these projects are sited, designed and constructed appropriately and will not have a significant adverse impact.

Balancing the Utilization of Low and Medium Zone Sub-basins

Basin hydropower sustainability will require balancing Low and Medium zone sub-basin utilization and protection rather than developing most of this combined area (covering over 75% of the country) for hydropower. In the early stages of SDF implementation it is recommended that all Low and Medium zone sub-basins 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 basins 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. Project were categorized, with the least conflicting and least expensive (Category I) granted licenses, while the most costly or conflicting (Category II) were not. 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

Priority sub-basins for hydropower development, subject to socio-economic impacts and conflict issues, 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.

As previously described, it is recommended that the GoM determine a balance between the development and reservation of Low and Medium zone sub-basins as more detailed information on natural resources and social conditions 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, while others will be retained intact with no medium/large HPPs permitted.

8.3.1 Cascade Development

The development of cascade hydropower projects in a limited number of sub-basins is usually preferable to similar total installed capacity developed across many sub-basins in terms of both lower environmental and social impacts and increased power generation. 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 development 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 additional development of existing "workhorse" sub-basins allows free-flowing sub-basins to be retained elsewhere while still meeting power-generation targets. In addition, cascade development provides the opportunity to coordinate environmental and social mitigation and management measures within the catchment and between different developers, while it may also be possible to share a common high voltage transmission line connection to the grid, thereby reducing related impacts.

In total, 82% (3,978 MW) of Myanmar's medium and large HPPs in operation and under construction are in sub-basin cascade arrangements, situated in seven sub-basins. An additional four sub-basins with a single HPP have one or more proposed projects that will form a cascade upon development. Eight of these sub-basins are zoned Low partly due to existing river regulation and fragmentation created by operational 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**
Chaung Ma Gyi	Low	4,341	4,341	Sedawgyi	**25**	Upper Sedawgyi	**64**
Mone Chaung	Low	5,974	5,974	Buywa Upper (150)* Mone Chaung (75) Kyee Ohn Kyee Wa (74)	**299**	Buywa	**42**
Myitnge Lower (& Myitnge Upper[a])	Low (Med.)	30,517	30,517	Upper Yeywa (280)* Yeywa (790)	**1,070**	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)*	**1,650**	Nam Paw (20)[c] Shweli 2 (520)	**540**
Zawgyi/Myogyi	Low	16,327	16,327	Kinda (56) Myogyi (30) Zawgyi I (18) Zawgyi II (12)	**116**		**0**
Thanlwin							
Baluchaung (tributary of Nam Pawn)	Med.	7,837	7,837	Upper Baluchaung (30)* Baluchaung 1 (28) Baluchaung 2 (168) Baluchaung 3 (52)	**278**		**0**
Nam Teng	Low	15,386	15,386	Upper Keng Tawng (54)* Keng Tawng (51)	**105**		**0**
Sittaung							
Paunglaung	Low	4,986	4,986	Upper Paunglaung (140) Nancho (40) Paunglaung Lower (280)	**460**	Paunglaung 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					**4,429**		**2,760**

Projects listed in order from upstream to downstream.
** Under construction.*

a. Myitnge Upper is considered with Myitnge Lower as this sub-basin has lost downstream connectivity due to the operation of the 790 MW Yeywa HPP.
b. Includes catchment within China.
c. On a tributary of the Shweli River.

This aggregation of projects is the result of a combination of suitable sub-basin 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/or under construction) medium/large projects - Mone Chaung, Myitnge Lower, Shweli, Nam Teng, and Paunglaung– are prime candidates for further development from a biophysical perspective given the large scale impacts that have occurred, subject to further investigation. The Dapein sub-basin, with an existing HPP in Myanmar, also falls into this group as the upstream catchment in China has been substantially developed. 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 HPPs, Baluchaung, is zoned Medium due to a very high aquatic ecosystem value 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 due of human activities, including unregulated tourism development and the introduction of exotic fish species. As there are no medium/large HPPs in the lake's watershed (the three existing HPPs and proposed Upper Baluchaung HPP are all located downstream), 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, with these headwaters each 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 within Myanmar (subject to socio-economic and conflict considerations) as additional development is expected to result in only a small incremental increase in key biophysical impacts if appropriate sites are selected and project 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 geomorphic value, the Myitnge Upper sub-basin is also a possible target for cascade development. The 130 m high Yeywa HPP dam, with a reservoir in excess of 50 km long in the Myitnge Lower sub-basin, already prevents sediment from reaching the mainstem Ayeyarwady, while upstream and downstream fish migration has been cut off.

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

Five undeveloped sub-basins with no existing HPPs larger than or equal to 10 MW capacity are currently being considered for cascade development with multiple projects proposed (Table 8.10). Each sub-basin is zoned Medium and combined 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, but it should be noted that the Namtabak sub-basin has a very high conflict rating, while Nam Pawn and Lemro have high conflict ratings.

Table 8.10: Undeveloped Sub-Basins with Proposed Cascade Arrangements

Sub-Basin/s	Sub-Basin Zone	Total Catchment Area[1] (km²)	Proposed/Identified Projects (MW)	Total (MW)
Ayeyarwady				
Namtabak	Med.	1,684 (718)	Nam Tabak 1 (141) Nam Tabak 2 (144)	285
Nawchankha	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 HPP capacity in Low and Medium zone sub-basins is in cascade arrangements. The potential for additional medium/large 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 suitable sites for hydropower 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 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). It will also move dispersed proposed projects across 18 other sub-basins, towards further cascade development in a number of priority Low and Medium zone sub-basins and their watersheds, plus some dispersed identified projects in other sub-basins in proximity to load centers.

Application of the Basin Zoning Plans recommends excluding all mainstem hydropower development on the Ayeyarwady, Chindwin, and Thanlwin rivers which 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 suspended Tamanthi HPP (1,200 MW) on the Chindwin River, to retain these major essential waterways as free-flowing rivers.

The recommended reservation of the 10 High zone sub-basins would result in no proposed large projects being developed on the main tributary of three sub-basins (Mali Hka, N'mai Hka, and Tanintharyi), totaling 13,895 MW (Table 8.11). Development in watersheds (on side streams) in these 10 sub-basins may provide important opportunities for renewable energy generation. It is recommended that such projects 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 the undue degradation of important processes and values. A summary of all proposed and identified projects by sub-basin zone is presented in Appendix D.

Table 8.11: High zone Sub-Basins - Proposed and Identified Project Capacity

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 is recommended to be permitted in Low and Medium zone sub-basins when the GoM deems that a project is appropriate based on site, design, operating regime and management. Some of these sub-basins, however, should be reserved to balance development with the protection of natural and social resources. To provide an estimate 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, environmental and social impacts 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 Low and Medium zone sub-basins potentially suitable for development totals 7,323 MW, as summarized in Table 8.12 and Table 8.13.

Table 8.12: Medium Zone Sub-Basins - Proposed and Identified Project Capacity

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
	Nawchankha	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
	Yunsalin	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 Project Capacity

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
	Chaung Ma Gyi	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

Basin	Sub-Basin	Planned HPPs	Planned Capacity (MW)	Identified HPPs	Identified Capacity (MW)
Thanlwin	Lam Pha	0	0	1	19
	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**	**1**

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 estimation is provided, although it has to be noted that actual development will be 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

Further investigation of the hydropower potential in priority sub-basins is likely to add further capacity 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. As described earlier, this evaluation was not used in the determination of sub-basin zoning because socio-economic issues are often highly location-specific within sub-basins, while the data available is broad scale and hence not a good indicator of HPP impact. Socio-economic impact assessment needs to commence during project site selection when alternative sites are being considered.

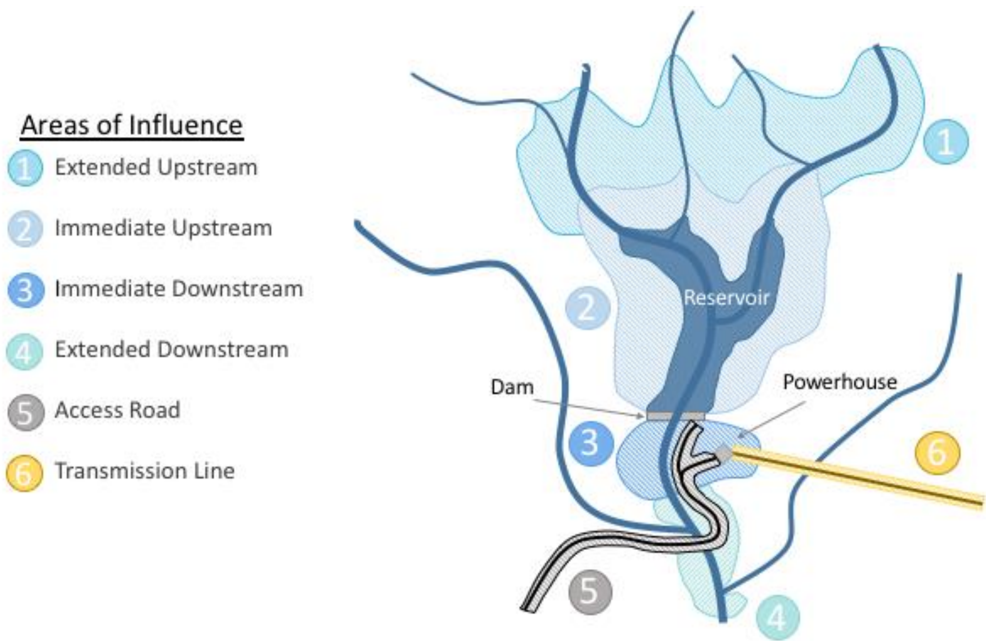
The sub-basin evaluation was restricted to data from the 2014 national census at the township level, with proxy indicators used for social vulnerability and poverty. To allocate township-level data the centroid points of the townships were overlain on sub-basins, which may have created some (unquantified) 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 livelihood dependence on natural resources and social vulnerability. Proxy indicators were used in the absence of poverty data, as the data from the MPLCS 2015 was not publicly available and the 2009-10 Integrated Household Living Conditions Assessment is outdated. The results from the MPLCS 2015 and the Multi-Dimensional Poverty Index being finalized by the World Bank will provide important inputs to future studies. Preliminary results show a correlation between poverty, hilly and mountainous regions, and intact forest. It can 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 by the local population.

8.5.1 Project Area of Influence

Recognizing that the social and livelihood impacts of hydropower are more localized, an 'area of influence' (AOI) approach is appropriate to assess social impacts, collect socio-economic data and design effective stakeholder engagement. The AOI approach can make use of higher resolution village tract and village-level population data, and incorporate specific technical data for hydropower projects. The AOI was used to assess the number of people potentially impacted by BAU hydropower development. The six AOIs of a typical HPP are illustrated in Figure 8.6.

Figure 8.6: Hydropower Project Area of Influence



This approach identifies different types of impacts potentially experienced by people living within the AOIs, as summarized in Table 8.14. This list is indicative only as the scale and significance of impacts will vary depending on HPP size and type (e.g. run-of-river or storage), and the operating regime (e.g. peaking versus base load generation). The social impacts associated with the construction of worker camps, access roads and transmission lines also need to be assessed.

Table 8.14: Areas of Influence 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 (less common) purposes
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 habitat for animals and reduced vegetation cover • Barrier to fish migration • Potential health impacts from still / stagnant water in the reservoir • Potential for cage/pen aquaculture in larger reservoirs • Potential for tourism
Zone 3: Immediate downstream	• Severe reduction of river flows - reduced availability for drinking water and irrigation, as well as fishing • Dry river bed (if peaking plant operation or river 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 • 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[43], covering:

- **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 (SIA) provisions, however, are not detailed. A review of EIAs in Myanmar shows that public participation, gender, ethnic minorities groups or livelihoods issues have not been well covered. Stakeholders consulted during the 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 SIA process. Where hydropower cascades are planned, CIAs should also provide opportunities to collect and analyze socio-economic data at either a sub-basin or watershed level, involving sample surveys of populations,

[43] MOECAF, 2015. *Environmental Impact Assessment Procedure*. Notification No. 616/2015. 29 December 2015.

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 the early identification and consideration of the conflict status 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 conflict status may range from workable to off limits. As such, the conflict layer prepared provides an additional essential layer for developers to consider when identifying potential sites, and for GoM to consider when assessing a project application. Maintaining the conflict layer separate from biophysical zoning allows it to be updated regularly as conditions change, whilst biophysical zoning remains unchanged and thereby provides clear overarching guidance.

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 Army or EAOs.

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 the presence of armed groups (disagreement over governance and territory), historic population displacement (a proxy indicator for equality and rights issues), recent conflict incidents (2012-2016 patterns of violence associated with contested territory), and estimated battle deaths (1989-2015). A map of armed conflict was developed based on aggregated media reports of such incidents since 2011 and academic estimates of battle deaths by 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) scores were grouped together to indicate "conflict prone" sub-basins, and medium (3), low (2) and very low (1) scores were grouped to indicate "non-conflict prone" (Figure 8.7).

Less than half of the sub-basins (45%) returned conflict vulnerability ratings of 'very low' or 'low'. Ten sub-basins (17%) were rated 'medium', nineteen were 'high' (33%), and three (5%) were 'very high' respectively. The very high ratings in Myanmar's west result from the high incidence of intercommunal conflict and displacement in Rakhine State between 2012 and 2016. Sub-basins in or across Ayeyarwady, Yangon, Bago, Magwe, Mandalay, and Saigang Regions were mostly rated low or very low, given the relative absence of armed group activity, population displacement or armed violence in these areas.

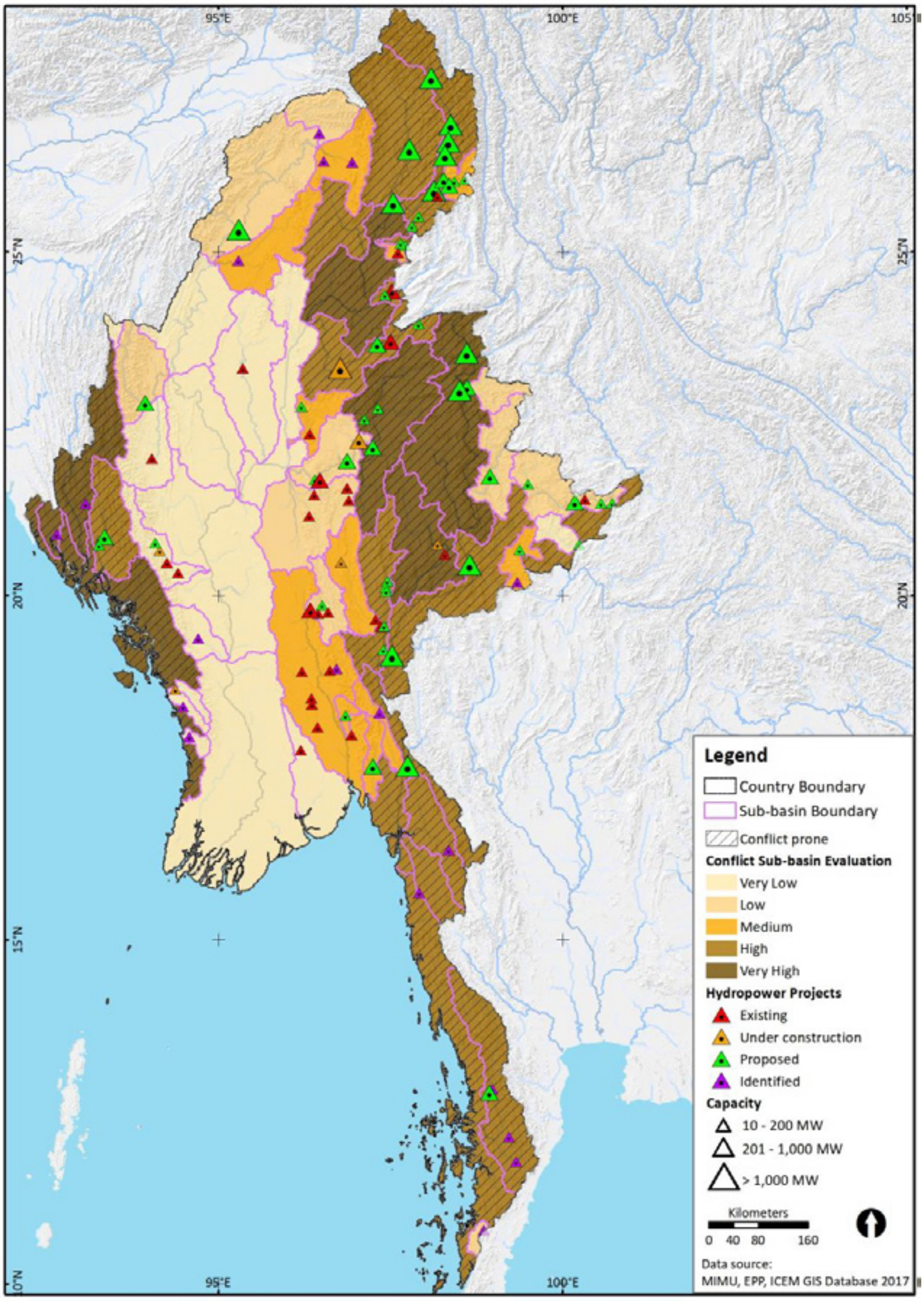
Sub-basins in Kachin and Shan State (North) were mostly rated as high or very high vulnerability for conflict, due to the presence of multiple armed groups and high levels of conflict and population displacement between 2012 and 2016. Sub-basins in Shan State (South and East), as well as Kayin and Kayah States, and Tanintharyi Region, were rated as medium or high based upon the presence of multiple armed groups, high historical conflict, and high historical displacement, even though much of these areas are currently under ceasefires. The Thanlwin (especially), Rakhine, and parts of the Ayeyarwady basin (middle) returned the highest conflict vulnerability ratings.

8.6.1 Conflict as a Peace-Building Model

To achieve sustainable hydropower development, it needs to be recognized 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 are 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 part 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 8.7: 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 conflict sub-basin ratings provided in Figure 8.7 can be used as a guide in the preliminary stages of project planning to identify if conflict may exist in the area. Detailed conflict assessments should be conducted as part of the pre-feasibility or feasibility studies. 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 all sub-basins and projects in the current development pipeline, particularly for those projects 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 actors. 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. EIAs 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 minorities 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, it is important to give CSOs and local communities the opportunity to make this distinction.
- **Strengthening oversight and legitimacy of consultations, EIA, 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 EIAs 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), and the Burma

Environmental Working Group (BEWG) among others, could be included in consultation and assessment procedures. The GoM should utilize their technical expertise and local knowledge, and 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 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. This would form the basis of a benefit sharing guideline that explores how 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 acknowledged and explored.
- **Incorporate ethnic minority and peace-and-conflict perspectives into hydropower policy and regulations**. Hydropower laws, regulations and policies are recommended to adequately reflect the risks of armed conflict to sustainable hydropower development, or the risks of hydropower development to the peace process. This would ensure that project proponents are required 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. 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 past the dam. 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 downstream to the sea, as well as 900 km of the Chindwin River from the headwaters of the Chindwin in the Hukawng Valley in Kachin State, downstream to the Ayeyarwady confluence in a free-flowing state. These intact mainstems 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 (Nawchankha, Myitnge Upper, and Myittha) discharging into an immediate sub-basin.

The proposed reservation of the five High zone sub-basins, coupled with mainstem reservation, would maintain seven intact rivers with unregulated connectivity with 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.

The reservation of these five sub-basins would maintain an estimated 47% of the total Ayeyarwady basin flow[44] in a natural state given the high contribution of these headwaters to river discharge. 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 be vulnerable to changes associated with the establishment and operation of non-hydropower river and 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 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.

[44] 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.

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 intact forest (above 80% canopy cover), which covers 72.2% of this area (56,213 km^2), 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 - 100% of this ecoregion is in these five sub-basins; (ii) Northern triangle sub-tropical forests - 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 recommended reservation of mainstem rivers and High zone sub-basins, relating to the maintenance of seasonal river flows and nearby forest cover, include:

- Helping to 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 maintenance of very high flow events;
- Supporting Ayeyarwady Delta ecosystems, mangrove forest cover, and the significant delta fishery, including the Meinmahla Kyun Ramsar site;
- Maintaining important areas for fish and floodplain agriculture;
- Allowing 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; and
- Helping to maintain adjoining catchment forest cover by minimizing HPP access road development in forested areas would minimize sediment from associated land disturbance and erosion. In the middle Ayeyarwady, high sediment loads from land-use changes and subsequent erosion has been linked with channel infilling and navigation problems.[45]

Unique values in the Ayeyarwady basin that would be protected by mainstem and sub-basin reservation include:

- high cultural value of the Ayeyarwady - considered by many as the mother river of Myanmar;
- confluence of the Mali and N'mai rivers - recognized as the cultural homeland of the Kachin people[46]; 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 22 sub-basins zoned Low (13) and Medium (9), covering 47.7% (177,848 km^2) and 31.4% (117,165 km^2) respectively in the Ayeyarwady basin within Myanmar, provide considerable scope to balance power generation with the maintenance of natural and social resources in these catchments.

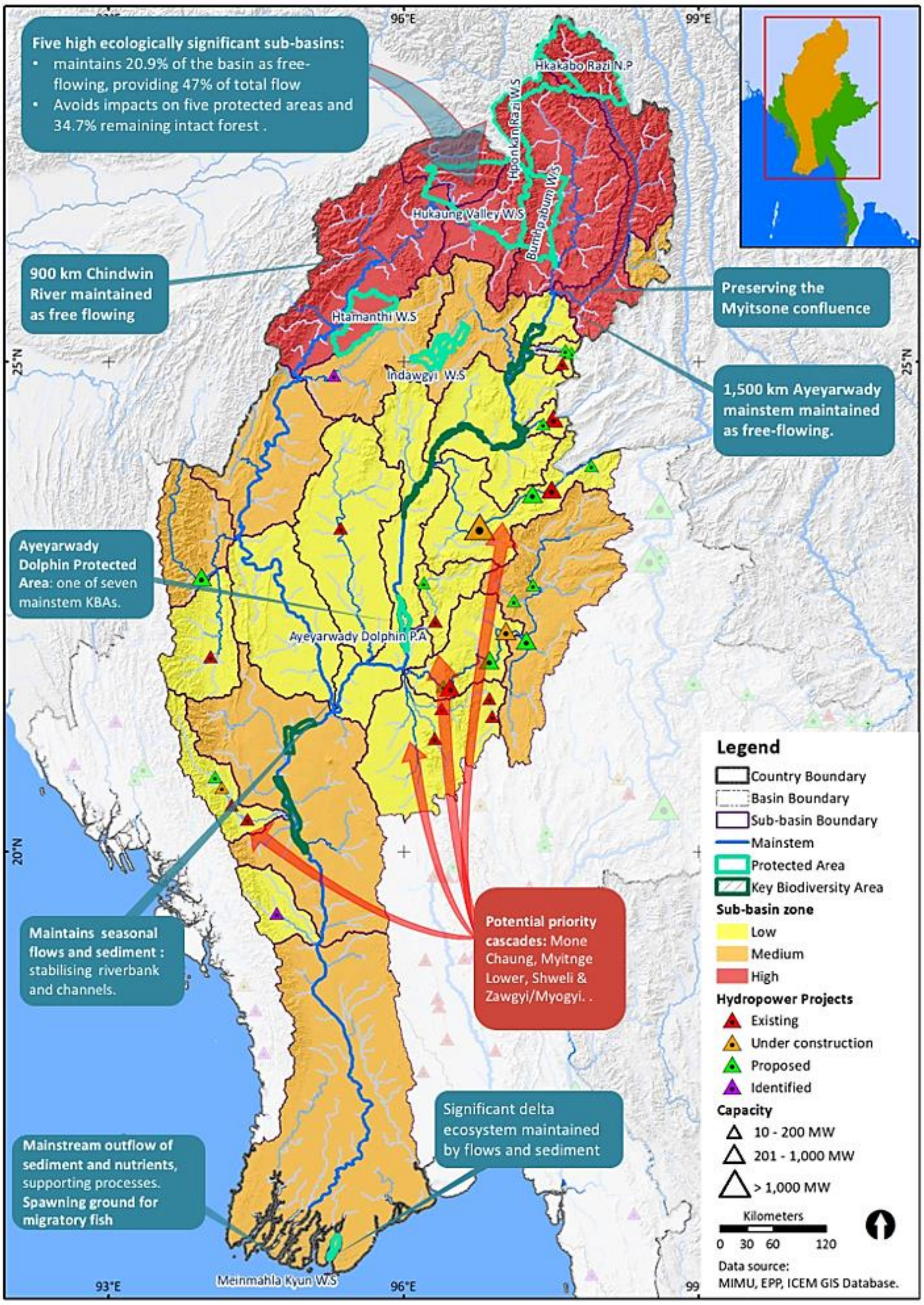
9.1.2 Power Generation

The total operational capacity of HPPs of 10 MW capacity or greater in the Ayeyarwady basin is currently 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

[45] WWF, 2017.
[46] Kiik, 2016.

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 potential priority sub-basins include the Myitnge Upper (due to the Myitnge Lower having cascade hydropower) and two other sub-basins each with an existing HPP and at least one additional proposed/identified project - Dapein and Chaung Ma Gyi. In addition, the Namtabak sub-basin, with headwaters already regulated in China, may have 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 within Myanmar (Figure 9.2), longitudinally disconnecting this area from the rest of the basin, thereby altering river flows and preventing the free flow of sediment downstream and the movement of fish upstream 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.[47] The Thanlwin remaining in a free-flowing state with no large HPPs on the mainstem would retain large-scale geomorphic functioning, with seasonal flow and sediment production from the steep, crystalline mountains, and would help to maintain the fragile coastal environment.

The Thanlwin has 37 different river-reach types, 29 of which are rare or very rare. The intact mainstem would provide connectivity between the confluences of 10 sub-basins and the sea. The proposed 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 15.9% (20,264 km^2) of the basin within Myanmar. The proposed reserved mainstem would also maintain connectivity with numerous very small tributaries that provide important habitat.

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 Nam Pang- Thanlwin confluence 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 that is comprised of nearly 85% (17,202 km^2) KBA. The area supports two relatively intact ecoregions: (i) Kayah-Karen montane rain forests - 78.3% (15,864 km^2) of this ecoregion in Myanmar, which is the fourth-richest type in the Indo-Pacific region for mammals; and (ii) Northern Indochina subtropical forests - 21.7% (4,400 km^2) of this ecoregion 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 the potential to significantly alter river connectivity, flows, water quality, 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 allow migratory fish such as Hilsa to continue to move up and down the river;
- maintenance of sediment and nutrient delivery to floodplains that support floodplain vegetation, agriculture, and fisheries as well as wetlands that are habitats for the Fishing Cat, the Asian Small-Clawed Otter, and the Siamese Crocodile; and
- maintenance of connectivity with the Nam Moei tributary that forms the border with Thailand, an area with rare and endemic fish and aquatic species.

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

[47] 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.

- 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[48], and
- habitat for a wide variety of fauna, including sandpipers, turtles, bats, and tigers in the Thanlwin Lower sub-basin.

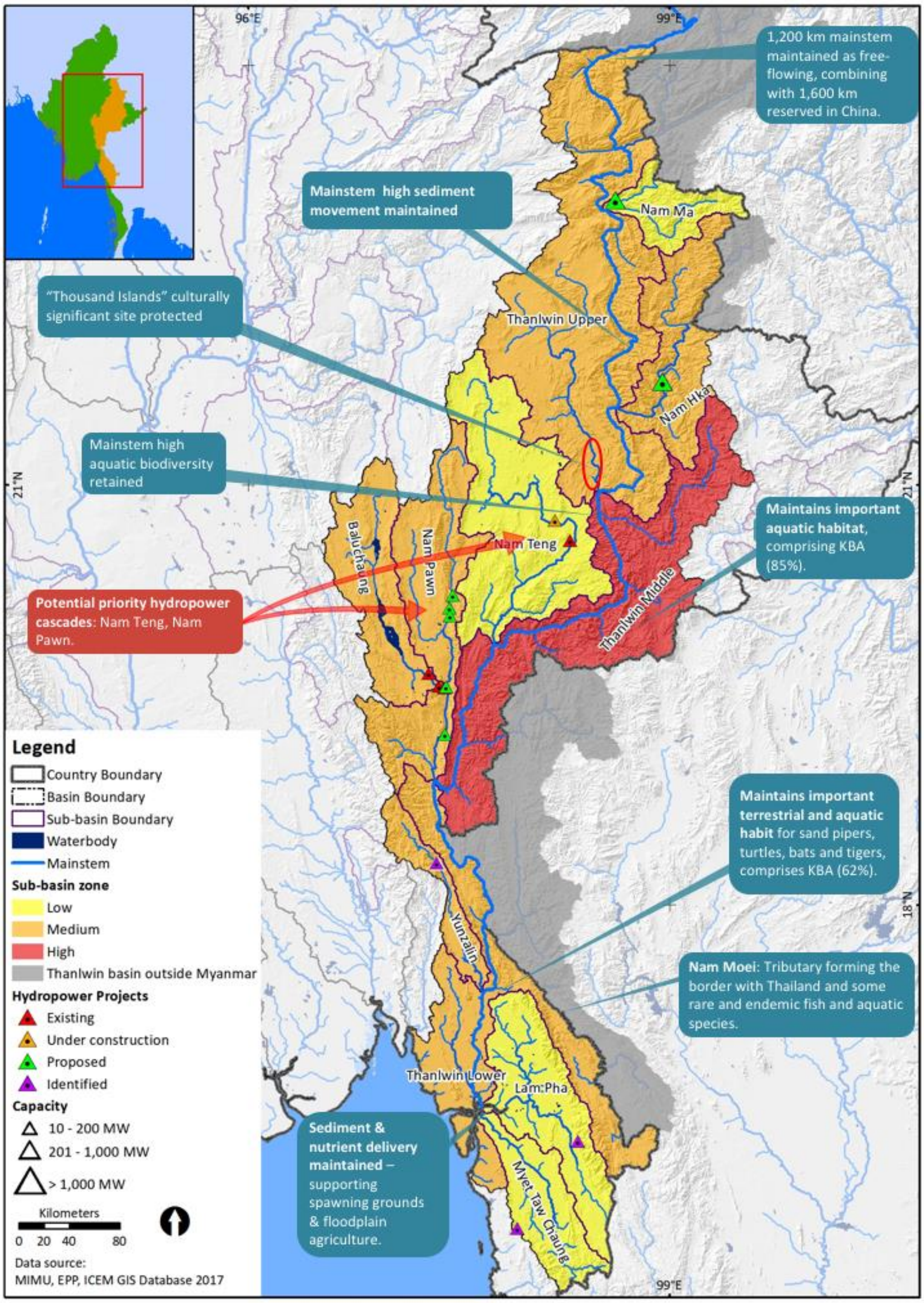
9.2.2 Power Generation

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 achieve basin sustainability.

The total operational capacity of HPPs of 10 MW capacity or greater in the Thanlwin basin is currently at 302 MW. The Baluchaung sub-basin has three operational HPPs (248 MW) and one project 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.

[48] http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/river_decline/10_rivers_risk/salween_river/

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 fish migration and 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. This reach would provide modified aquatic habitat due to upstream regulation in China but would not add to these existing flow and sediment changes.

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

The Mekong Other sub-basin drains into 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 flow, sediment and habitat connectivity with the mainstem. The area has a very high ecological value due to the presence of migratory and critically endangered/endangered fish species, with the Mekong mainstem recognized as a riverine KBA.

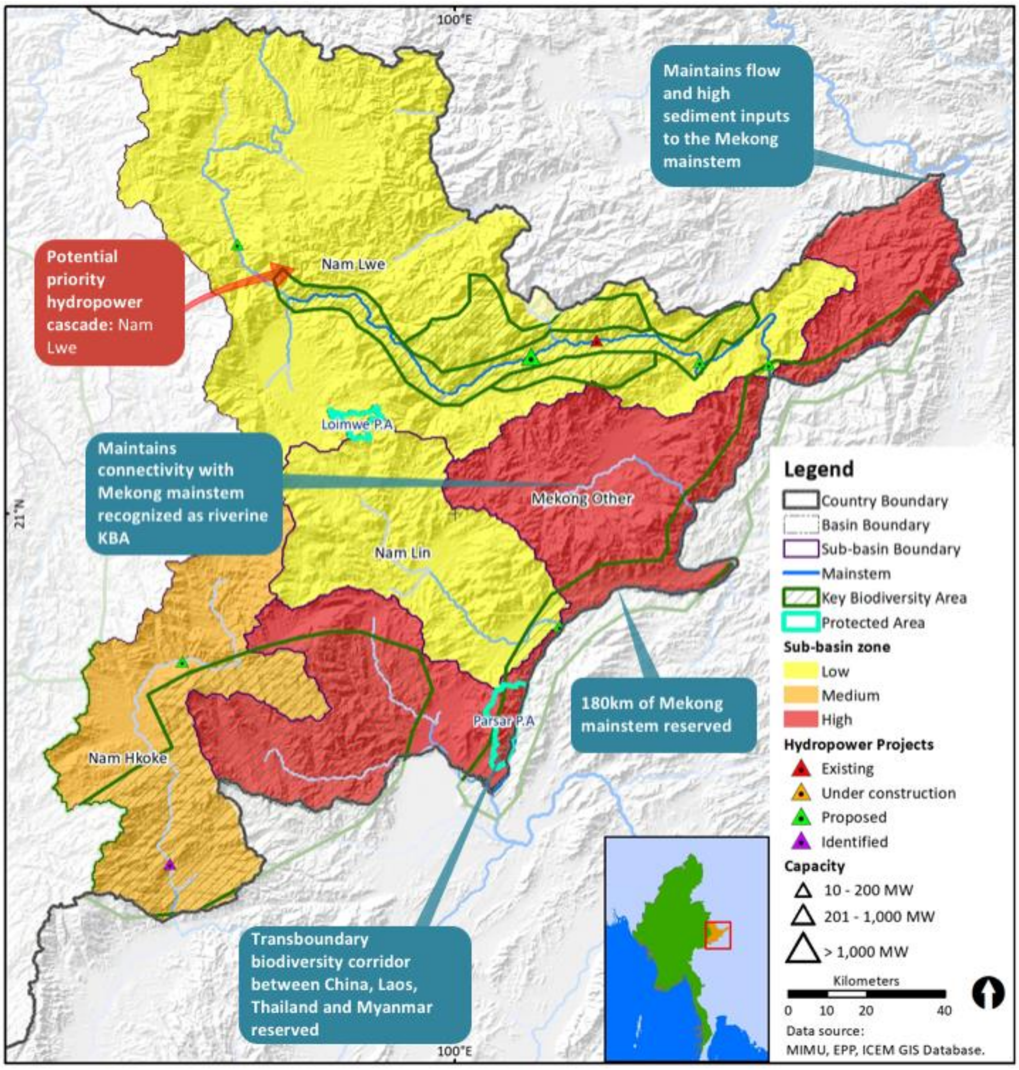
Sub-basin reservation would avoid direct and indirect impacts on an area comprising KBA (40%), intact forest (12%), and the Parsar Protected Area (2%). The KBA is an important habitat for small mammals and a transboundary biodiversity corridor between China, Lao PDR, Thailand, and Myanmar. The area falls 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 projects) regulating 32.2% (11,258 km^2) of the basin. The projects disconnect these catchments from the sea, alter river-flow patterns, prevent the free flow of sediment downstream, and prevent the movement of fish upstream and 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.[49]

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

[49] Anthony et al., 2017.

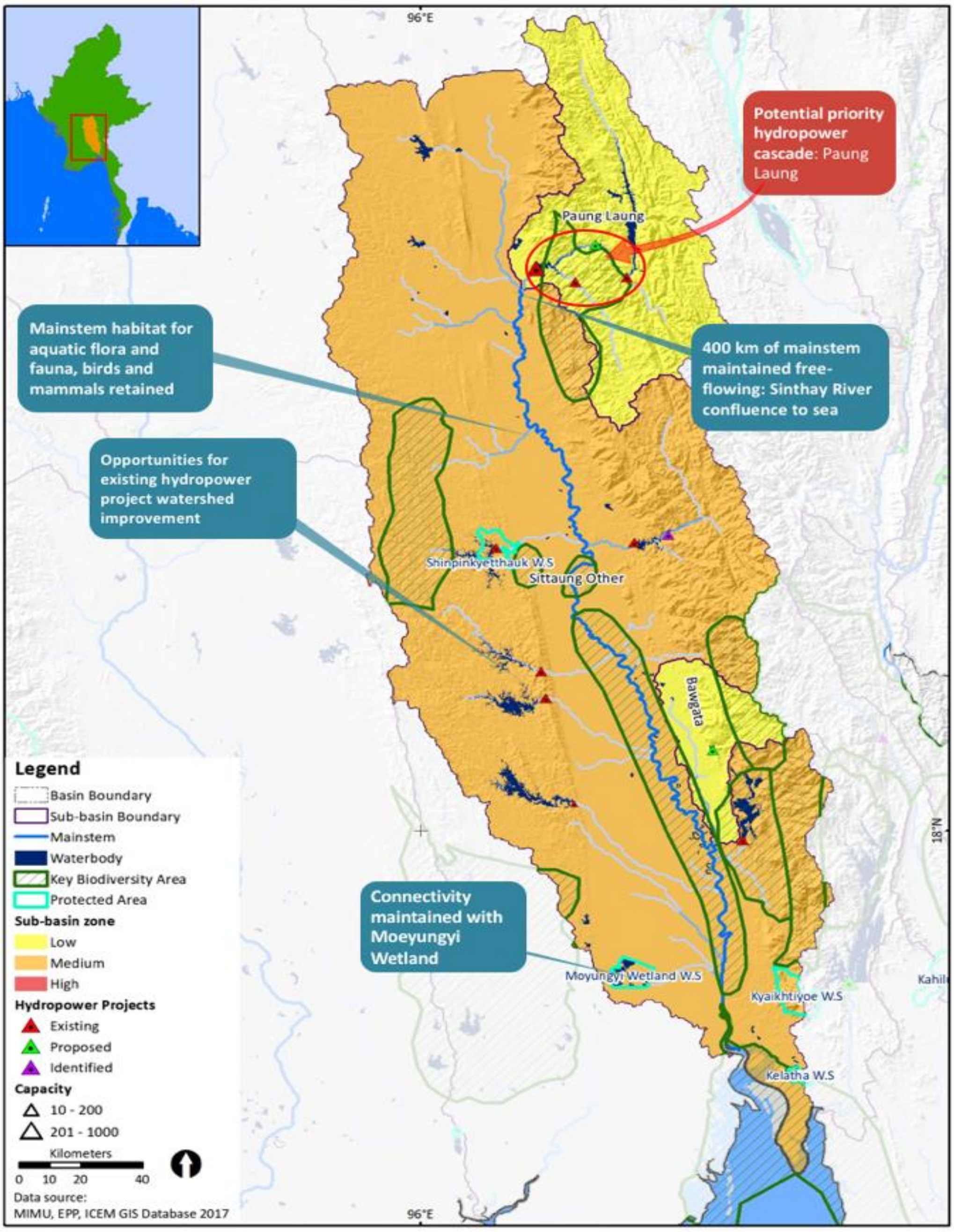
Other important processes and unique values that would be maintained by the reservation of the mainstem river include:

- 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 - allowing 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 Paunglaung), covering 82.2% (28,698 km^2) and 17.8% (6,215 km^2), respectively. The total operational capacity of nine HPPs of 10 MW capacity or greater in the Sittaung basin is currently at 810 MW, with proposed and identified HPPs in these sub-basins totalling 345 MW. Additional potential hydropower may be identified in the basin, subject to investigation, with a possible priority being on the Paunglaung sub-basin that already has cascade projects. Where additional projects are sited, how they are designed and their operating regimes will dictate hydropower sustainability in the basin beyond current 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 km²) of the small Bago basin (10,261 km²). 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 upstream and 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 therefore is potentially suitable for hydropower development. No projects are currently proposed or identified in this catchment, but if projects are proposed they are recommended to be subject to sustainable project siting, design, and operation requirements. The siting, design and operation of approved projects 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 the relatively small catchment with a low Strahler Order main river. The single sub-basin has been zoned Low and is therefore potentially suitable for hydropower development. One project is currently proposed in the basin: the 280-MW Bilin storage project that has a high dam (131 m), a very large reservoir (310 km^2), and long reservoir-residence time (around 578 days), This project 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 upstream and downstream.

Additional HPPs identified in the basin should be subject to sustainable project siting, design, and operation requirements, which will influence hydropower sustainability.

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 catchment of the main basin river, the Tanintharyi, covers 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 proposed reservation of the two High zone sub-basins - Tanintharyi and Tanintharyi Other, covering 97.8% (43,884 km^2) of the basin - would retain six intact rivers with unregulated connection to the sea:

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

Sub-basin reservation would maintain the key processes of river discharge and sediment supply, supporting large coastal areas that 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:

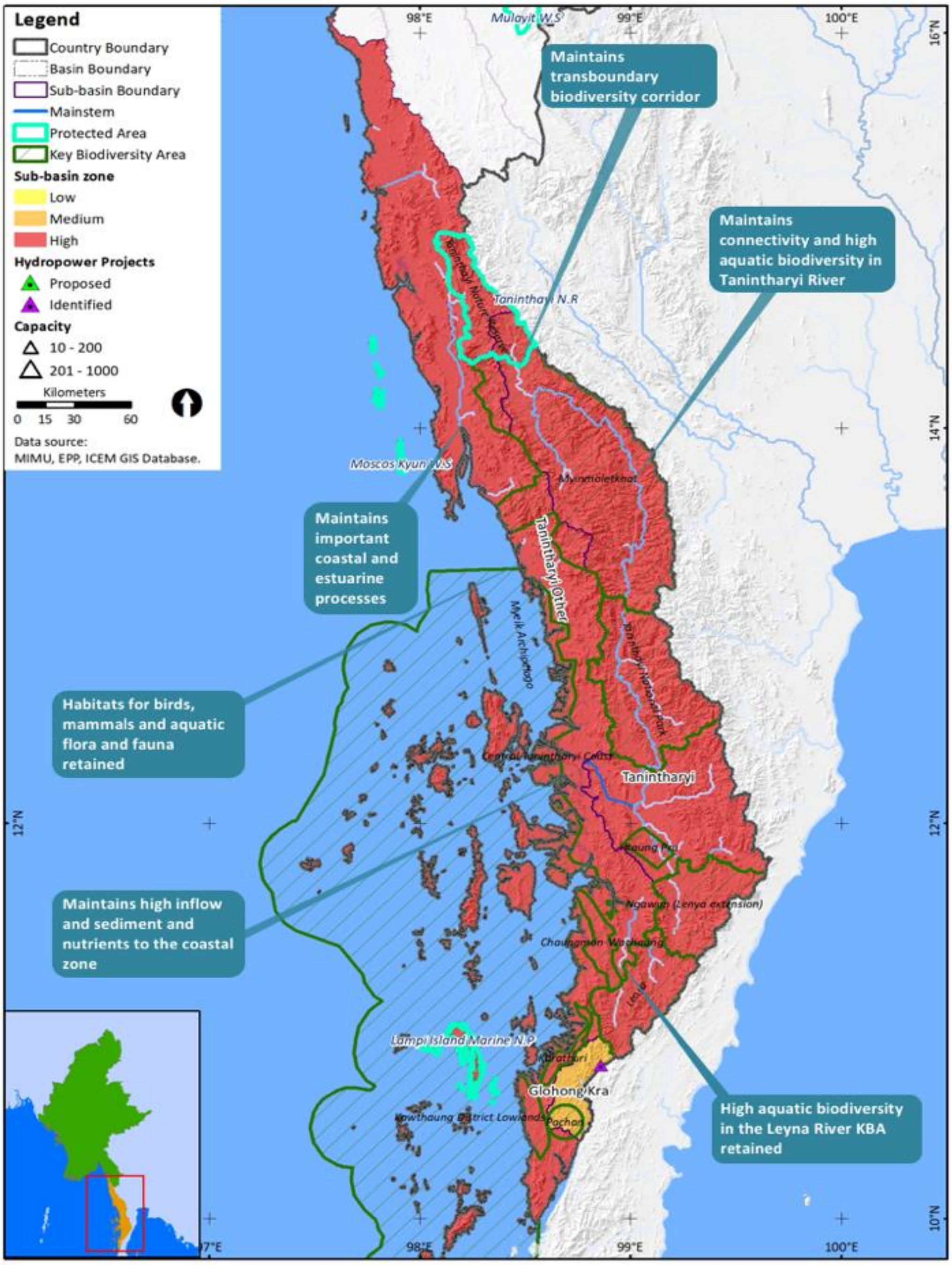
- Tanintharyi Forest Corridor - an important habitat for tigers and elephants in the Tanintharyi sub-basin that is being considered for World Heritage listing. This sub-basin consists of 90% KBA and 64% intact forest; and
- Tanintharyi Other sub-basin - an important habitat for birds, mammals, and aquatic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

In addition, conflict sensitivity analysis should be undertaken for any larger-scale hydropower development in areas within 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 of 10 MW or greater 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 and the movement of fish upstream or downstream.

The proposed 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, the largest coastal river, receives high rainfall, with river discharge and sediment supply maintaining large coastal areas. It has been recognized as a riverine KBA with a high aquatic ecosystem value due to the presence of endemic and migratory fish species.

Sub-basin reservation would avoid 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 catchment 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:

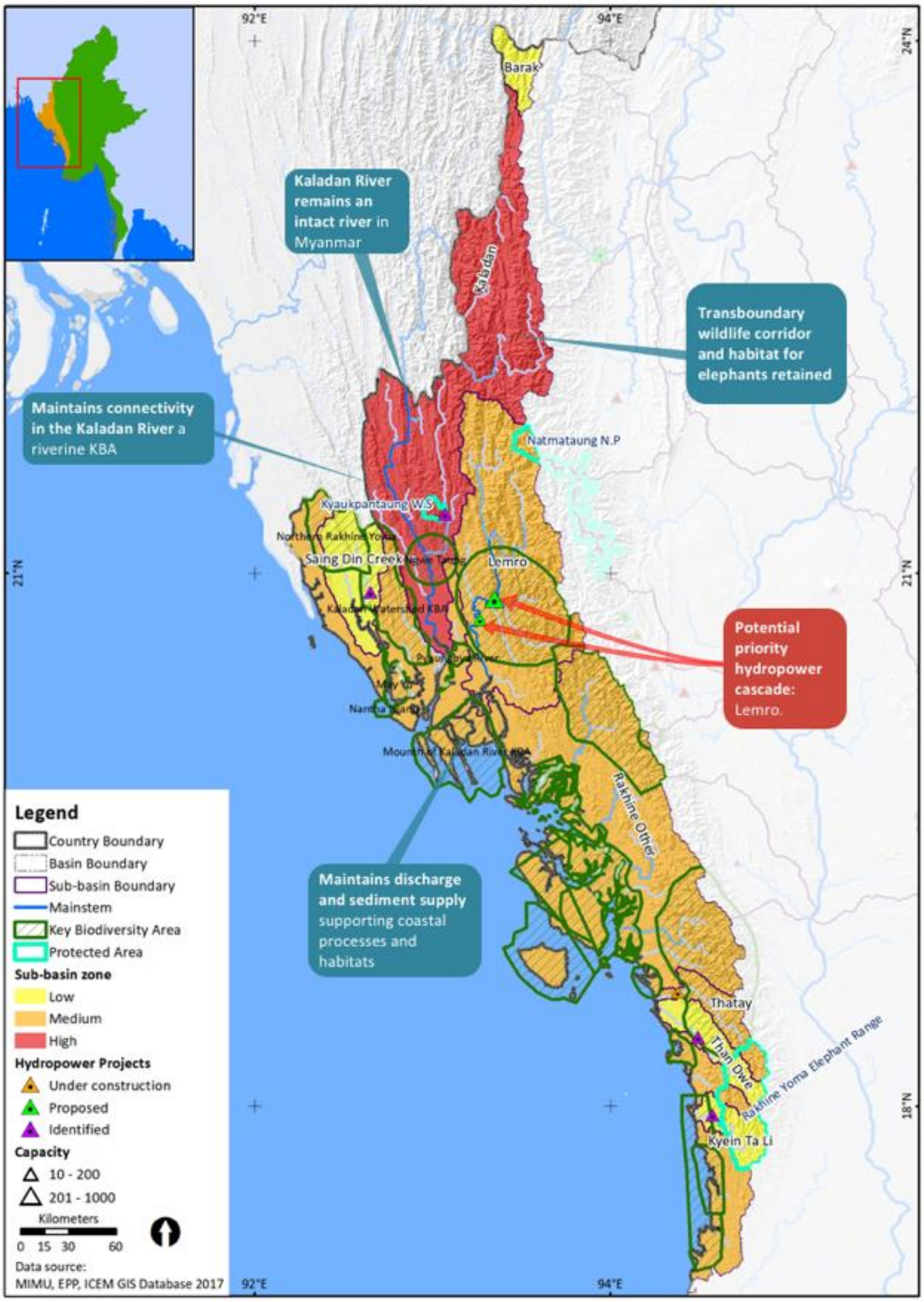
- river discharge and sediment supply supporting large coastal areas that include mangrove forests;
- connectivity with the headwaters and Tyao and Boinu rivers, supporting fish migration and endemic species;
- the marine section of the Kaladan River marine KBA that is an important habitat for waterbirds, 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 basin within Myanmar, consisting of 8.6% (4,751 km^2) and 66.9% (37,040 km^2) respectively. Proposed and identified HPPs sited within Low and Medium zone sub-basins total 834 MW. Additional potential hydropower may be identified in the basin, subject to investigation. The siting, design and operation of approved projects will influence hydropower sustainability in the basin, with some conflict prone sub-basins providing a development constraint.

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 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;
- planning and overseeing the implementation and monitoring of other SDF actions;
- coordinating planning and data gathering with other government agencies; and
- ensuring mechanisms for meaningful and on-going consultation with stakeholders are established and maintained.

Outside the Planning Committee it is recommended that MOEE screen all project proposals against the Basin Zoning Plans and MONREC review each proposal to determine if a CIA is required to be prepared by the proponent.

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

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

Coordination between the Union and state/region governments will also be critical in implementing the SDF for all hydropower projects of 10 MW capacity or greater as the states/regions have the right to approve 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 Myanmar EIA Procedures (2015).

10.2 Sustainable Hydropower Policy

An overarching Sustainable Hydropower Policy is recommended, stating the government's vision for and commitment to sustainable development and 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, social and conflict considerations into, and meaningful public participation, into project decision making from the early stages of project planning.

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 MOEE's website. This information would provide clear guidance on the recommended reserved mainstem rivers, 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 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 a MoU.

A developer should be required to submit the concept-project proposal to MOEE for screening prior to applying for a MoU. Where the project is sited in a Low or Medium zone sub-basin, it is recommended that MOEE allow the project developer to apply for a MoU. Projects proposed on reserved mainstem rivers and large projects proposed in High zone sub-basins are not recommended for further consideration. 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 against strict additional criteria to determine if they should proceed to an MoU and more detailed planning.

The screening procedure should also include MONREC's review of the project concept to determine if the developer is required to prepare a CIA for a defined sub-basin or watershed. The procedure should also outline how the Basin Zoning Plans could be applied to proposed projects to be developed by a state/region government, incorporating the EIA procedure. Proposals for multi-purpose projects need to include the MOALI in project screening.

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

10.3.3 Project Screening Criteria for High Zone Sub-Basins

Screening criteria is needed 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. For projects that meet pre-defined selection criteria, it is recommended that MOEE allow the project developer to apply for a MoU. Projects that do not meet the criteria 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, MW capacity);
- 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, 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 resulting 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 area, 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 minimize major environmental and social impacts. Key project design options that should be considered include:

- **Environmental flow (EFlow) release:** EFlow releases should be incorporated into the design of each HPP that will affect a downstream river section. IFC has issued a good practice handbook on EFlows[50] and is working in collaboration with Yangon Technical University, World Wildlife Fund (WWF), and IHE Delft Institute for Water Education to advance work on EFlows, including policy guidance, in Myanmar.
- **Hydropower generation off the EFlow 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 reservoir drawdown, allowing water to be drawn off the water column with the best possible quality for such parameters as temperature, oxygen content, suspended sediment and nutrient levels.
- **Reservoir mixing at the intake**: Different water-mixing options should be assessed to improve water quality drawn from the reservoir by 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 daily downstream river flow changes (volume, velocity, depth) over distance, thereby affecting aquatic habitat and posing a safety risk.
- **Fish passage**: While current fish passage technology is considered ineffective for fish species in the Greater Mekong region where a head difference of more than 10 m exists,

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

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 in Lao PDR. Depending on its performance, this design may be appropriate for projects with higher dams in Myanmar. Fish-friendly turbines may be appropriate for small and medium run-of-river projects, or screens that prevent the entrainment of fish into the intake.

- **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 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 should be investigated to maximize generation, optimize the value of EFlows, and reduce the incidence of flooding.

The *Myanmar Hydropower Standards*[51] prepared by MOEE with the support of the Government of Norway, recommends design requirements for hydropower facilities to protect human safety and livelihoods, 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. A cascade 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 EFlows to maintain the riverine ecosystem. The process would involve capacity building for MOEE and consultation with hydropower companies, as different developers will need to develop joint mechanisms for cascade project operation. 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 transboundary issues.

10.5 Impact Assessment and Management Planning

10.5.1 Improved Implementation of the Environmental Impact Assessment Procedure

It is recommended that the existing environmental assessment framework set out in the Environmental Conservation Law 2012 and Myanmar EIA Procedures 2015 needs to be reviewed to improve implementation. Key focus areas to improve existing procedures include:

- ensuring that the environmental assessment process commences during project siting and design so that the EIA/IEE contributes to siting and design to avoid and minimize major environmental and social impacts;
- integrating SIA 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

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

undertaken before, during, and after project construction, not just as part of the EIA or resettlement process, and incorporates expanded stakeholder engagement in conflict affected areas; and
- approving and implementing the EIA Guidelines for Hydropower Projects developed by IFC for MOEE and MONREC.

Based on the experience of implementing this SEA for the hydropower sector, it is recommended that a SEA procedure be developed under the Environmental Conservation Law 2012 to provide regulatory guidance on when to apply an SEA to sectors such as mining and transportation, or to areas such as special economic zones. The procedure would provide guidance on development/project screening, and the review and approval process incorporating the SEA.

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 VECs 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 need for a CIA should be identified by MONREC when multiple projects are being considered or are likely to be proposed in a sub-basin or watershed. A CIA should ideally be conducted for one or more HPPs proposed in an undeveloped sub-basin or a large watershed, or where such projects are proposed in a partly developed watershed. The CIA should assess other proposed or likely developments that would affect the VECs (e.g. small HPPs designed to provide power for mines and special economic zones, irrigation and other water supply projects, agricultural developments, and mining). It should also include opportunities for joint management platforms for combined biodiversity offset initiatives and to pool resources.

10.5.3 Conflict Sensitivity Analysis Guideline

A conflict sensitivity analysis guideline is recommended to be developed and applied to all projects proposed in conflict prone areas (sub-basins rated high or very high for conflict) to explicitly assess the risks of conflict as part of the project concept stage assessment, 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 were residing 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. Many past 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[52], 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 Land Acquisition Act 1894 (currently under review by parliament). *One Map Myanmar*, an eight-year national mapping project that commenced in 2016, provides 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 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 the 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/region 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 maintain hydropower project performance over time by maintaining or improving seasonal runoff distribution across the year and by minimizing erosion and sedimentation. The infiltration rate in a well vegetated catchment, with the water retained in the soil profile and as groundwater, is usually far higher than that retained in a denuded catchment. Monsson rainfall recharges the soil and groundwater, then it is released as a low flow during the dry season. 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. The main environmental service local communities can offer hydropower plants is watershed protection.

[52] 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."

10.6 Research and Planning

Baseline monitoring and studies are recommended to provide key data and information for basin, natural resource and hydropower planning, commencing early in the initial three-year SDF implementation plan. Important information on hydrology, sediment movement, aquatic ecology and livelihoods is required for more detailed planning.

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 hydropower capacity in Low and Medium zone sub-basins. A secondary focus area is the Mekong basin where 11.4% of Low and Medium zone sub-basin national hydropower capacity 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 are:

- mainstem rivers: monitoring of key system features at selected points along these rivers (primarily along the Ayeyarwady, Chindwin and Thanlwin) to better understand system processes and values;
- Low and Medium zone sub-basins where multiple projects are proposed; and
- Low and Medium zone sub-basins with no proposed projects but similar biophysical conditions to sub-basins being investigated for multiple HPPs, that could form set-asides for the catchments being developed.

10.6.1 Basin Baseline Data

Defining the long-term hydrological and geomorphological characteristics of each basin is essential in understanding basin dynamics and to effectively plan the sustainable development of major rivers, however limited data is available on these features in Myanmar. Similarly, little is known about freshwater ecology and fish migration in Myanmar's rivers. More detailed baseline information is starting to be obtained, 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)[53] under the AIRBMP is the most comprehensive integrated environmental, social, and economic baseline for 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 close to one-fifth of the country, combined with the scale of proposed hydropower development in the basin (14 proposed/identified projects totaling 16,000 MW) and the limited understanding of basin processes and values.

The following studies are recommended to be prioritized at the basin level.

Hydrology

River gauging across Myanmar's eight basins is limited. Just nine gauging stations exist in the Ayeyarwady basin, although there is some uncertainly over the reliability of some of this data.[54] 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.

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

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

No surface water modelling has been conducted for any other basins in Myanmar. Actions needed to improve baseline hydrological information include:

- reviewing the adequacy and reliability of hydrological data from all existing river gauging stations in Myanmar;
- assessing the priorities of the 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;
- requiring 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 analyzed by various government agencies.

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 integrating discharge monitoring and the collection of physical samples. It also recommended that uniform methods and protocols be established, together with a suitable data management system. A similar approach could be developed for the Thanlwin River consisting of: (i) baseline sediment sampling and remote-sensing analysis, and (ii) a monitoring framework for sediment and discharge.

Fisheries and Biodiversity

Assessments of aquatic biodiversity, freshwater habitats, and river health are needed along target river reaches in all major basins in Myanmar. Migration studies for the Hilsa and other fish and aquatic animal species, although limited, are being conducted on the Ayeyarwady River. This local survey approach is suitable to identify sites along the mainstem for further fish migration monitoring. 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.

The biodiversity technical working convened during the SEA preparation identified areas for potential expansion of the KBA network. These identified areas plus existing protected areas are seen as candidates for expansion should be prioritized for survey to enhance boundaries to be refined to include higher value areas.

Aquatic biodiversity assessments should be integrated with socio-economic surveys to determine the importance of local fisheries for livelihoods and household consumption. Current national statistics on fish production are best estimates only, that focus on commercial fish production, hence they do not fully consider the contribution of capture freshwater fisheries to small-scale and part-time fisher livelihoods.

Socio-Economic Conditions

Socio-economic surveys and livelihood studies are best 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 can help inform sub-basin and 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 specified area of influence of major rivers and tributaries. More information is needed at the sub-basin level regarding the local 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 farming them, and their role in the household and community economies;
- **Dependency on capture fisheries -** number of households, intensity of fishing, catch use (consumption or sale); and
- **Livelihoods dependent on river navigation -** use patterns, and role in household and local economies.

The priorities areas for survey are the Ayeyarwady and the Thanlwin basins due to their overall size and the scale of planned hydropower. Smaller river-basin assessments could also be carried out in the 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 coordinated data management system is recommended to manage all relevant hydropower project data and natural resource information. The system should be managed by MOEE and MONREC, and incorporate:

- Basin Zoning Plans, related hydropower planning and design guidance, and related SEA GIS layers - managed by MOEE;
- a HPP database - developed as part of the SEA and maintained by MOEE;
- river flow and meteorological data - managed by MOEE;
- natural resource and biodiversity information - established by MONREC; and
- a public disclosure database of all existing and future hydropower environmental assessments and management plans (CIAs, EIAs, IEEs, EMPs) - established by MONREC.

The information would be made available to end users, including government agencies and, where appropriate, hydropower developers and other stakeholders, via websites or online platforms.

Once the above information is consolidated, then a review of other planned water data management systems is recommended 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 should involve MOALI (irrigation reservoirs and land use), Department of Fisheries (fisheries production trends, leaseholds), DWIR (navigation) and other agencies.

It is recommended that MONREC request that private owners of existing HPPs provide river gauging data to the Ministry every six months, and that this be a condition placed on all new HPPs.

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 other natural resources across sectors within a given river basin. This planning aims to optimize the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring ecosystems.[55]

In Myanmar integrated river basin planning has commenced with the three-year AIRBMP that is developing a "*river 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

[55] 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.

develop a master plan for the Thanlwin basin as a priority, covering an additional 19% of Myanmar, and then prepare similar plans for the other six basins.

A review of the legal and institutional framework for river basin management and the need for river basin organizations should be undertaken. 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 HIC. The Stockholm Environment Institute is developing a framework for a Chindwin River Basin Organization. In December 2017, the DWIR proposed a Thanlwin Basin Commission to be established by Myanmar, Thailand, and China. The concept of the Commission was 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-Basin Baseline Assessment

Targeted biophysical and socio-economic surveys and assessments are recommended to be prioritized in the 12 Medium zone sub-basins with planned hydropower development (Table 10.1). Detailed baseline information is needed on these sub-basins to identify unique environmental and social values, river health status, and catchment contribution to basin processes. These studies should connect river health with existing levels of human pressures to determine the drivers of change and how they can be managed. Further research should include fisheries and aquatic ecology assessments, terrestrial biodiversity surveys relating to the potential expansion of the KBA network and socio-economic surveys of people living in proximity to major tributaries with planned hydropower projects to determine their use and reliance on these resources. A CIA or similar integrated approach can provide a framework for identifying VECs in sub-basins relating to hydropower development.

Table 10.1: Medium Zone Sub-basins with Planned Hydropower

Basin	Sub-basins with Proposed / Identified Hydropower Projects
Ayeyarwady	Nawchankha, Myitnge Upper, Manipur
Thanlwin	Nam Hka, Nam Pawn, Baluchaung, Yunsalin
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 to identify the cumulative impacts of multiple projects, develop appropriate management measures, and optimize power generation. Key studies should include:

- **Cascade opportunity identification:** assessing the potential for new cascade developments and additional projects in partly developed catchments in Low and Medium zone sub-basins. Where feasibility studies for sub-basin or watershed hydropower development have already been undertaken in Low or Medium zone sub-basins, these studies should be reviewed. Depending on how extensive these surveys have been, further investigation is recommended as a priority to assess if there are additional sites that could be developed in preference to proposing projects in undeveloped sub-basins.
- **Cascade CIA for developed catchments with additional proposed project/s**: a pilot CIA is recommended in a Low or Medium zone sub-basin with existing hydropower project/s where one or more additional HPPs are proposed. Priority sub-basins for this

assessment are Myitnge Lower and Myitnge Upper (Ayeyarwady basin), Nam Teng (Thanlwin), and Paunglaung (Sittaung basin).

- **System-scale planning for proposed cascades:** system-scale planning is an approach to assess both the impacts and benefits of hydropower cascades, and to identify optimal solutions (trade-offs) at sub-basin or basin level. WWF, The Nature Conservancy (TNC), and The University of Manchester demonstrated system-scale planning in the Myitnge sub-basin.[56] Initial priority sub-basins with proposed cascades that appear suitable for system-scale planning, subject to development interest and conflict status, are Lemro (Rakhine coastal basin), Nam Pawn (Thanlwin), and Nawchankha (Ayeyarwady).
- **CIA for a proposed cascade:** Following system-scale planning in a defined sub-basin, a CIA is recommended in that sub-basin to assess environmental and social impacts in more detail, to determine if medium/large scale hydropower development is appropriate. If deemed appropriate, project siting, design, and operation and management should be optimized to avoid and minimize major environmental and social impacts.

10.7 SDF Implementation Program

10.7.1 Policies, Procedures, and Guidelines

The three-year SDF implementation program consists of 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	Year 1		Year 2		Year 3	
Policy						
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		■				

[56] The Nature Conservancy, WWF, and the University of Manchester, 2016. *Improving hydropower outcomes through system-scale planning: an example from Myanmar*. Prepared for the United Kingdom's Department for International Development. 2016. Arlington, Virginia, USA.

10.7.2 Data Collection and Research

Priority research and studies to fill critical data gaps, improve the understanding of hydropower cascades and various other issues at basin and sub-basin levels are summarized in Table 10.3. The initial stages of the program focuses 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 Research and Planning

Research and planning	Year 1		Year 2		Year 3	
Basin						
SOBA - Thanlwin River Basin	■	■				
Hydrology - consolidate existing water data (all basins)		■	■			
Hydrology - review existing hydro-met systems			■	■		
Hydrology - propose hydro-met system for Thanlwin & other basins					■	■
Sediment transport - initial sediment sampling (Thanlwin)	■	■				
Sediment transport - 2 year monitoring program (Ayeyarwady)	■	■	■	■		
Sediment transport - 2 year monitoring program (Thanlwin)			■	■	■	■
Sediment transport - monitoring proposal for other basins						■
Fisheries - determine target river reaches for assessment (Ayeyarwady, Thanlwin)	■					
Fisheries – aquatic biodiversity, habitat, river health assessment on target river reaches (Ayeyarwady & 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 assessment survey sites and approach (Ayeyarwady and Thanlwin mainstem)		■				
Socio-economic - conduct socio-economic surveys (Ayeyarwady)			■	■		
Socio-economic - conduct socio-economic surveys (Thanlwin)					■	■
River basin planning - review legal framework for basin planning	■	■				
River basin planning - develop river basin master plan					■	■
Sub-basin						
Integrated assessment - Ayeyarwady medium zone sub-basins	■	■				
Integrated assessment - Thanlwin medium zone sub-basins	■	■				
Integrated assessment - Sittaung medium zone sub-basins			■	■		
Integrated assessment - Rakhine medium zone sub-basins			■	■		
Integrated assessment - Mekong medium zone sub-basins					■	■
Integrated assessment - Tanintharyi medium zone sub-basins					■	■
Hydropower cascades						
Cascade CIA for developed sub-basin with additional proposed	■	■				
System-scale planning for proposed cascades		■	■			
Hydropower feasibility study in sub-basins with existing cascades			■	■		
CIA for proposed cascades				■	■	
Water data and information systems						
Develop natural resource and hydropower databases	■	■				
Integrate databases with water information management systems			■	■	■	■

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 others to maintain system processes and unique values. The initial revision of the SDF is recommended three years after the release of this SEA.

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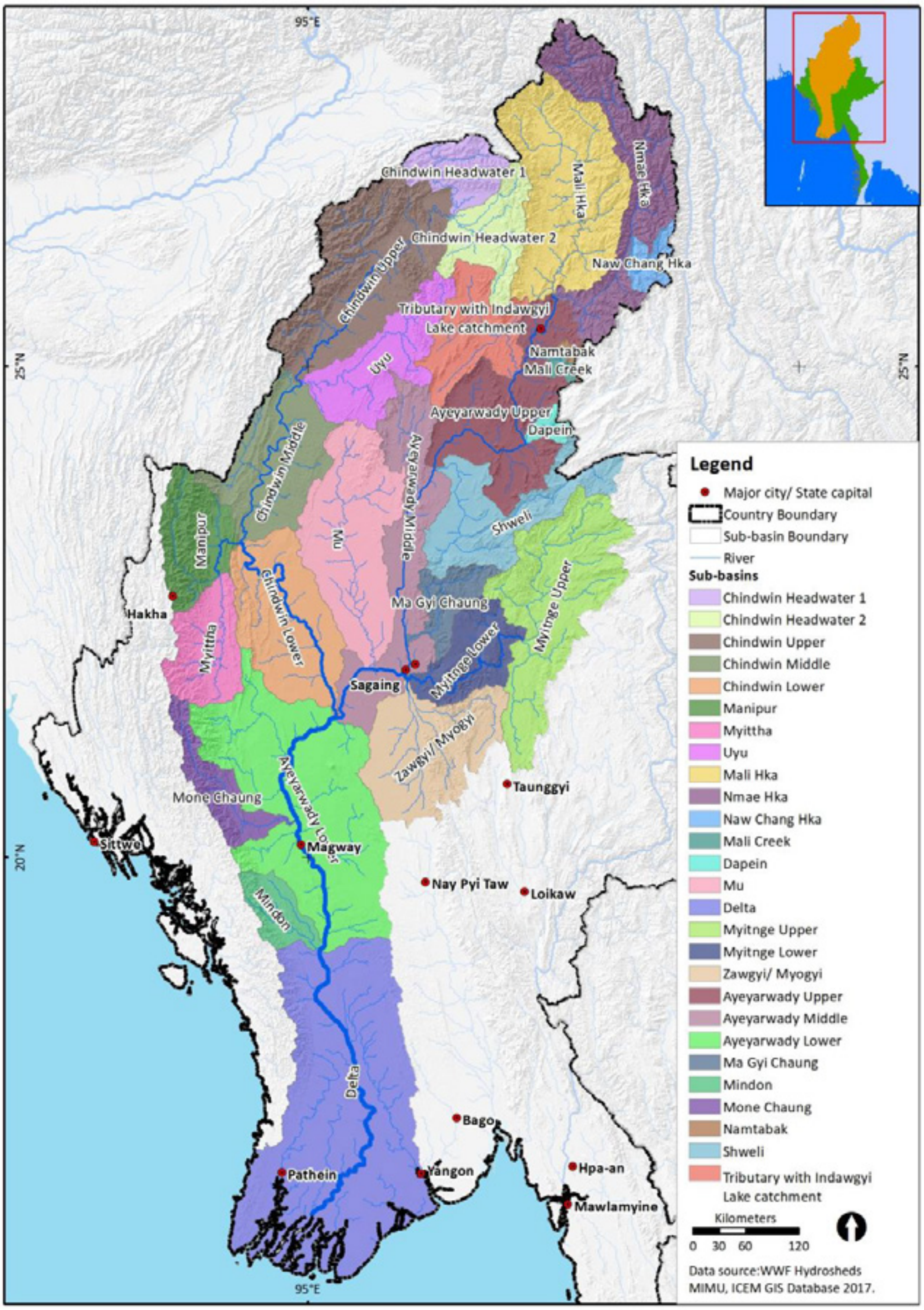
APPENDIX A: MYANMAR SUB-BASINS

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 A 1).

Figure A 1: Sub-Basins of the Ayeyarwady Basin

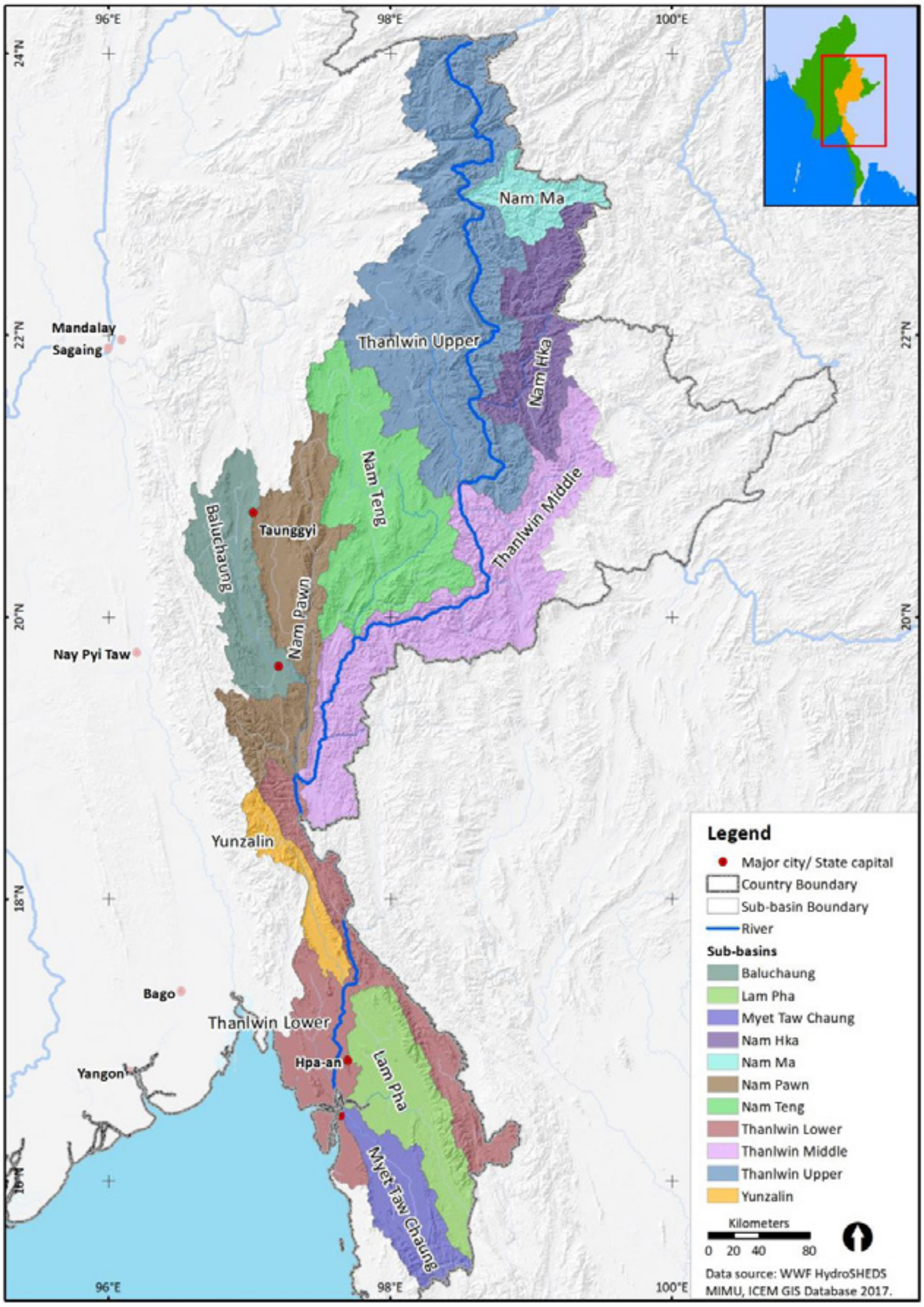


Sub-basin	Area		Population[57]	State/Region
	km²	% of basin		
Ayeyarwady Lower	37,114	13.5	3,563,016	Bago, Chin, Magway, Mandalay, Nay Pyi Taw, Rakhine, Sagaing
Ayeyarwady Middle	17,940	6.5	3,344,726	Kachin, Magway, Mandalay, Sagaing, Shan
Ayeyarwady Upper	17,939	6.5	894,488	Kachin, Sagaing, Shan
Chindwin 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
Dapein	1,235	0.5	62,914	Kachin
Delta	53,084	19.3	11,815,891	Ayeyarwady, Bago, Magway, Rakhine
Chaung Ma Gyi	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
Manipur	8,972	9.2	516,151	Chin, Sagaing
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
Myittha	8,644	8.9	230,513	Chin, Magway, Sagaing
Nam Tampak	718	0.3	N/A	Kachin
Nawchankha	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
Uyu	11,440	11.8	370,874	Kachin, Sagaing
Zawgyi/Myogyi	16,327	5.9	2,099,186	Magway, Mandalay, Sagaing
TOTAL	**372,905**	**100**	**27,645,115**	

[57] Census, 2014.

2. Thanlwin Basin

Figure A 2: Sub-Basins of the Thanlwin Basin

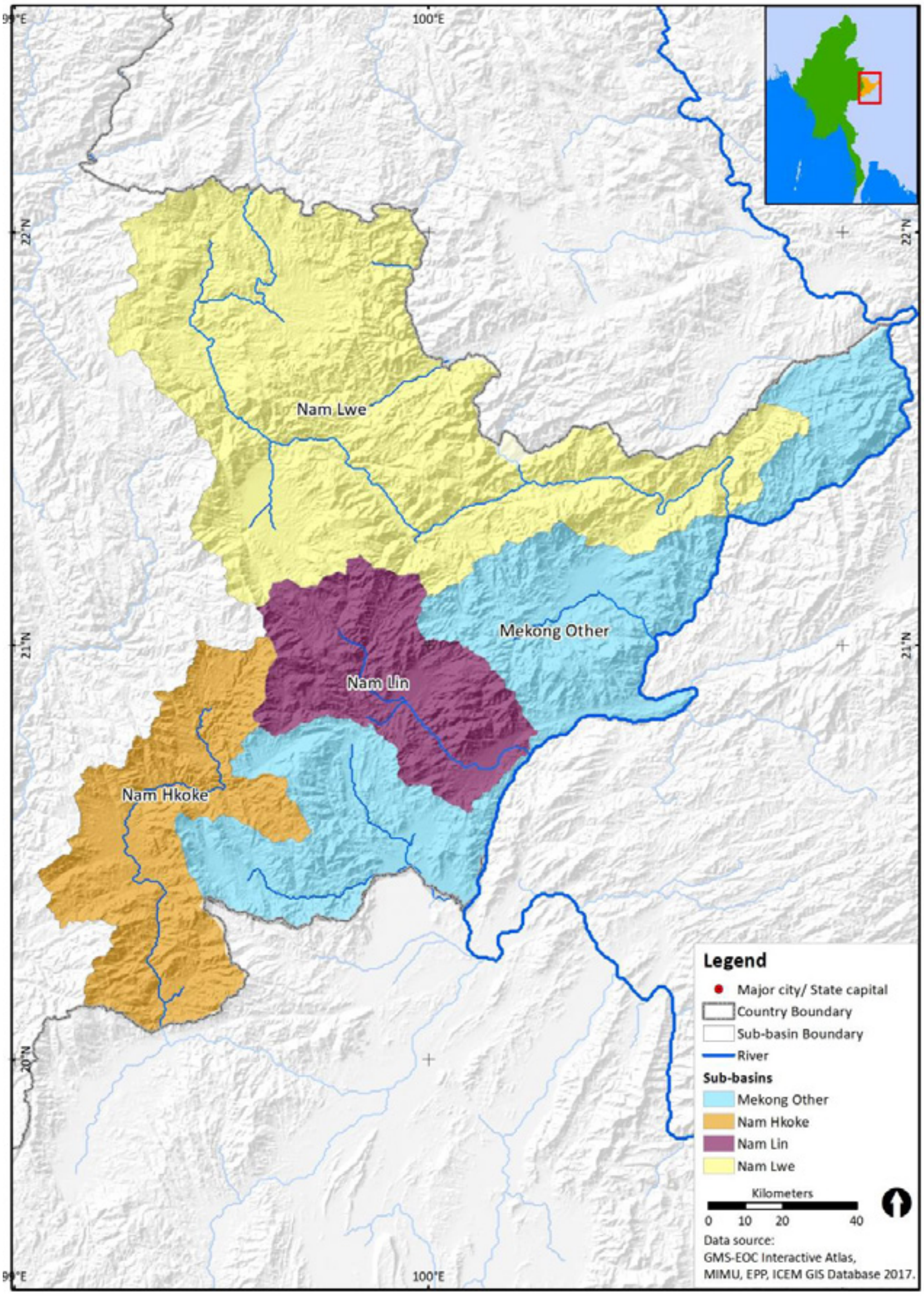


Sub-basin	Area		Population	State/Region
	km²	% of basin		
Baluchaung	7,837	6.1%	892,747	Kayah, Mandalay, Shan
Lam Pha	8,910	7.0%	486,225	Kayin, Mon
Myet Taw Chaung	5,665	4.4%	450,659	Kayin, Mon
Nam Hka	8,074	6.3%	19,732	Shan

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

3. Mekong Basin

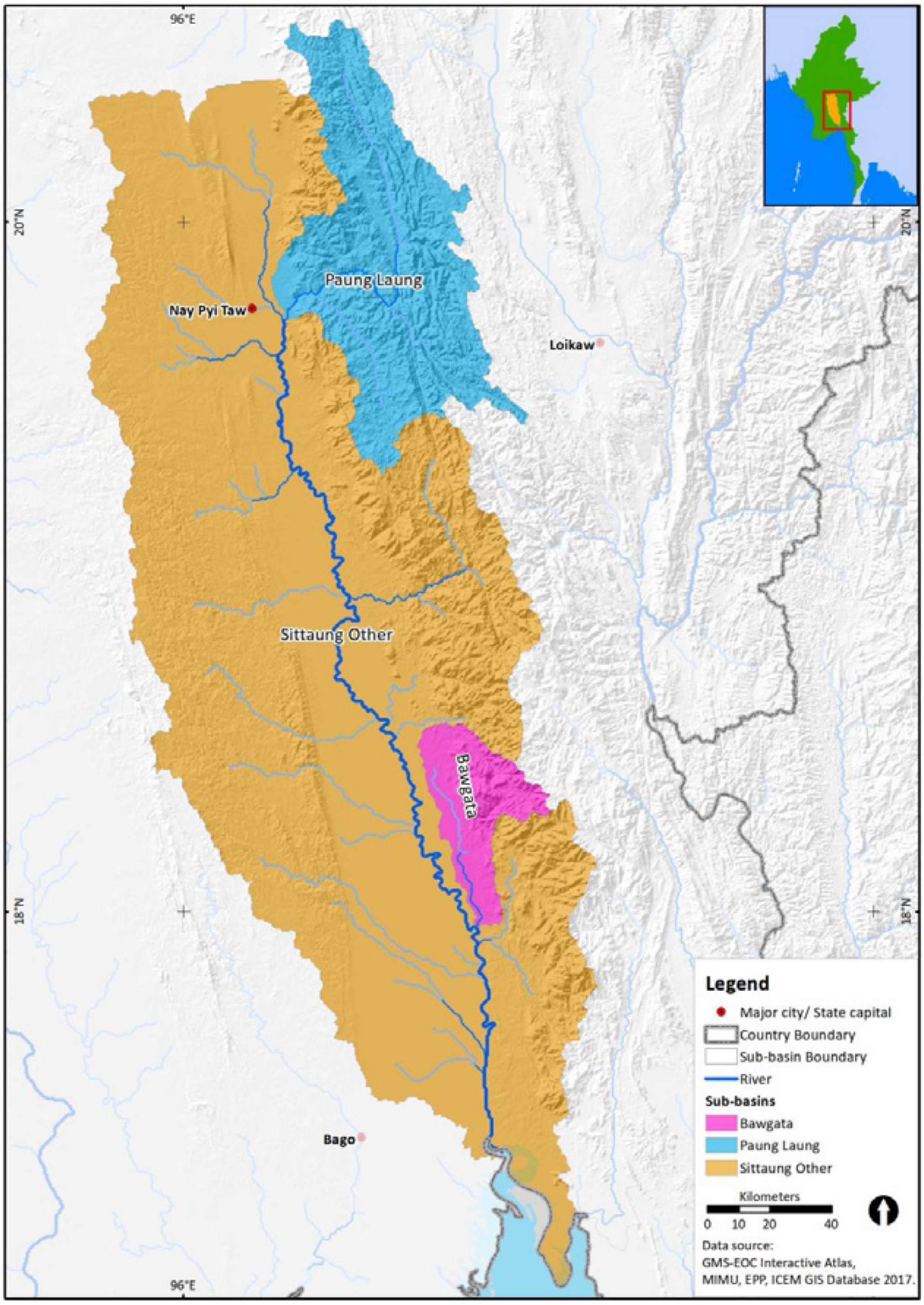
Figure A 3: Sub-Basins of the Mekong Basin



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

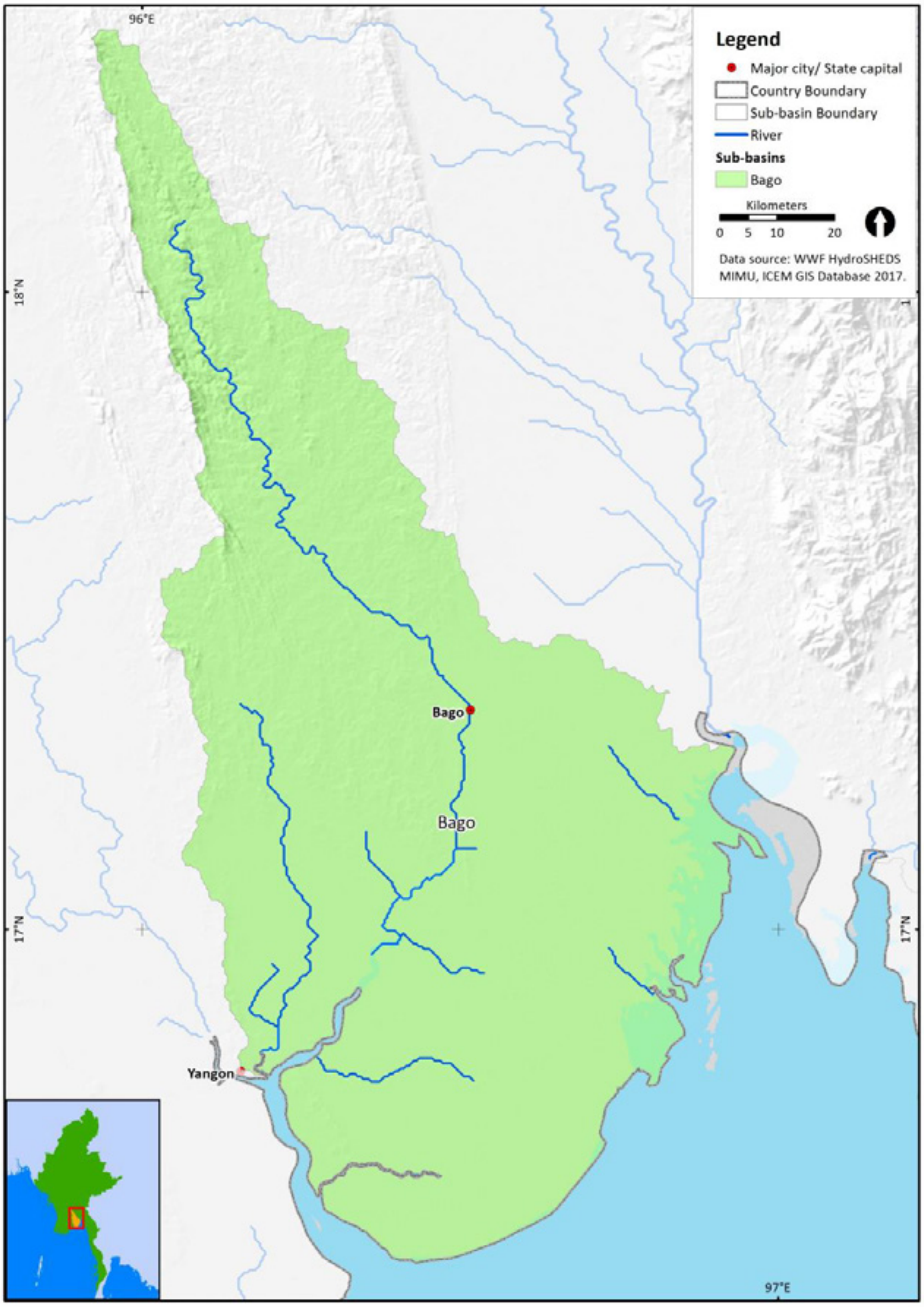
Figure A 4: Sub-Basins of the Sittaung Basin



Sub-basin	Area		Population	State/Region
	km²	% of basin		
Bawgata	1,229	3.5	892,747	Bago, Kayin
Paunglaung	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

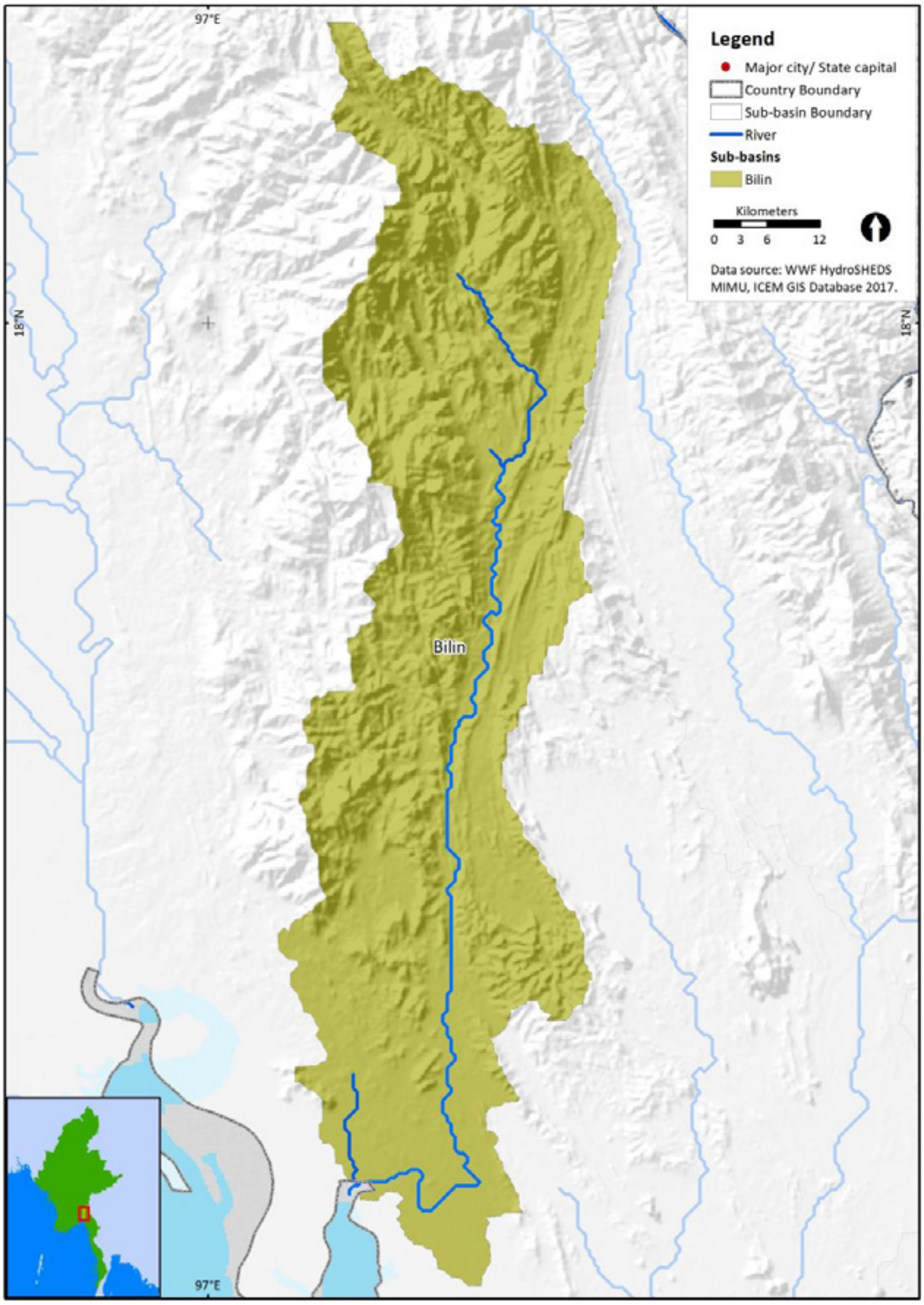
Figure A 5: Bago Basin



Sub-basin	Area		Population	State/Region
	km²	% of basin		
Bago	10,261	100	4,610,213	Bago, Yangon

6. Bilin Basin

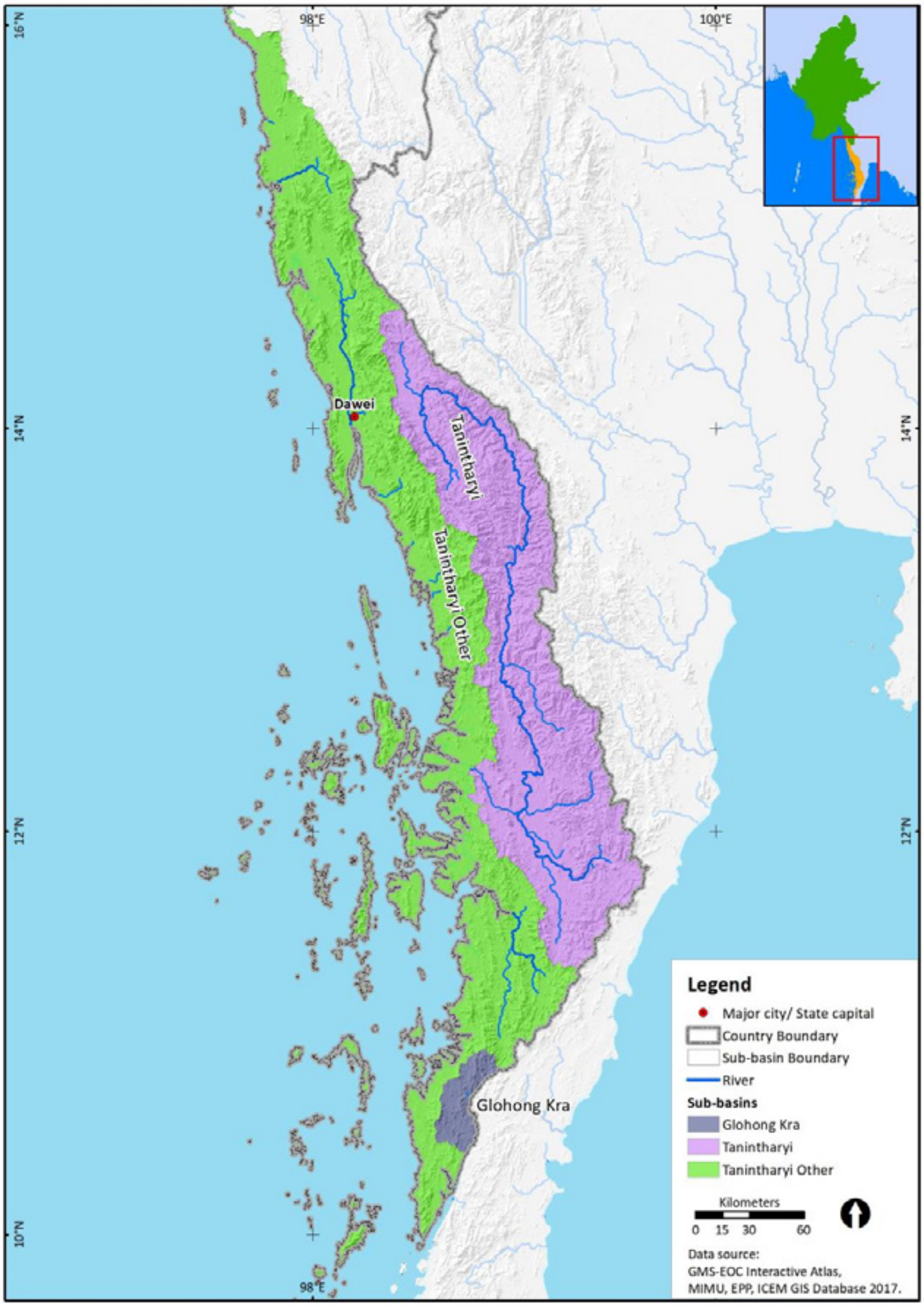
Figure A 6: Bilin Basin



Sub-basin	Area		Population	State/Region
	km²	% of basin		
Bilin	3,056	100	216,160	Bago, Kayin, Mon

7. Tanintharyi Basin

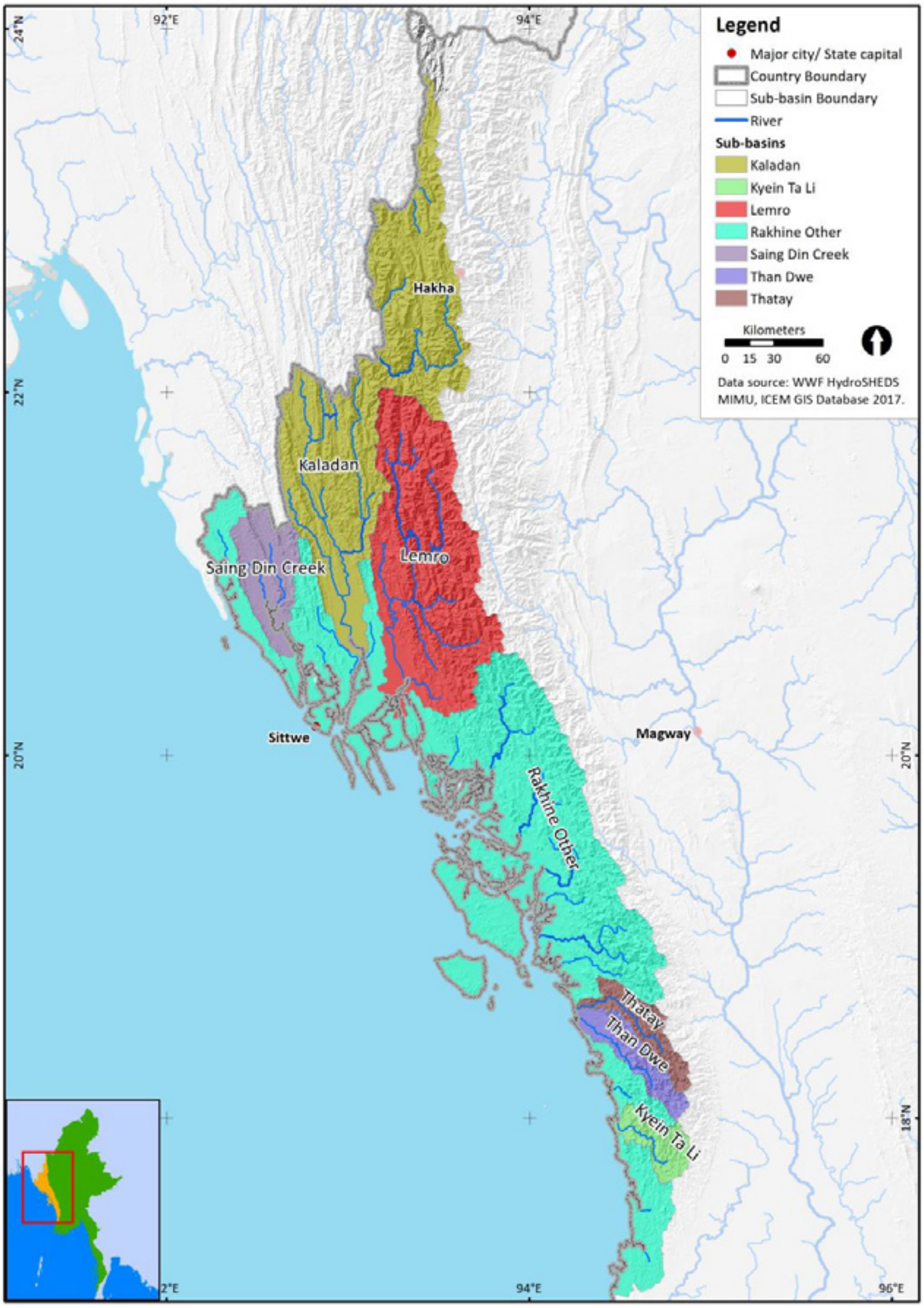
Figure A 7: Sub-Basins of the Tanintharyi Basin



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 A 8: Sub-Basins of the Rakhine Basin



Sub-basin	Area		Population	State/Region
	km²	% 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**	

APPENDIX B: OPERATIONAL AND UNDER CONSTRUCTION HYDROPOWER PROJECTS

Sub-basin	Project	Installed Capacity (MW)	Type (storage / run-of-river)	Dam Height (m)	Reservoir Area (km^2)	Reservoir Length (km)
Ayeyarwady Basin						
Dapein	Dapein 1	240	RoR	46	0.35	0.4
Chaung Ma Gyi	Sedawgyi+	25	S	57	41	16
Mali Creek	Mali	11	RoR	NA	NA	NA
Mone Chaung	Buywa+*	42	NA	46	38	NA
	Kyee Ohn Kyee Wa+	74	S	50	33	30
	Mone Chaung+	75	S	61	42	19
Mu	Thapanzeik+	30	S	33	397	43
Myitnge Lower	Yeywa	790	S	132	59	75
	Upper Yeywa*	280	S	97	27	54
Myittha	Myittha+	40	S	63	12	NA
N'mai Hka	Chipwi Nge	99	RoR	48	0.07	0
Shweli	Shweli 1	600	NA	47	1.3	11
	Shweli 3*	1,050	S	150	43	65
Zawgyi/Myogyi	Kinda+	56	S	72	29	15
	Myogyi+	30	S	79	10	11
	Zawgyi I	18	RoR	NA	NA	NA
	Zawgyi II+	12	S	44	39	8
Thanlwin Basin						
Baluchaung	Baluchaung 1	28	RoR	11	0	0.2
	Baluchaung 2	168	RoR	NA	NA	NA
	Baluchaung 3	52	RoR	NA	NA	NA
	Upper Baluchaung*	30	NA	35	10	NA
Nam Teng	Keng Tawng	54	S	27	0.1	1
	Upper Keng Tawng *	51	S	56	23	NA
Mekong Basin						
Nam Lwe	Mongwa	66	RoR	51	8	31
Sittaung Basin						
Paunglaung	Nancho	40	RoR	72	0.3	3
	Paunglaung Lower+	280	S	131	17	16
	Upper Paunglaung	140	S	98	61	50
Sittaung Other	Kabaung	30	S	61	150	16
	Kun Chaung	60	S	73	150	23
	Phyu Chaung	40	S	75	24	27
	Shwegyin	75	S	57	58	35
	Thauk Ye Khat 2	120	S	94	14	22
	Yenwe+	25	RoR	77	77	36
Bago Basin						
Bago	Zaungtu	20	S	45	15	19

Sub-basin	Project	Installed Capacity (MW)	Type (storage / run-of-river)	Dam Height (m)	Reservoir Area (km²)	Reservoir Length (km)
Rakhine Basin	1					
Thahtay	Thahtay*	111	NA	91	NA	32
Total		**4,862**				

** - under construction.*
+ - multipurpose project.
NA – not available.

APPENDIX C: SUB-BASIN RATING METHODOLOGY

1. Geomorphology and Sediment Transport

Geomorphology was evaluated to describe the large-scale characteristics of sub-basins that contribute to the geomorphic functioning of river systems at a sub-basin and basin level. It is based on a high-level approach, recognising that river geomorphology is largely controlled by water and sediment inputs. For each sub-basin, three large-scale parameters were assessed: 1) Connectivity, 2) Sediment production potential, and 3) Flow input, as summarised in C.1. A score between 1 and 5 was assigned to each indicator for each sub-basin. The final sub-basin 'rating' is the sum of the three indicators. For each indicator, '5' denotes the highest 20% of the basins with respect to sensitivity to change or value, indicating that the sub-basin is functioning at or close to its natural state, with '1' assigned to the lowest 20% of the sub-basins. A low value is generally due to a sub-basin already being modified with respect to the parameter.

Table C 1: Summary of geomorphology and sediment transport parameters, input information and rationale for inclusion in the analysis

Indicators	Input Parameters	Rationale
1. River connectivity and delta and coastline stability	• Strahler order* • Area of sub-basin • Position of sub-basin with respect to the coast • Size and distribution of existing dams	River systems are maintained by the production and transport of sediment from the headwaters of rivers to the sea. Delta and coastline stability are dependent on the delivery of material from river systems. Dams reduce the connectivity of rivers, prevent the passage of sediment or alter the flow regime of rivers and fundamentally alter geomorphic processes.
2. Potential sediment production	• Distribution of the geomorphic land units identified within sub-basins	Potential sediment production is a measure of how much sediment a sub-basin is likely to generate. It is dependent on geology and slope, and altered by land use changes. Areas that generate coarse grained sand and gravels provide the materials that maintain channel, delta and coastline stability. Areas that generate fine-grained material provide transport for nutrients to flood plains and underpin coastal productivity.
3. Flow input	• Rainfall/run-off • Sub-basin area • Position of sub-basin with respect to the coast	The unregulated flow of water through river systems transports sediment, shapes river channels and establishes the seasonal timing of processes that control ecological functioning (e.g. flood pulse, dry season, floods, etc.).

**See text box 1*

Connectivity scores are based on the highest Strahler Order present in the sub-basin, the sub-basin area and the presence of existing hydropower projects. Sub-basin areas were ranked by percentile to provide a relative difference between sub-basins whilst eliminating the order of magnitude difference that exists between the sub-basin areas. The percentile value was multiplied by the Strahler Order with the product assigned a value of 1 - 5 based on percentile rankings (e.g. 1 - 20th percentile = 1, 21 - 39th percentile = 2, etc.).

This initial scoring was modified based on the presence of existing or under construction hydropower projects within the sub-basins. Sub-basins where projects are currently located had their connectivity scores modified based on the following criteria:

- No modification if <5% of the sub-basin is located upstream of hydropower projects;
- Score reduced by '1' if >5% but <90% of the sub-basin is located upstream of hydropower projects;
- Score reduced by '1' if the connectivity of the sub-basin is reduced due to hydropower projects in a downstream sub-basin (only applied to the Upper Myitnge sub-basin);

- Score reduced by '2' if >90% of the sub-basin is located upstream of hydropower projects.

Totals that resulted in negative values, or zero, were scored as '1'.

Table C 2: Connectivity adjustment factors for sub-basins with existing or under construction HPPs

Sub-Basin	No. of HPPs in sub-basin	Maximum Strahler Order	Approx % catchment upstream HPPs	Connectivity Adjustment Factor
Bago	1	2	10	-1
Balachaung	4	2	>90	-2
Dapein	1	3	>90	-2
Chaung Ma Gyi	1	2	80	-1
Mali Creek	1	1	40	-1
Mone Chaung	3	2	80	-1
Mu	1	3	50	-1
Myittha	1	3	20	-1
Myitnge Lower	2	4	>90	-2
Myitnge Upper	0	3	0	-1*
Nam Lwe	1	3	>90	-2
Nam Teng	2	3	40	0
Nam Hka	1	3	<5	0
Other Sittaung	6	3	30	-1
Paunglaung	3	2	90	-2
Shweli	2	3	>90	-2
Thahtay	1	1	>90	-2
Zawgyi/ Myogyi	4	4	60	-1

** The Myitnge Upper sub-basin does not have any existing hydropower projects, but connectivity is affected by the projects in the Myitnge Lower sub-basin.*

In the Connectivity assessment, the mainstem of the Ayeyarwady, Chindwin and Thanlwin with Strahler Order 4 or greater are excluded from the sub-basin analysis and treated as unique units. Sub-basins containing the mainstem reaches were assigned the highest Strahler Order present in the sub-basin excluding the mainstem. In the two sub-basins in which river reaches have a Strahler Order of 4 (Lower Myitnge and Manipur) but these stretches are not deemed to be mainstem rivers, these reaches are not considered as a special case, and are therefore included in the Connectivity indicator scoring with all other sub-basins.

Potential Sediment Input scores are based on the distribution of geomorphic land units within each sub-basin, determined by the physical attributes of the landscape. Each land class was assigned a weighting based on its estimated relative sediment production potential as summarised in Table C 3. A score was calculated for each sub-basin by multiplying the weighting by the percentage of each geomorphic land class present in the basin. The percentile ranking of these scores was used to assign final scores of 1 to 5. The potential sediment input scores for the Shweli, Dapein and Upper Thanlwin were adjusted by +1 to account for the large catchment areas and high sediment input potential associated with the catchments located outside of the Myanmar national boundaries.

Table C 3: Weightings for determination of sediment production potential.

Geomorphic Class	Sediment Production Potential Weighting
Slopes >10° and hard rock geology	5 - High potential to produce sand and gravel
Slopes >10° and Intermediate hardness geology	4 - Good potential to produce sand and gravel and silt and clay

Geomorphic Class	Sediment Production Potential Weighting
Slope <10° and hard geology	3 - Moderate potential to produce sand and gravel
Slope 3-10° and 'soft' geology	2 - Low potential for sand and gravel, high potential for silts and clays
Slopes <3° and elevation >30 m	1 - Very low input of 'new 'sediment. Areas of re-working
Slope <3° and elevation <30 m	0 - Generally areas of deposition and re-working

The **Flow Input** indicator is based on the water volume input from each sub-basin using the following calculation:

Area of SB x Average Rainfall in SB X Runoff-coefficient = Water Volume Input

The runoff coefficient estimated for each basin / catchment are summarised in Table C 4.

Table C 4: Basin/Catchment Runoff Coefficients

Basin/Catchment	Runoff Coefficient
Upper Ayeyarwady	0.83
Lower Ayeyarwady	0.54
Chindwin	0.73
Thanlwin	0.72
Mekong	0.57
Sittaung	0.80
Bago	0.80
Tanintharyi	0.98
Rakhine	0.77

The resultant water volumes were ranked by percentile similarly to the other indicators (e.g. 1 - 20 percentiles = '1', 21 - 39 percentiles = '2', etc.). In sub-basins containing a mainstem reach, only the inflow from the sub-basin area was considered. The importance of the through-flow of water in the mainstem reaches is recognised and accounted for in the Connectivity score.

The final sub-basin ratings for geomorphology were determined by adding the three indicator scores, and normalising the totals to a range of 1 to 5. Similar to the indicator methods, scores that were <0.5 were assigned a final score of '1'.

2. Aquatic Ecology and Fisheries

Sub-basin evaluation of aquatic ecology and fisheries involved identifying the ecological values of river sub-basins. Multiple GIS layers were combined to calculate the ecological sensitivity of river reaches within each sub-basin.

2.1. Ecologically Sensitive River Reaches

The analysis was based on the WWF Greater Mekong Programme River Reach Classification for the Greater Mekong Region (2014). The basic spatial unit of this classification is 'river reach' - a linear unit that represents a stretch of river located between two consecutive confluences. Lehner and Dallaire's (2014) classification applies a range of hydrological, physio-climatological and geomorphological classifications to river reaches. In addition, a set of geospatial variables linked to ecological sensitivity were applied to the river reaches of the Ayeyarwady and Thanlwin basins to create an overall measure, with reaches classed as having low, medium, high or very high ecological sensitivity.

2.2. Ecological Sensitivity

River reach rarity: the total length of the river reaches within each of Lehner and Dallaire's (2014) combined classes was calculated for each basin. The percentage of the total length of each Simple Hydrological class that each Combined class occupied was then calculated and used to score each reach for rarity. The rarest reaches, with Combined class reaches occurring in 0-5% of their constituent Simple Hydrological class, were given a rarity score of 4, 5-10% were given a score of 3, 10-20% were given a score of 2 and the remainder, 20-71%, were given a score of 1.

Table C 5: Combined classes and total length of river reaches in Myanmar

Combined Class Description	Sum Reach Length (km)	Percentage Simple Hydrological	Rarity Score
Large river, in dry broadleaf forest region, with floodplains	0.6	0.01	4
Medium river, in dry broadleaf forest region, with low gradient	18.74	0.09	4
Large river, in mangrove region	8.50	0.12	4
Large river, in montane region, with low gradient	12.16	0.17	4
Medium river, in montane region, with high gradient	145.32	0.73	4
Large river, in moist broadleaf forest region at high elevation, with low gradient	56.07	0.78	4
Medium river, in mangrove region	185.76	0.93	4
Medium river, in moist broadleaf forest region at low elevation, with high gradient	245.39	1.23	4
Large river, in dry broadleaf forest region, with floodplains and sediment	108.99	1.52	4
Medium river, in moist broadleaf forest region at high elevation, with high gradient	325.86	1.64	4
Medium river, in karst within montane region	347.02	1.74	4
Medium river, in moist broadleaf forest region at high elevation, with floodplains	363.43	1.83	4
Medium river, in coniferous region, with high gradient	422.47	2.12	4
Large river, in moist broadleaf forest region at high elevation, with floodplains	169.94	2.37	4
Main stem, meandering channel with alluvium	112.68	2.39	4
Medium river, in dry broadleaf forest region, with floodplains	493.92	2.48	4
Large river, in moist broadleaf forest region at low elevation, with floodplains and sediment	204.91	2.86	4
Large river, in karst region at high elevation	206.21	2.88	4
Large river, in karst within montane region	251.70	3.51	4
Large river, in moist broadleaf forest region at high elevation, with sediment	353.20	4.93	4
Medium river, in coniferous region, with low gradient	1,172.14	5.89	3
Medium river, in montane region, with low gradient	1,239.07	6.23	3
Large river, in large delta region	448.08	6.25	3
Medium river, in large delta region	1,284.07	6.45	3
Main stem, large delta	304.58	6.47	3
Medium river, in moist broadleaf forest region at high elevation, with low gradient	1,305.72	6.56	3
Large river, in moist broadleaf forest region at low elevation, with low gradient	506.75	7.07	3
Medium river, in karst region at high elevation	1,436.37	7.22	3
Large river, in moist broadleaf forest region at low elevation, with sediment	634.06	8.85	3
Large river, in coniferous region, with low gradient	1,033.71	14.42	2
Medium river, in karst region at low elevation	2,980.58	14.98	2
Medium river, in moist broadleaf forest region at low elevation, with floodplains	3,215.01	16.16	2
Main stem, anastomose channel	959.36	20.38	1
Large river, in moist broadleaf forest region at low elevation, with floodplains	1,585.62	22.12	1
Large river, in karst region at low elevation	1,587.79	22.15	1
Medium river, in moist broadleaf forest region at low elevation, with low gradient	4,719.35	23.72	1
Main stem, rock cut river channel	3,330.83	70.76	1

Source: Lehner & Dallaire, 2014

Endemic areas: Polygons delineating the presence of Endemic species were delineated based upon the literature, e.g. (Allen, 2010) and from consultation with organisations such as FFI and WCS. River Reaches intersecting these areas were given a score of 3.

Key Biodiversity Areas, Ramsar sites and important wetland areas: polygons delineating KBAs were obtained from the World Database of Key Biodiversity Areas. Additional KBAs were identified during a workshop held in June 2017, as an important activity of the SEA. These areas were further classified as Terrestrial only, terrestrial or river, aquatic birds, or fully riverine wetland by expert review. Areas that were recognized as globally important, e.g. as Ramsar sites, World Heritage sites or on the 2004 Wetland Inventory were given the highest scores. River Reaches intersecting these areas were given the following scores outlined in Table C 6.

Table C 6: Scores for KBA classification

KBA classification	Score
Recognised as Globally important	**5**
Fully Riverine Wetland	4
Aquatic Birds	3
Terrestrial on River	2
Terrestrial Only	1

Confluences, recognized as areas of mixing water and migration routes, often have important habitat features. River confluence points were identified by reviewing the reach classification dataset. Buffer zones of varying sizes were applied to each point to create an expert defined area of influence, with river reaches intersecting these areas of influence given the scores set out in Table C 7.

Table C 7: Scores for confluence type and buffer size (km)

Confluence Type	Buffer Size	Score
Large River Confluence with Large River	10 km	2
Large River Confluence with Main Stem	20 km	3

Karst geology: river reaches classified as flowing through Karst landscapes by Lehner and Dallaire 2014 were given a score of 3.

Presence of threatened fish and other aquatic organisms: the predicted presence of Critically Endangered, Endangered and Vulnerable species of fish and other aquatic organisms in each sub-basin was taken from the IBAT/Red List Freshwater assessment. River reaches within those sub-basins were scored as outlined in Table C 8.

Table C 8: Scores for presence of threatened fish and other aquatic organisms

Reach intersects with a basin polygon with where the presence of Red List fish species has been indicated	Vulnerable Fish	Endangered Fish	Critically Endangered Fish
Score	3	4	5
Reach intersects with a basin polygon with where the presence of Red List species (not fish) has been indicated	Vulnerable Aquatic Sp. (not fish)	Endangered Aquatic Sp. (not fish)	Critically Endangered Aquatic Sp. (not fish)
Score	3	4	5

Ecological Sensitivity score: a combined score was calculated for each river reach, with the range being between +1 and +23:

- reaches with a score of less than or equal to 4 were classified as Low sensitivity;
- reaches with a score between +4 and +9 were classified as Medium sensitivity;
- reaches with a score between +9 and +13 were classified as High sensitivity; and

- reaches with a score greater than +13 were classified as Very High sensitivity.

Ecological rating: the ecological sensitivities of each river reach within a sub-basin were then combined to calculate an ecological value for each sub-basin. The combination was done by weighting the lengths of each river reach with its ecological sensitivity score, and dividing by the total length of river reaches in that sub-basin. These values were then normalized on a scale of 1 - 5, where 1 is a basin with very low ecological value and 5 is a basin with very high ecological value.

3. Terrestrial Biodiversity

The sub-basin evaluation of terrestrial biodiversity used four main criteria to identify areas of biodiversity value: key biodiversity areas; protected areas; intact forest; and ecoregions.

Key biodiversity areas: a new tool for identifying areas of remaining important biodiversity is the Key Biodiversity Area (KBA) designation. Key Biodiversity Areas are sites of global significance with clearly defined boundaries - they are sites that contribute to the global persistence of biodiversity, including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems. KBAs are nationally identified using globally standardized criteria and thresholds, and represent the most important sites for biodiversity conservation worldwide.

Sites qualify as global KBAs if they meet one or more of 11 criteria, clustered into five categories: threatened biodiversity; geographically restricted biodiversity; ecological integrity; biological processes; and, irreplaceability. They are an 'umbrella' designation, usually covering existing protected areas, Important Bird Areas, Important Plant Areas and Important Sites for Freshwater Biodiversity.

A preliminary KBA listing for Myanmar was considered at January 2012 stakeholder workshop convened by the Wildlife Conservation Society (WCS) leading to the definition of 132 KBAs. In July 2017, to update that initial KBA database, the SEA convened a second two day working session of government agencies, international conservation organisations, local NGOs, private sector and academia. The KBA boundaries were defined based on field research, GIS analysis and expert knowledge and participatory mapping. Based on that expert gathering, KBAs now cover close to 41% of the country including 182 sites, with boundaries to be adjusted and refined as greater effort is invested in biodiversity surveys and as collective expert knowledge and experience is applied. It is that updated KBA database which is used in this assessment of biodiversity values.

Protected areas: the national protected areas system covers almost 6% of the country, including national parks, wildlife reserves and sanctuaries, forest parks and nature reserves. PA boundaries are officially defined under national legislation. While some KBAs and PAs overlap, the KBA network is more extensive, comprehensive, and representative of remaining biodiversity values in Myanmar. While PA establishment in Myanmar has not been a systematic process, they were included in sub-basin evaluation because their establishment over the past ten years has been shaped by biodiversity conservation priorities.

Intact forest: this proxy for biodiversity was used because intact forests provide greater species biodiversity, productivity of goods, variety and integrity of services and connectivity attributes and processes than degraded forest. Intact forest is an unbroken expanse of natural ecosystems, showing no signs of significant human activity and large enough that all native biodiversity, including viable populations of wide-ranging species, could be maintained.

Two sources of data were used in analysing forests: the Myanmar Forest Cover Change (2002-2014) report; and Hansen et al. (2013). Data from the Myanmar Forest Cover Change study were used to create forest cover maps of intact forest (greater than 80% canopy cover), degraded forest (between 10% and 80% canopy cover), and plantation and non-forest (less than 10% canopy cover), as well as graphs and tables of intact forest, degraded forest, degraded regions and changed forest cover.

Plots of annual cumulative loss of forest by basin, where forest loss was determined for open and medium-closed canopy cover, and intact forest, were derived from Hansen et al. (2013). The canopy cover metrics adopted for these plots were based on those from the Myanmar Global Forest Resources Assessment 2015, and Myanmar Forest Cover Change (2002-2014) study. The term 'open forest' refers to forest with greater than 10% and less than or equal to 40% canopy cover; 'medium-closed forest' has a canopy cover of more than 40% and less than or equal to 80%; and 'intact forest' has greater than 80% canopy cover.

Ecoregions: Myanmar is represented by 14 ecoregions which describe the original assemblage of plants, animals, climate and geomorphological characteristics in the country. Each ecoregion contains a geographically distinct mix of species, natural communities, and environmental conditions. Ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. They are identified by analyzing the patterns and composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity, including geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology. When combined with one or more of the other parameters, ecoregions are an important source of information on the relative value of biodiversity found in KBAs, PAs and intact forest.

3.1. Biodiversity sub-basin evaluation

As overarching proxies for biodiversity, KBAs and intact forest were combined to make up a biodiversity index which identified areas of value within each river basin and ranked river sub-basins from very low to very high value. PAs and ecoregions were then applied to ensure important areas were not overlooked in the index - either due to their relatively small area or because their values have not been recognised.

KBAs and intact forests were overlaid on river basins and total % coverage of each parameter calculated. That index gives a measure of current biodiversity status. Biodiversity index ratings were then calculated for the 58 sub-basins as follows:

- % KBAs (1 to 5 score)
- % intact forest (1 to 5 score)
- Add scores and average
- Results in a rating from very low (1) to very high (5) (i.e. five sub-basin categories)

The 1 to 5 scores were given based on equally distributed percentiles - each score representing 20 percent of the total range. The percentile ranges were defined by the highest value among each sub-basin, which was 99% for KBAs and 85% intact forest.

Finally, critically endangered ecoregions and PAs were mapped to identify sub-basins or small pockets of biodiversity of global importance which were not captured in the KBA and intact forest index.

4. Social and Livelihoods

Three indicators were selected to evaluate social and livelihood issues:

1. ***Social vulnerability = % of female headed households (Census 2014).***

   Female-headed households are assumed to be more vulnerable to social change as the often have only one head of family and fewer income earners than male headed households which often have at least two.

2. ***Dependence on natural resources (NR) = the mean % of 'Own Account Workers as % of work force' in Townships within sub-basins (Census 2014).***

The category includes independent, self-employed people (farmers, fishers, handicrafts etc.), which are assumed to be more vulnerable to potential hydropower impacts such as relocation and changes in land and water access.

3. Poverty = % of households that own a television (Census 2014)

This indicator for general poverty level was selected after a number of regression analysis runs on the only available rural poverty data, from 2010. The data are by State/Region/Division and were placed as the independent variable while Census 2014 data on Township percentages of households having various house materials, drinking water source, ownership to various assets were placed as dependent variables. None of the tested Census 2014 variables had a significant statistical correlation with the poverty data from 2010 (at PValue < 0.005). Percentage of households owning a TV was the only indicator which had a significant correlation to the 2010 poverty data, and is therefore selected as the poverty indicator.

The index has been constructed by allocating Townships to sub-basins based on Township area centroids (their mid-point), thereby transforming polygons to points so that Townships and sub-basin boundaries would not overlap. Vulnerability scores were then calculated by:

1. Census 2014 percentages of households with various characteristics by Township were averaged by sub-basin.
2. The 10% percentiles of the average percentages were calculated and given a score from 1 to 10, 1 being the lowest score in terms of social vulnerability.
3. The scores from the three indicators were added and the 20% percentiles for these values were calculated. Each percentile was given a score between 1 to 5. This is the total social vulnerability score presented here.

5. Conflict and Peace

Conflict evaluation assessed the presence and likelihood of conflict by sub-basin. Armed conflict is a constraint to hydropower development, and, in instances where the precursors of armed conflict are present, hydropower development can potentially exacerbate conflict. The key issues that the evaluation sought to assess were: (i) political disputes over governance and territory; (ii) issues related to equality and human rights; and (ii) patterns of violence associated with contested territory. Each issue had one or two indicators in the analysis. Data for each indicator was normalised from its raw form and scaled 1-5. Indicators were combined to produce vulnerability ratings that scale from very low (light green) to very high (dark green).

Table C 9: Conflict indicators

Indicator	Methodology	Results
Criteria 1. Presence and status of armed groups (disagreement over governance and territory)	Data is sourced from the Asia Foundation. The presence of armed groups in sub-basins is scaled from 1-5: 1: no armed group presence or armed group with constitutional territory (accommodated claims) 3: tolerated claims (ceasefires), 5: hostile claims to territory (conflict). These ratings were averaged when there was a range in armed group presence within a sub-basin.	The presence and status of armed groups is intrinsically linked to historical and contemporary disputes over governance and territory, and poses differing conflict risks depending upon the nature (or absence) of political agreements between armed groups and the state.
2. Historical population displacement (proxy indicator for equality and rights issues)	Data and scaling is sourced and adapted from the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). A five point scale for historical population:	Historical population displacement (due in the vast majority of cases to displacement) is a proxy measure for a variety of equality and rights issues that can complicate hydropower development and act as a conflict driver (e.g. land tenure issues,

Indicator	Methodology	Results
0.5 weighting	1: 0-29 2: 30-499 3: 500-1999 4: 2000-10,000 5: 10,000 +	relatively limited access to services/weaker social contract, relatively high human rights abuses). Populations displaced by conflict are significantly more likely to have experienced human rights abuses.
3.a. Conflict incidents 2012-2016 (patterns of violence associated with contested territory)	Data is sourced from Myanmar Peace Monitor (www.mmpeacemonitor.org). A logarithmic scale is used based on the average number of conflict incidents per year per sub-basin. The accuracy of this scale has been compared against the HIIK 2012-2016 global conflict barometer results. 1: 0 conflict incidents 2: 1 conflict incident 3: 2-3 conflict incidents 4: 4-9 conflict incidents 5: 10+ conflict incidents	Armed conflict sub-basins poses a challenge to hydropower development and is associated with the potential the projects could be delayed or prevented together. Armed conflict is a significant risk – a potential show stopover – and might need to be considered differently than vulnerability ratings of other themes. Hydropower development also has the risk to initiate or exacerbate conflict in areas where territories are contested, as under the first indicator.
3.b. Estimated battle deaths 1989-2015 (patterns of violence associated with contested territory) *0.5 weighting*	Data is sourced from the Uppsala Conflict Data Program, which estimates battlefield deaths based on media, academic and civil society reporting. Scale 1-5 Normalised to HIIK conflict intensity rating (country/year) 25> 25-49 50-199 200-499 500+	Historical conflict data is included as well as more contemporary conflict data to make conclusions more robust/based on more sources. But more importantly, the use of historical conflict data is used because even in areas that are currently peaceful, the potential for violence remains as Myanmar has yet to reach sustainable political agreements to end its armed insurgencies. As has been seen multiple times in the country's history, peaceful areas under ceasefires can become violent again when ceasefires break down, which would have significant implications for hydropower development in those areas. Also, hydropower development in peaceful areas under ceasefires, if mismanaged, can be damaging for the political process intended to move beyond ceasefires to more permanent political agreements and solutions.

APPENDIX D: SUB-BASIN EVALUATION RATINGS – SOCIAL/LIVELIHOODS AND CONFLICT

Figure D 1: Social and Livelihoods Sub-Basin Ratings

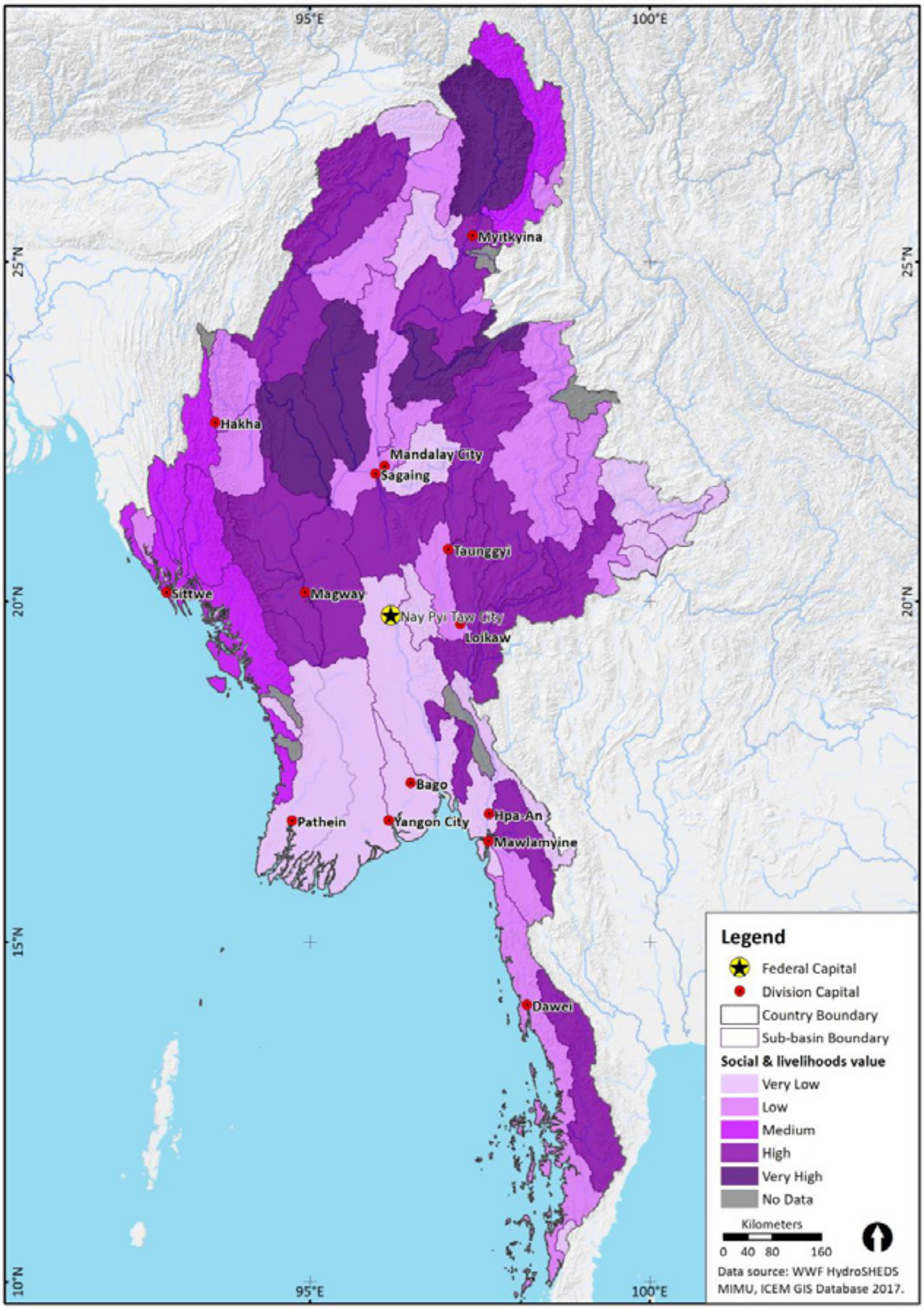


Figure D 2: Conflict Sub-Basin Ratings

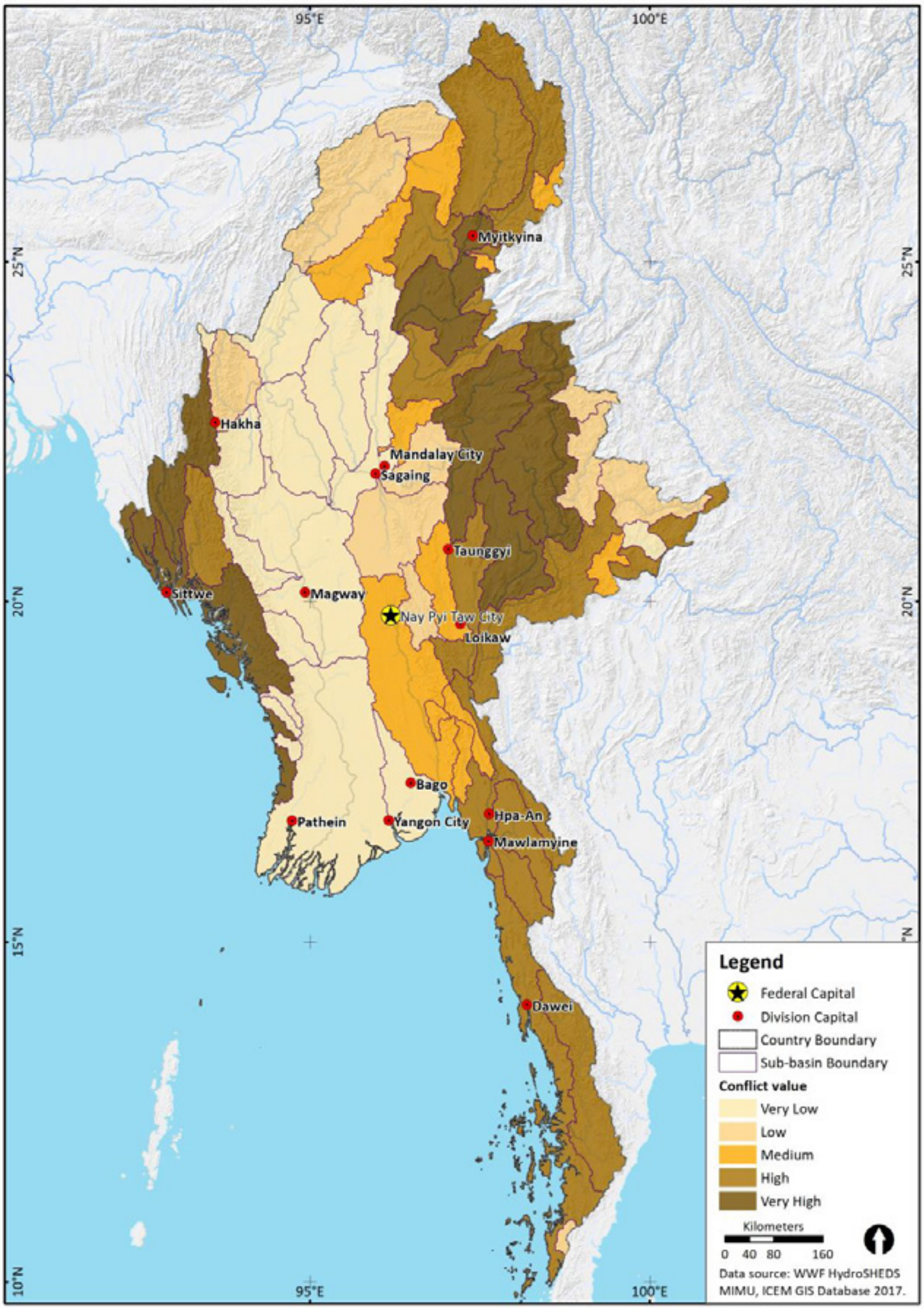


Table D 1: Social/Livelihood and Conflict Sub-Basin Ratings

Basin	Sub-basin	Social and Livelihoods	Conflict
Ayeyarwady	Ayeyarwady Lower	4	1
	Ayeyarwady Middle	2	1
	Ayeyarwady Upper	4	5
	Chindwin Headwater 1	1	2
	Chindwin Headwater 2	2	3
	Chindwin Lower	5	2
	Chindwin Middle	4	1
	Chindwin Upper	4	2
	Dapein	2	4
	Delta	1	1
	Indawgyi Lake tributary	1	4
	Chaung Ma Gyi	2	3
	Mali Creek	NA	3
	Mali Hka	5	4
	Manipur	2	2
	Mindon	4	1
	Mone Chaung	4	1
	Mu	5	1
	Myitnge Lower	1	2
	Myitnge Upper	4	5
	Myittha	2	1
	Namtabak	NA	5
	Nawchankha	2	3
	N'mai Hka	3	4
	Shweli	5	4
	Uyu	2	3
	Zawgyi/ Myogyi	4	2
Thanlwin	Baluchaung	2	3
	Lam Pha	4	4
	Myet Taw Chaung	2	4
	Nam Hka	2	2
	Nam Ma	NA	2
	Nam Pawn	4	4
	Nam Teng	4	4
	Thanlwin Lower	1	4
	Thanlwin Middle	4	4
	Thanlwin Upper	2	5
	Yunsalin	NA	3
Mekong	Nam Hkoke	2	3
	Nam Lin	1	1
	Nam Lwe	1	2
	Mekong Other	1	4
Sittaung	Bawgata	4	3
	Paunglaung	1	2
	Sittaung Other	1	3
Bago	Bago	1	1
Bilin	Bilin	4	3
Tanintharyi	Glohong Kra	1	2
	Tanintharyi	4	4
	Tanintharyi Other	2	4

Basin	Sub-basin	Social and Livelihoods	Conflict
Rakhine	Kaladan	3	5
	Kyein Ta Li	NA	1
	Lemro	3	4
	Rakhine Other	3	5
	Saing Din Creek	2	5
	Than Dwe	1	1
	Thahtay	NA	1
Surma-Meghna	Barak	NA	1

APPENDIX E: PROPOSED AND IDENTIFIED HYDROPOWER PROJECTS IN MYANMAR

Table E 1: High zone - Proposed and Identified Projects

Basin	Sub-Basin	Total MW	Proposed Project		Identified Project	
			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 E 2: Medium Zone - Proposed and Identified Projects

Basin	Sub-Basin	Total MW	Proposed Project		Identified Project	
			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		
	Nawchankha	**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		
	Yunsalin	**100**			Yunsalin	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		**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 E 3: Low Zone - Proposed and Identified Projects

Basin	Sub-Basin	Total MW	Proposed Project		Identified Project	
			Name	MW	Name	MW
Ayeyarwady	Dapein	**140**	Dapein 2	140		
	Chaung Ma Gyi	**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	19
	Myet Taw Chaung	**10**			Myet Taw Chaung	10
	Nam Ma	**225**	Mantong (MoA)	225		
Sittaung	Bawgata	**160**	Bawgata (MoU)	160		
	Paunglaung	**100**	Paunglaung 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		**3,270**		**3,079**		**191**

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).*

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