STATE of KNOWLEDGE

River Health in the Salween

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The Nu-Salawin-Thanlwin River (collectively known as the Salween) is one of the last wild rivers in Southeast Asia and the second longest river in the region, flowing 2,400 km through China, Thailand, and Myanmar. While still mostly undeveloped, the river has very significant potential for hydropower, and governments of all three basin countries are actively promoting development, despite local opposition in many areas. This State of Knowledge paper reviews what is known about river health in the Salween Basin, including both the current state and uses of the river and its catchment, and issues likely to drive change in the near future.

Salween River basics

The Salween Basin covers 283,500 km^2 of which 48% is in China, 7% is in Thailand and 44% is in Myanmar. It is common to refer to it as the Nu (Upper Salween) in China and the Thanlwin (Lower Salween) in Myanmar and Thailand. The Nu (or Nu Jiang) rises on the Tibetan Plateau and flows through a narrow gorge in northern Yunnan, part of the Three Parallel Rivers UNESCO World heritage site, into mountainous areas in southwest Yunnan where agriculture is developed along the river valley. The river falls around 4,000 meters (m) in altitude before leaving China.

In Myanmar, the river is joined by several tributaries, including the Nam Pang and the Nam Pilu/Nam Pawn (which flow from Inle Lake), and the Moei River, which flows north out of Thailand. In Shan State, the Thanlwin mainstream flows through deep gorges that make the river inaccessible in many stretches, and it is not navigable for long and medium range transport. In the Lower Salween Basin in Myanmar and Thailand, more than 60% of land is moderately to very steep, but there are areas of land suitable for agriculture, particularly in South Shan State; along the floodplains of the Thanlwin mainstream in Kayin State and the Moei River in Thailand; and on the coastal plain in Kayah and Mon states. The river enters the sea through a complex of estuarine islands. The Thanlwin and its tributaries (Gyaing and Ataran) are tidal for up to 75 km inland from the river mouth (MYPO, 2007).

People of the Salween Basin

Over 10 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; Gaughan et al, 2013). Population density is highest in Mon State (more than 300 persons per km^2) and western Yunnan (up to 100 persons per km^2), and lowest in Tibet (5 people per km^2) (Figure 1).

Around 6.1 million people, 11% of Myanmar's population, live within the Thanlwin Basin, in Shan State (48%), Kayah (4%), Kayin (22%) and Mon State (26%). The population density averages 49 people per km2, and is highest on the coastal plain in Mon State. The main urban centers are Taunggyi in Shan State (population ~380,000), Loikaw in Kayah (~140,000), Hpa An in Kayin (~120,000) and Mawlamyine in Mon (~440,000), at the mouth of the river.

The population of the Salween Basin is ethnically very diverse. In the Upper Salween the main ethnic groups include Bulang, De'ang (Baoshan), Wa (Licang), Nu, Lisu, Drung, Shan, and Tibetan. In the Lower Salween, the main ethnic groups are Shan, Hmong, Yao, Lahu, Lisu, Kachin, Kokang, Akha, Pa-O, Karenni (Kayah), and Karen (Kayin) (Stimson Center 2011).

The Lower Salween Region has seen significant civil conflict, active war zones and displacement of populations since independence in 1948. Large areas of northern and eastern Shan State remain contested by ethnic armed organisations and the Tatmadaw (the Myanmar Armed Forces), including a diverse range of militias (Buchanan, 2016). Large numbers of people have been displaced by the conflict, both internally

1 - International Water Management Institute
2 - International Centre for Environmental Management
3 - Ecosystem Conservation and Community Development Initiative
4 - Myanmar Institute for Integrated Development

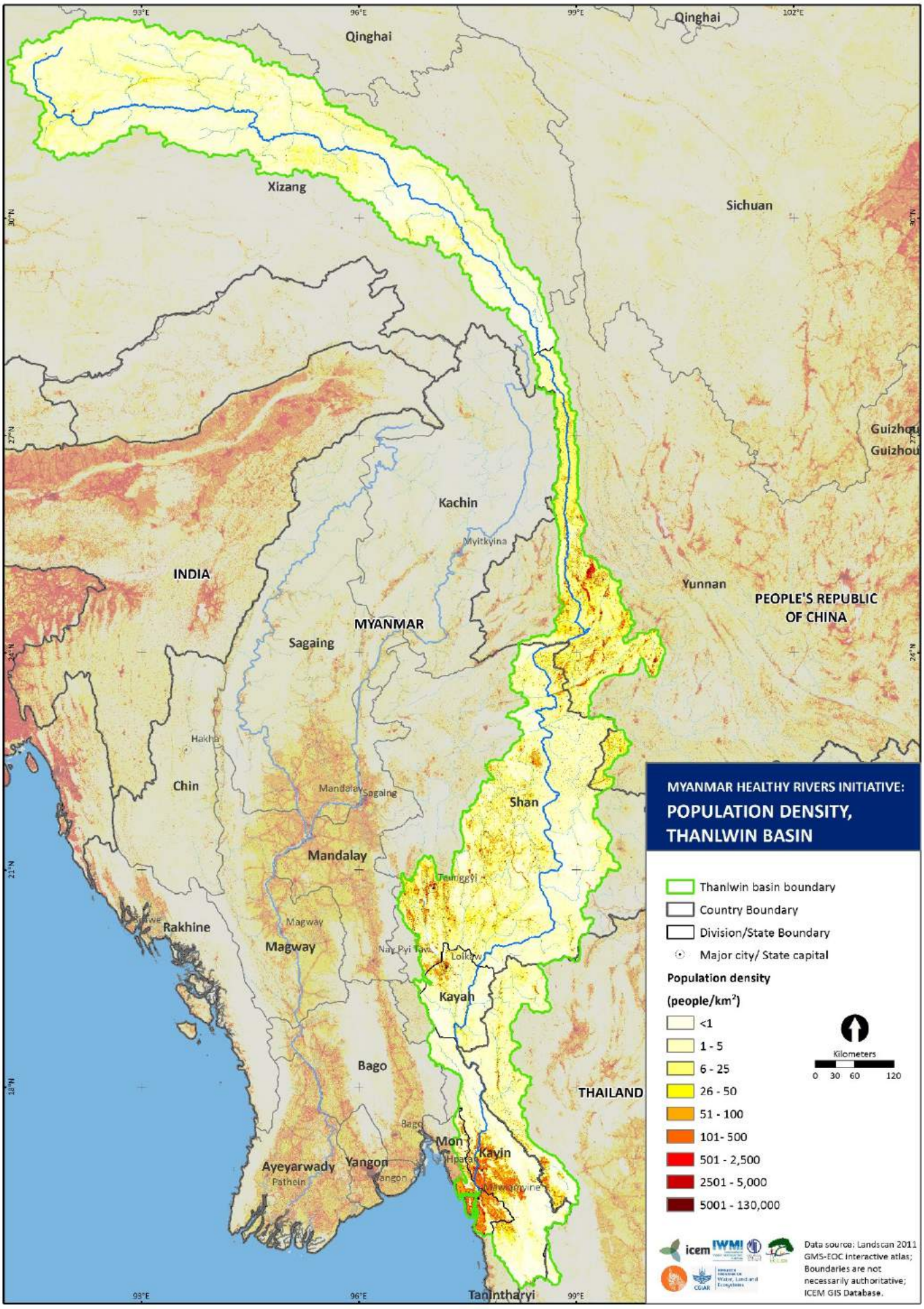

Figure 1: Population density in the Thanlwin Basin.

within Myanmar and across the borders to neighbouring countries. There are over 120,000 refugees in camps in Thailand and more than 30,000 in Yunnan. While some ethnic armed organisations have engaged in a peace process with the Myanmar government, large areas of northern and eastern Shan State remain contested, and the number of Internally Displaced People (IDPs) has recently increased with the resumption of fighting in northern Shan State. There is considerable in-migration and economic involvement of ethnic Chinese, particularly in eastern part of the Shan State adjacent to China. Poverty levels in the remote areas of the basin are high. UNDP estimates that 37 to 46% of the population fall below the poverty line in North and East Shan. Poverty levels in Mon (16%), Kayah (11%) and Kayin (17%) are below the national average of 25% (IHCLA, 2011). A study carried out by USAID/Winrock (2015) in Shan State found that female-headed households more often face barriers to obtaining land titles and are more likely to live in poverty.

Agriculture is the main economic activity, with a wide range of crops in the different eco-climatic zones: principal crops are paddy, maize, wheat, chili, cotton, potatoes, groundnut, sesame, pulses, betel, tea, vegetables, tobacco, rubber (particularly in Mon State) and opium (in Shan and Kayah states). Forestry is also a major industry. Illegal logging, a source of income for both government and ethnic armed groups, has seriously degraded forests in the past 20 years. Tourism is very important economically in the area around Inle Lake, and increasingly for Mawlamyine and Hpa An regions, but government restrictions on tourist movement have limited development in other areas.

Conclusion: *The transboundary basin is home to around 10 million people, many from ethnic minorities. The river contributes directly to livelihoods of many of the basin's inhabitants, through fisheries, riverbank farming, water supply, local navigation and small-scale irrigation, as well as supporting diverse ecosystems and biodiversity. Though the river system receives little attention at the national level in Myanmar, it is critically important for the 6.1 million Myanmar people within the basin. The majority of the Salween communities rely on natural resources and the ecosystems underlying these as the basis of their livelihood activities.*

What are the flow characteristics of the Salween?

Flow in the Salween is highly seasonal, responding to the annual monsoon and snowmelt. Average annual flow is estimated at 53 km^3 at Dao Jie Ba in Yunnan, increasing to 169 km^3 at Hpa An, about 60 km from the mouth. The river is navigable for about 70 km from its mouth in the dry season. Further upstream, it is navigable for small craft in some sections, but rapids impede long-distance travel. Based on modelling studies, Lutz et al. (2014) calculate that in the Nu on the Tibetan Plateau, 8% of flow is from glacial meltwater, 28% from snowmelt, 22% from base flow (water from the ground that seeps slowly into the river channel over time) and 42% from rainfall (with seasonal variations). There are a number of lakes on the Tibetan Plateau around Angqu within the Nu Basin, the largest around 20 km in length. In the lower basin, Inle Lake in Shan State, is the second largest lake in Myanmar. It is approximately 116 km^2 in area, but is shallow with an average depth of around 2 m. Lake Inlay became a UNESCO Biosphere Reserve in 2015.

Dam storage in the Salween system is currently limited, estimated at less than 1% of total mean annual flow. The only large storage in the Thanlwin system in Myanmar is at the Mobye - Datawcha dams on the Balachaung in Kayah (826 million m^3). WLE (2016) list a total of 23 reservoirs[5] in the Nu Basin in Yunnan; of these, three have storage greater than 100 million m^3: Chalong (138 million m^3), Qiezishan (125 million m^3), and Tingminghe (102 million m^3).

Along the Nu in China there are 16 monitoring stations, with varying length, quality and type of record. The most complete and consistent record is from Dao Jie Ba in Yunnan. In Myanmar, the Department of Meteorology and Hydrology (DMH) has one long-term hydrological monitoring station reporting discharge on the Thanlwin, at Hpa An in Kayin State. Average flow over the period 1966 – 2009 is reported as 169 km^3 (ranging from 136 to 207 km^3). Data on water level (but not flow volume) are available at Kunlong, Mawlamyine and Myawady (on the Moei River). Other estimates of annual discharge from the Thanlwin, mainly from modelling studies, range from 94 to 263 km^3 per year (see Johnston et al, 2016).

Conclusion: *The hydrology of the Thanlwin is not well described and estimates of flow vary widely. There is insufficient data to reliably characterize flow regimes in the basin or to detect changes due to development or climate change.*

What is the status of water quality?

The limited information available on water quality in the Salween indicates that quality is generally good, though the impacts of development are beginning to be seen. A study to assess water quality in the Nu in Yunnan in 2013 saw some impacts of pollution in the middle reaches of the Nu (Li et al. 2013), although earlier studies report little evidence of impact from agriculture and other human activities (Huang et al, 2009).

In the Thanlwin, water-quality measurements are reported only for the lower reaches near Hpa An and Mawlamyine. Moderate nutrient (nitrates and phosphates) enrichment was observed in the rainy and cold seasons and some contamination with petroleum hydrocarbons up to 0.29 ppm (US EPA standard is 0.2 ppm). Dissolved oxygen (DO) and Biological Oxygen Demand (BOD) show seasonal variation, but within US EPA standards (Win Aung 2014).

The Thanlwin carries very high sediment loads in its lower reaches and ranks in the top five rivers in the world for delivery of particulate organic carbon to the ocean. Sediment loads are strongly correlated with seasonal discharge, and

5 - WLE (2017) lists only reservoirs with an area greater than 0.5 km^2.

around 92% of annual load is estimated to come during the wet season from June to November (Bird et al, 2008).

Conclusion: *The limited information available on water quality in the Salween indicates that quality is generally good, though the impacts of development are beginning to be seen. There are claims that deforestation and erosion have led to large increases in sediment in the river in recent years, but without baseline data this is difficult to substantiate.*

How important are fisheries in the Salween?

Inland fisheries are known to be an important source of nutrition in Myanmar generally, but there is little information available on the patterns of consumption, interregional differences, and availability and types of fish consumed. The extent of inland fisheries and aquaculture in the Thanlwin system is not clear. Studies at Kunlon in Shan State (Lunn and Shein, 2013) and Khoe Kay in Kayin (KESAN, 2008) identified 54 and 32 fish species respectively, and local communities along the river rely on fishing for both food and income. There is a significant fishery in the Inle Lake system, where 49 species have been reported (Kano et al, 2016)

Fishing is an important source of livelihoods for communities in the Thanlwin river mouth and floodplain in Mon State (MYPO, 2007). Many species migrate between the river and the sea, and the area supports a major commercial fishery around Mawlamyine, including prawn and shrimp fisheries (Aung and Soe 2013).

Conclusion: *The Thanlwin supports both local and commercial fisheries, but there is limited information available on the volume, species and value of fish catch, or on trends in availability.*

What is the status of biodiversity in the basin?

The Salween Basin stretches across 17° of latitude, 5,500 m of elevation, climate zones from tropical monsoonal to tundra, and five major ecoregions (Olson and Dinerstein, 2002). Altogether there are 11,500 km^2 of protected areas in the basin; 836 km2 in Myanmar (Inle Lake, Kahilu and Taunggyi), around 2,000 km^2 in Yunnan, and the rest in national parks and nature reserves in Thailand (most are not explicitly associated with the river system). Birdlife International identifies three important bird areas (IBA) within the Thanlwin Basin in Myanmar: the Nam San Valley, Nadi Kan and Inle Bird Sanctuary (Chan et al, 2004).

The Nu Gorge is part of the Three Parallel Rivers UNESCO World Heritage Site, which supports over 25% of the world's and 50% of China's animal species, with 77 species of animals, 34 species of native plants and four fish species listed as protected or endangered (UNEP 2008).

In Myanmar and Thailand, the basin includes a range of subtropical forests, and montane and coastal rainforests, the biodiversity of which has not been well studied. A preliminary study at Khoe Kay in Kayin documented 194 plant and 200 animal species (including 32 fish species), of which 42 species are listed on IUCN's Red List of Threatened Species (KESAN, 2008). The wetlands of the river mouth support populations of the fishing cat, the Asian small-clawed otter and the Siamese crocodile. The river has the world's greatest diversity of turtles (Wong et al., 2007). Inle Lake hosts a range of endemic fish and gastropods (snails and slugs) species including the Inle carp, a cultural symbol of the local people and an important food source. Mangrove forests occur at the mouth of the Thanlwin around the island of Bilugyun, but there is limited information on their extent and condition.

Conclusion: *The basin hosts a very rich biodiversity, with large areas that have not been documented in detail. There is limited information on the wildlife and plants both within the river and in the subtropical and coastal forests in the basin.*

How will population growth impact river health?

The population of Yunnan grew from 19 million in 1960 to 46 million in 2010. Though the population has now stabilized to a growth rate of 0.7% in 2011, economic activity continues to expand. Similarly, Myanmar's population has grown over the last 40 years, from 28.9 million in 1973 (Maung, 1986) to 51.5 million in 2014, of which 52% are female. Population growth in the Thanlwin Basin states has equalled or exceeded the national rate, possibly from in-migration of Han Chinese into eastern Shan and Kachin states in recent years, although official statistics are not entirely reliable (DOP, 2015).

Conclusion: *Population growth has driven agricultural development and the intensification of land use in some areas (particularly Yunnan, the Moei subbasin and the area around Inle Lake), but within Myanmar, population density remains mostly low. An influx of economic activity facilitated by population growth may put significant pressures on the river's natural resources.*

How will irrigation affect the river?

FAO estimates that there are around 400,000 ha of irrigation in the Salween Basin overall (AQUASTAT, 2015); most of this is in Yunnan and the Moei subbasin in Thailand. WLE (2016) identify 14 irrigation dams with reservoir area of 0.5 km2 surface area and above in the basin, 10 in China, 4 in Myanmar. Myanmar's Ministry of Agriculture, Livestock and Irrigation (MOALI) report only 53,000 ha of irrigation in the Thanlwin Basin currently, and have proposed to increase this area to around 96,000 ha (Hasman, 2013). Irrigation development is limited by topography in much of the Thanlwin, and expansion of irrigation is not likely to significantly impact total flows.

Conclusion: *Neither current nor proposed irrigation withdrawals in the Thanlwin in Myanmar are likely to have a large impact on overall flows in the lower basin, though there may be significant withdrawals in some tributary catchments (e.g., Moei, Baluchaung).*

Will land use change and deforestation impact the quantity and quality of water?

In response to a growing population, cropped area in Yunnan increased from an estimated 4 to 6 million ha from 1960 to 2003, resulting in deforestation, increased erosion, and a decline in both biodiversity and water quality due to huge increases in the use of fertilizers and pesticides (Li et al., 2006). To combat these problems, the Sloping Land Conversion Program (SLCP) and the National Forest Protection Program (NFPP) were instituted in 1999 in north-west Yunnan and elsewhere.

Between 1975 and 2009, Myanmar lost an estimated 24% of its forest cover, with significant losses in the Salween Basin, particularly in southern Shan State and northern Kayin (WWF, 2013). Much of the logging occurs in natural forests in border areas with ethnic conflicts, in Shan, Kayah and Kayin states. Rubber plantations have also been a major driver of deforestation, particularly in Mon, Kayin and Shan states, where large areas of land have been granted as agricultural concessions. The area of rubber in Mon State increased from 31,000 ha in 1998 to over 171,000 ha in 2010. There has been significant intensification of agriculture in South Shan, resulting in sedimentation and declining water quality in Inle Lake.

Land-cover maps for the basin are available from global and regional datasets, but comparisons over time are not reliable, and quantification of land-cover change remains problematic. Agricultural statistics are available from MOALI (see, for example, MOAI, 2013) and the FAO Digital Agricultural Atlas of Myanmar. Data at township level are not in the public domain. Agricultural statistics for Yunnan are available in Yunnan Statistical yearbooks (in Mandarin).

Conclusion: *There has been rapid intensification of agriculture along the Nu in southern Yunnan, the Moei subbasin in Thailand, and within Myanmar around Inle Lake. Forestry is a major industry, and illegal logging has seriously degraded forests in the past 20 years, potentially accelerating erosion and adding to the sediment load of the river. Comprehensive and easily accessible agricultural and land use statistics are unavailable.*

How is hydropower energy being harnessed in the basin?

Governments of all three basin countries are actively promoting hydropower development, with financing through a mix of government and private investment. WLE (2016) identifies a total of 81 current and proposed hydropower projects[6] in the basin, of which 18 are commissioned, three are under construction, 34 are planned or proposed, and 10 listed as 'cancelled' (Figure 2). There are 16 completed (mainly small) hydropower projects in the Nu Basin, including Qiezishan Dam on a tributary of the Nu in Yunnan which supplies electricity to Baoshan; and Ajiutian dam with installed capacity of 115 MW. Dams at Chalong and Jiqian on the headwaters of the Nu Jiang in Tibet are now operational. In Myanmar, hydropower plants on the Baluchaung tributary in Kayah state supply around a quarter of Myanmar's total electrical power (installed capacity 248 MW), and Kentawng Dam in Shan State a further 54 MW. An additional 80 MW will be supplied by three projects currently under construction in the Upper Baluchaung and Upper Kentawng.

Up to 22 new dams have been proposed in China in the Nu Basin. The Nu River Project put forward by China's National Development and Reform Commission includes a 13 dam cascade with a total installed capacity of 21,320 MW. Construction of the dams would require resettlement of 56,000 people, and Chinese NGOs have urged the government not to proceed with the project. In late 2016 there were reports that the Chinese Government had shelved plans to develop hydropower on the Nu (Guardian, 2016). As of early 2017, there have been no reports of major construction.

A cascade of dams is also proposed for the Thanlwin in Myanmar (WLE 2016; International Rivers, 2014), comprising up to seven large mainstream dams with a total installed capacity of over 17,000 MW. KESAN reports that another 12 large dams are at various stages of planning and construction on tributaries of the lower Salween basin, the majority in Shan State (A. Scott, pers. comm.) Projects have been proposed jointly with both Chinese and Thai partners, and it is likely that a large proportion of energy generated would be exported. Within Thailand, developments have been proposed at Mae Sariang (792 MW) and at Mae Lama Luang (240 MW), where it is proposed to divert 2,184 million m^3 per year (80% of annual volume of the Yuam River) to the Bhumibol reservoir.

The proposed developments constitute a very high density of dams in the Nu-Salween, and if completed would cause extensive river fragmentation. They have also generated considerable opposition amongst local communities and civil society organizations in both Myanmar and Thailand, as well as from international conservation agencies. Many of the projects in Myanmar are in areas with on-going conflict between ethnic groups and government forces. Ongoing displacement of local people, logging concessions around proposed dam sites and the militarization of project areas, with troops deployed to protect construction, have compounded local resistance.

Detailed information on proposed hydropower projects is generally not in the public domain; available information comes mostly from websites of organizations such as International Rivers Network and Salween Watch.

Conclusion: *Currently, only a small fraction of the hydropower potential of the Salween has been harnessed, but hydropower development, albeit relatively small scale at this stage, has already begun in the upper reaches of the Nu. Proposals for large-scale development of hydropower*

6 - Projects of 15 MW and above.

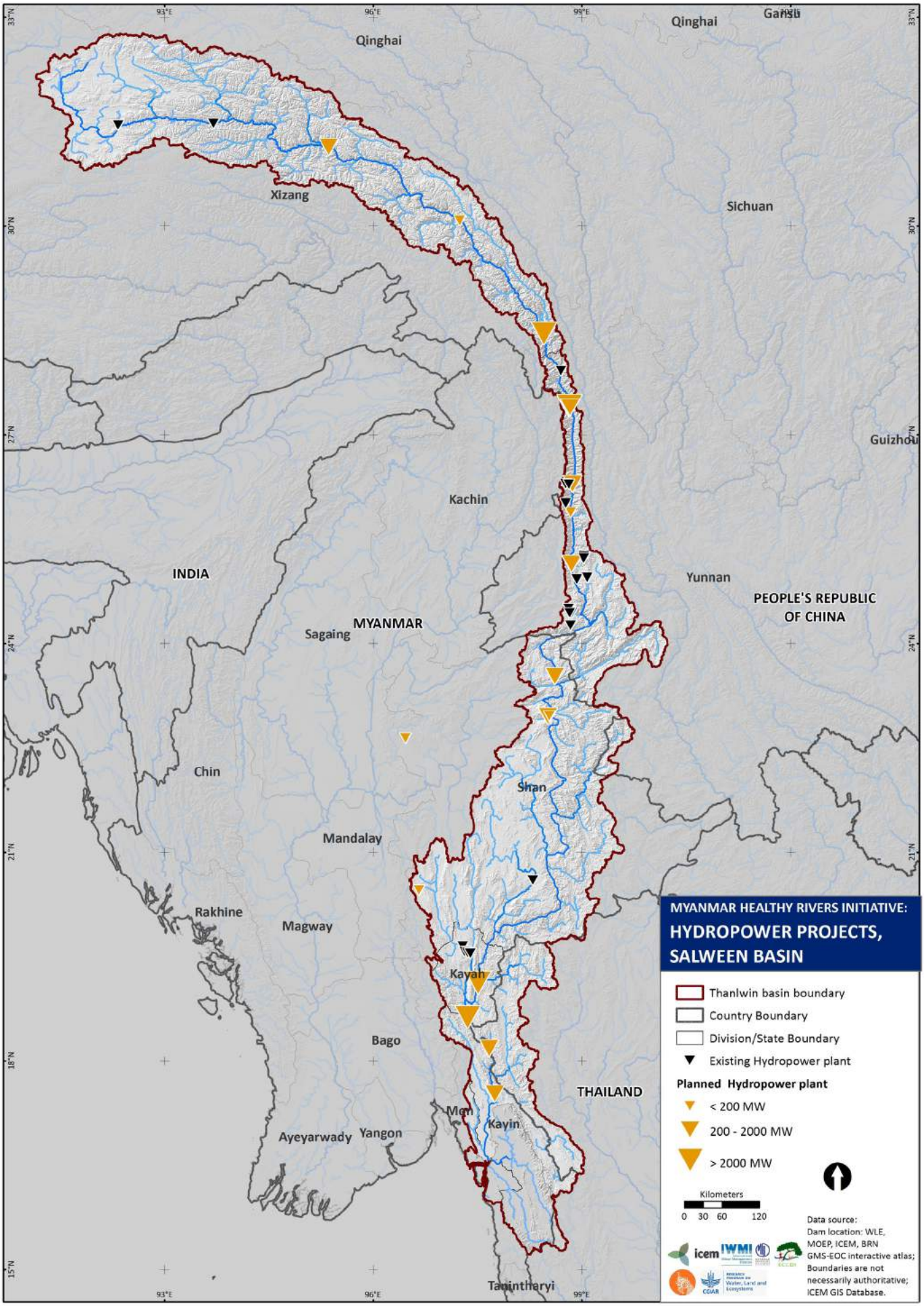

Figure 2: Hydropower Projects, Salween Basin.

on the Salween system in both China and Myanmar have focused international and national attention on the river system, with increasing concern about the potential impacts on both livelihoods and ecosystems.

How does mining affect river health?

The Thanlwin Basin has significant mineral potential for a wide range of commodities (Australia – Myanmar Chamber of Commerce, 2014), and there is considerable formal and informal mining activity. The sector is largely unregulated and there are concerns about local pollution of waterways, for example, the potential impact of pollutants from the Tigyit open-cut coal mine in Shan on Inle Lake (PYO, 2011). Artisanal sand mining for construction is common and increasing along the river as demand for building materials grows, particularly in the lower reaches around Hpa An.

Foreign investment in mining has been minimal, but since 2012 there has been increasing interest from the international mining sector, and the Government of Myanmar is proposing a new mining law to boost investment (OBG, 2015). A large increase in mining activity can be expected over the next 10 years. McKinsey Global Institute (2013) predict that by 2030, mining will contribute USD 8.68 billion to Myanmar's GDP.

Conclusion: *Mining is opening up in Yunnan and Shan states, and if internal ethnic conflicts within eastern Myanmar can be resolved, the area is highly prospective for mining. Large-scale mining can have significant impacts on river health due to extraction of water for mining, pollution from mines, and increased sediment loads as a result of disturbance and erosion around mine sites. There is currently no formal process for coordinated planning or monitoring the impacts of proposed developments.*

How will climate change impact the river?

The Department of Meteorology and Hydrology (DMH) estimates that mean temperatures across Myanmar have increased by 0.08 °C per decade since 1951. Rainfall trends are less clear, with an increase in overall rainfall in most areas but a declining trend in others. Overall, there has been an increase in extreme weather events and a rise in sea level (GCCA, 2014). The lower reaches of the Thanlwin, in Kayin and Mon states, were amongst the state-declared disaster areas affected by Cyclone Nargis in 2008 (MIMU, 2008).

Climate projections for Myanmar (Han Swe, 2014) suggest that temperatures will continue to rise, with longer summers, heavier rainfall during the rainy season and higher annual total precipitation. Lutz et al. (2014) predict an overall increase in flows from the upper basin to at least 2050, due mainly to increased rainfall across the Tibetan Plateau. Higher temperatures will result in loss of glaciers with only 32-56% of the current glacier area remaining by 2050.

Conclusion: *Climate change could impact river flows due to changes in rainfall and glacier melt. Because the implications of climate change effects on hydrology and sediment loads in the river have not been investigated in great detail, hydrological modelling studies to improve the understanding of flows and sediment dynamics constitute a high priority.*

Who is involved in the management of the river?

A range of national and regional government agencies have responsibility for managing the Thanlwin River within Myanmar, but there is no central authority for planning and management. In Myanmar, responsibility for issues relating to river management is distributed among different agencies; for example, irrigation and fisheries with the Ministry of Agriculture, Livestock and Irrigation; navigation and river training (Ministry of Transport); and hydropower development (Ministry of Electricity and Energy). The National Water Resources Committee provides coordination of water-related issues, but does not at this stage have an active role in implementing activities. In practice, regional parliaments and local agencies (district and municipal authorities) have responsibility for most day-to-day management issues. A wide range of civil society actors, private companies and others have a stake in river issues, but there are no clear pathways for them to participate in development of policy and planning relating to river development. Much of the Salween Basin is militarized, and the presence of various armed groups, along with a lack of rule of law, impedes effective management of natural resources.

Conclusion: *There is no single agency specifically tasked with the management of the Thanlwin River within Myanmar. No supra-national body exists with authority to consider transboundary issues in the Salween system, and foreign ministries of each nation deal with these bilaterally. A process for coordinated planning or monitoring of the river could help facilitate future river development, but is impeded by continuing military conflict within the basin.*

What data are currently available and where are the information gaps?

Biophysical information on the Salween River system is generally sparse and relies heavily on global datasets supported by detailed studies at very few sites, such as Inle Lake and the river mouth at Mawlamyine. In Myanmar, government monitoring of climate, river flows and water quality has focused on the lower reaches below Hpa An, with very few stations in the more remote areas covered by the Salween Basin. Myanmar's political isolation until 2012 and continued conflict has limited scientific studies by international research groups. Local universities, particularly Mawlamyine and Yangon universities, have carried out some studies in the areas of fish biology and estuarine science in the lower basin.

The lack of data on river flows and sediment loads is a concern, as information is needed to provide baselines against which future changes can be compared. Poor-quality input data and lack of measurements for calibration have made global and national assessment attempts difficult. Despite the fact that flooding is common in the lower reaches of the river, no detailed studies of flooding patterns or flood risk are available.

Although data relating to land use, agriculture and infrastructure are available from the relevant national ministries, they are usually reported at the level of state or region. More detailed data collected at the village to township level are held in local offices, making it difficult to access and compile. This limits efforts to build a picture of change and dynamics at local scales. Comprehensive, reliable gender-disaggregated data on land titles is not available at present.

Environmental impact assessments relating to proposed dams have been conducted for all the projects in Yunnan and some in Myanmar, but have not been released. This has fuelled distrust and resistance to the projects. Some local groups, such as the Karen Environmental and Social Action Network (KESAN), have conducted their own scientific studies to assess local impacts.

Conclusion: *The need for baseline studies is urgent, to establish current conditions, uses and values of the river before large-scale development proceeds, and as the basis for future planning. Global datasets and remotely sensed data can provide regional analysis and a framework for identifying drivers and patterns of change, and areas most at risk.*

Conclusion

The Salween is possibly the least modified major river basin in Southeast Asia and the overall health of the river is good in most reaches. Decades of civil war in the lower Salween basin have limited the development of the region, but as it begins to open up, investment in natural resource sectors presents new challenges and opportunities for the region. Decisions made now will greatly influence the future health of the river, the ecosystem services that it provides and who benefits. Ultimately, the future of the Salween and the people who live in the basin will depend, to a large extent, on the stewardship of its natural resources, including its water. The development pathway is not yet fixed: options remain and important lessons can be learned from neighbouring river basins.

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