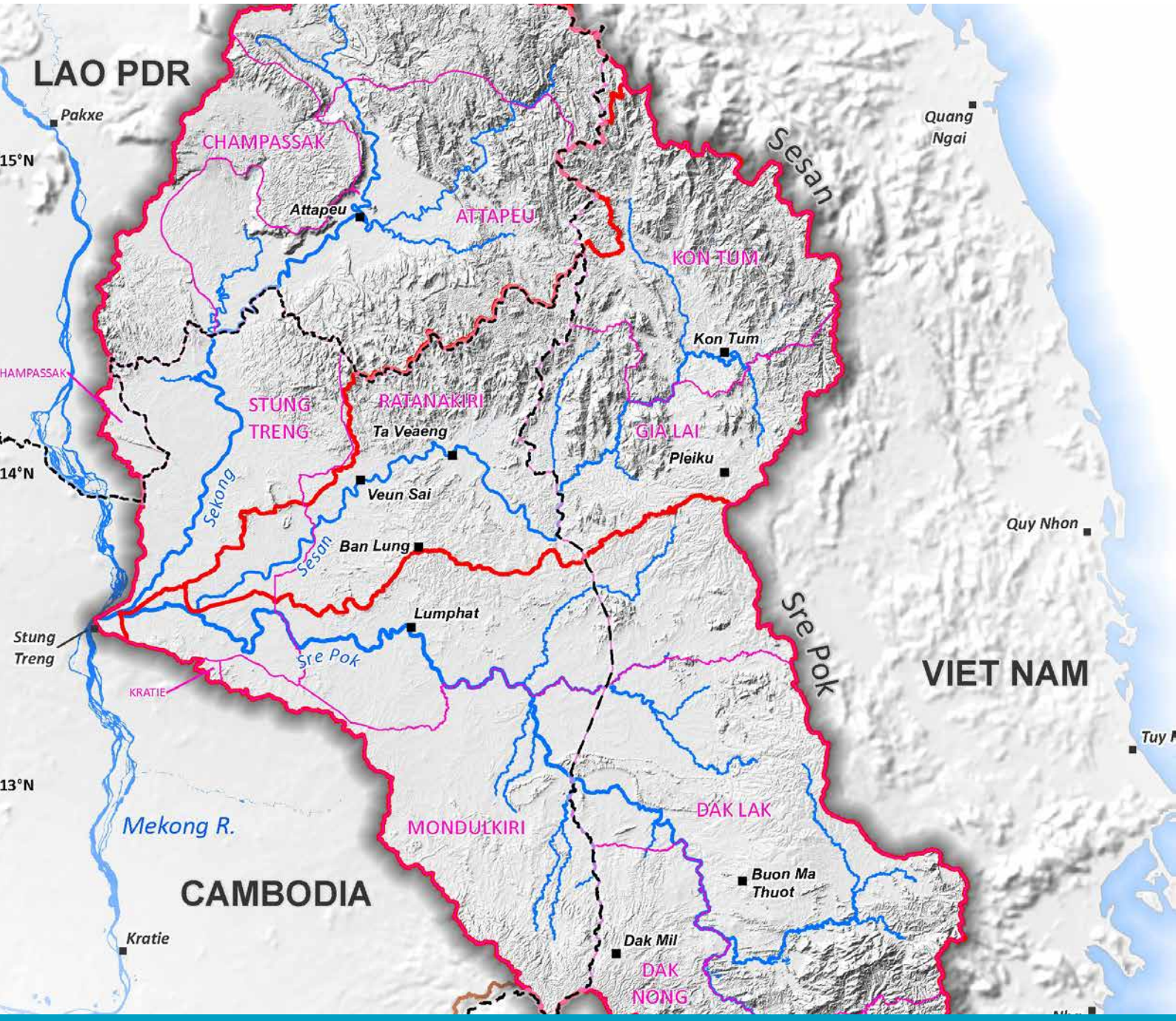
Atlas of the 3S Basins

(The Sekong, Sesan and Sre Pok Trans-boundary Basins)



BRIDGE: Building River Dialogue and Governance

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Swiss Agency for Development and Cooperation SDC

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Building River Dialogue and Governance (BRIDGE) is an initiative that focuses on enhancing water governance capacities in 14 trans-boundary rivers and lakes in five regions across the globe. BRIDGE is implemented by IUCN with the support of the Swiss Agency for Development and Cooperation (SDC). In the Mekong region, BRIDGE activities are carried out in the Sekong, Sesan and Sre Pok River Basins (collectively called the 3S Basins).

The project seeks to facilitate cooperative processes in the 3S region by developing and strengthening water governance capacities through governance reforms, stakeholder dialogues and knowledge exchange programmes to catalyse trans-boundary cooperation for equitable and sustainable water resources development.

For more information visit: www.iucn.org/bridge and www.3sbasin.org.

Acknowledgements

This atlas was made possible with the generous support of SDC. In addition, many thanks go to Raphaël Glémet and Vishwaranjan Sinha (IUCN) for their advice and assistance in developing this atlas. We also express our gratitude to the staff of the Mekong River Commission (MRC) in Vientiane and Phnom Penh for providing key databases and patiently answering our many inquiries.

Data access and disclaimers

Primary thematic data sources are noted in the references accompanying each map. For more information on data and access please see Annex A. The Mekong River Commission (MRC) provided the majority of data used to develop this atlas. Additional data sources include reports by National Mekong Committees, private companies, NGOs, and scientific literature. Data remains the intellectual property of the MRC and other individual data providers and use of data does not imply endorsement by MRC or any other data providers. The MRC makes no warranties about the data delineated in this atlas and disclaims all responsibility and liability for all expenses, losses, damages and costs which may be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

Atlas of the 3S Basins

The Sekong, Sesan, and Sre Pok Basins

Research and text by Daniel Constable

Preface

Over the past half-century the Mekong River has been extensively studied for its potential to provide natural resources, generate electrical power, and serve as a connecting thread between the nations of Southeast Asia and beyond. As early as the 1950s the Mekong was identified as a key asset in the development of the region. Some of the grandest plans, for example the construction of the Sambor Hydropower Dam on the mainstream of the Mekong, have yet to materialise. However, over the past half-century these have continued to be discussed, and new threats have emerged. Now the region is under increasing pressure from growing demand for and over-exploitation of natural resources, changes in hydrological regimes and land cover change. Projected changes to the regional climate could further stress this critical river basin which is home to millions of people and is the world's largest inland freshwater fishery. Yet, despite these threats, optimists note that improved management and shifting attitudes can help build a brighter future.

The Mekong River originates in mountains in China's Qinghai Province, travelling for more than 4,350 kilometres (km) until it discharges through the Mekong Delta in Viet Nam. For management purposes it is often divided into an upper portion, mainly in China, and the Lower Mekong Basin (LMB), which overlaps primarily with Cambodia, Lao PDR, Thailand, and Viet Nam. Within the LMB three large tributaries – the Sekong, Sesan, and Sre Pok – are of particular importance. The eponymous watersheds for these rivers are known collectively as the 3S Basins, a reference to the "S" at the beginning of each river's name.[1] Together the 3S Basins form the largest and most important trans-boundary watersheds and tributaries to the Mekong River, providing 18% of its total discharge. The 3S Basins also provide important fish habitat and support communities throughout the region through the migration of fish and flow of water and sediment. Recognising their importance, the Mekong River Commission, academic research institutions, and non-governmental organisations are paying increasing attention to the area.

The issues present in the 3S Basins are many and varied. This atlas gives a brief overview of the basins in an attempt to illustrate their importance, complexity, and trans-boundary setting. In doing so, these maps can provide a starting point for discussion and dialogue. One reason for producing the atlas was the relative lack of easily accessible information and thematic maps for the 3S Basins. Although heavily studied, data is often presented on a Mekong Basin-scale or along national boundaries. This atlas attempts to give a more focused view than provided by the MRC's excellent, but broader *Planning Atlas of the Lower Mekong River Basin*. It is our hope that this atlas will help policy makers, natural resource managers and practitioners, and interested parties to better understand the 3S Basins and that it can add to the discussions on water governance within these important trans-boundary watersheds.

[1] The Sekong is also transliterated as Xe Kong or Xekong. In this report the river, basin and town are referenced as Sekong, while dams retain the "Xe" prefix. Sesan is also spelled Se San.

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List of abbreviations

3S	Sekong, Sesan and Sre Pok (River Basins)
ADB	Asian Development Bank
BRIDGE	Building River Dialogue and Governance
ESA	European Space Agency
FAO	United Nations Food and Agriculture Organization
GMS	Greater Mekong Sub-region
HYMOS	Hydrological Modelling System
IBA	Important Bird Area
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
LMB	Lower Mekong Basin
MRC	Mekong River Commission
NGO	Non-government organisation
NSDP	National Strategic Development Plan
NMC	National Mekong Committee
WHO	World Health Organization

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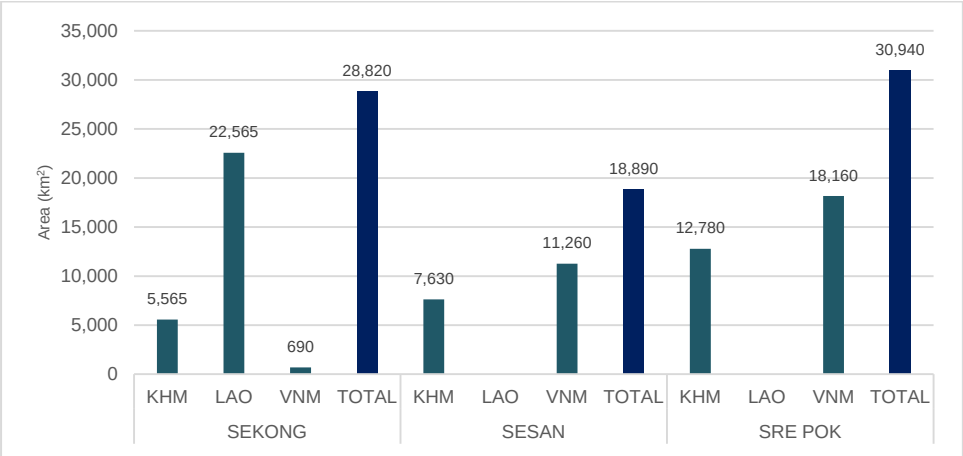
1. Location

1.1. Location and administrative boundaries

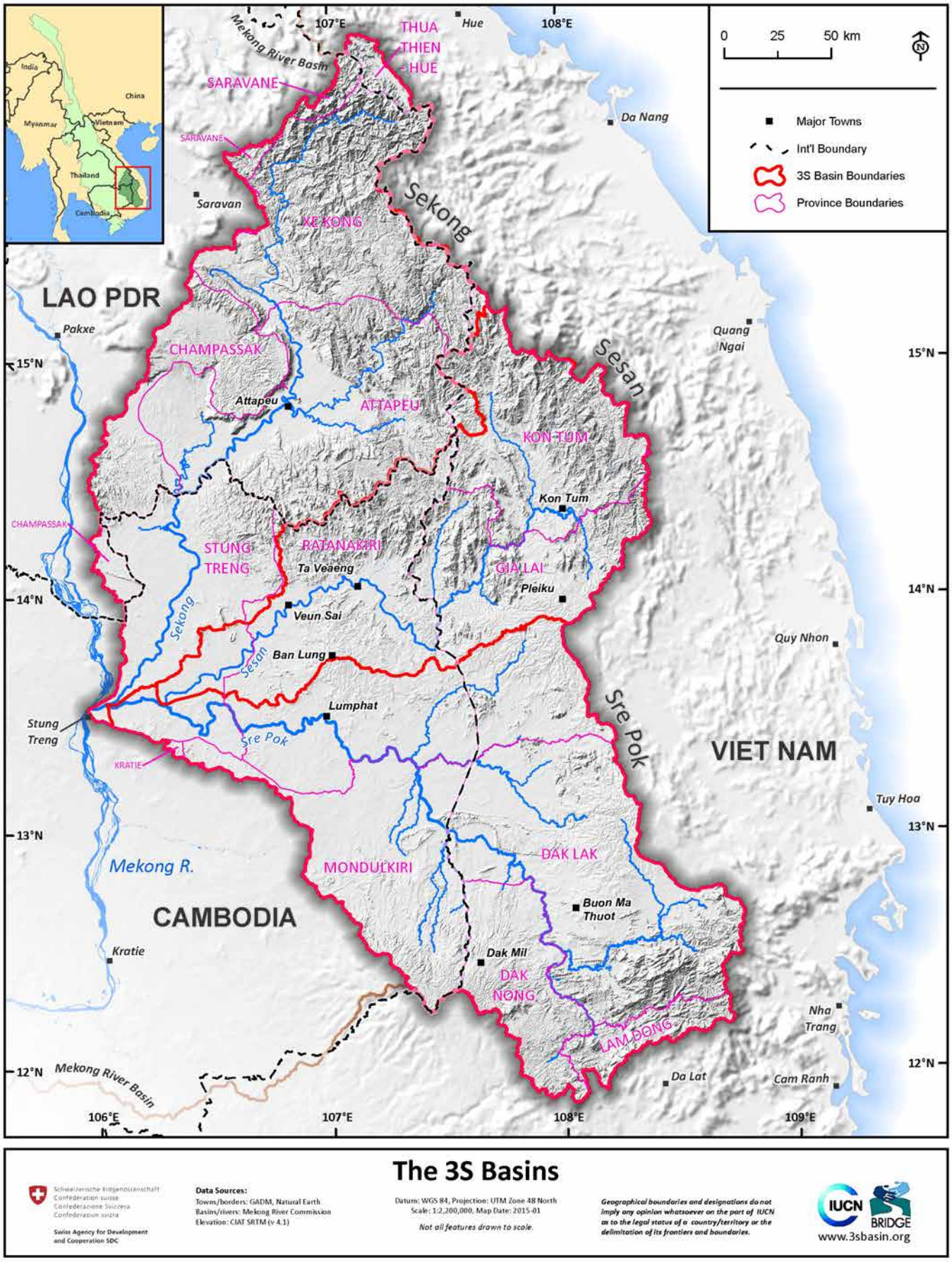
The Sekong, Sesan, and Sre Pok River Basins (3S Basins) are the three largest trans-boundary tributaries to the Mekong River. Located to the east of the Mekong mainstream, they are shared by Cambodia, Lao PDR, and Viet Nam. In total the three basins cover 78,645 square kilometres (km$^{2)}$, roughly evenly divided between the Sekong in the north at 28,815 km^2, the Sesan in the centre covering 18,800 km^2, and the Sre Pok to the south, which is the largest at 30,942 km^2. Although the three basins share common characteristics, they are distinct enough to warrant separate consideration, especially with regard to differences in terrain and the different states of development and interests between basins and countries. The Sekong is the most administratively unique: 78% of its watershed falls within Lao PDR. A smaller area (19%) of the lower basin is part of Cambodia, while just 2.4% in the uppermost basin crosses into Viet Nam. In contrast, the Sesan and Sre Pok are nearly evenly divided between Cambodia and Viet Nam.

This map shows provincial boundaries within the 3S Basins, but most of these extend further, overlapping with areas outside of the 3S, or even areas outside of the Lower Mekong Basin (LMB).

Figure 1: Size of the 3S Basins by basin and country



Note: KHM = Cambodia, LAO = Lao PDR, VNM = Viet Nam



The 3S Basins

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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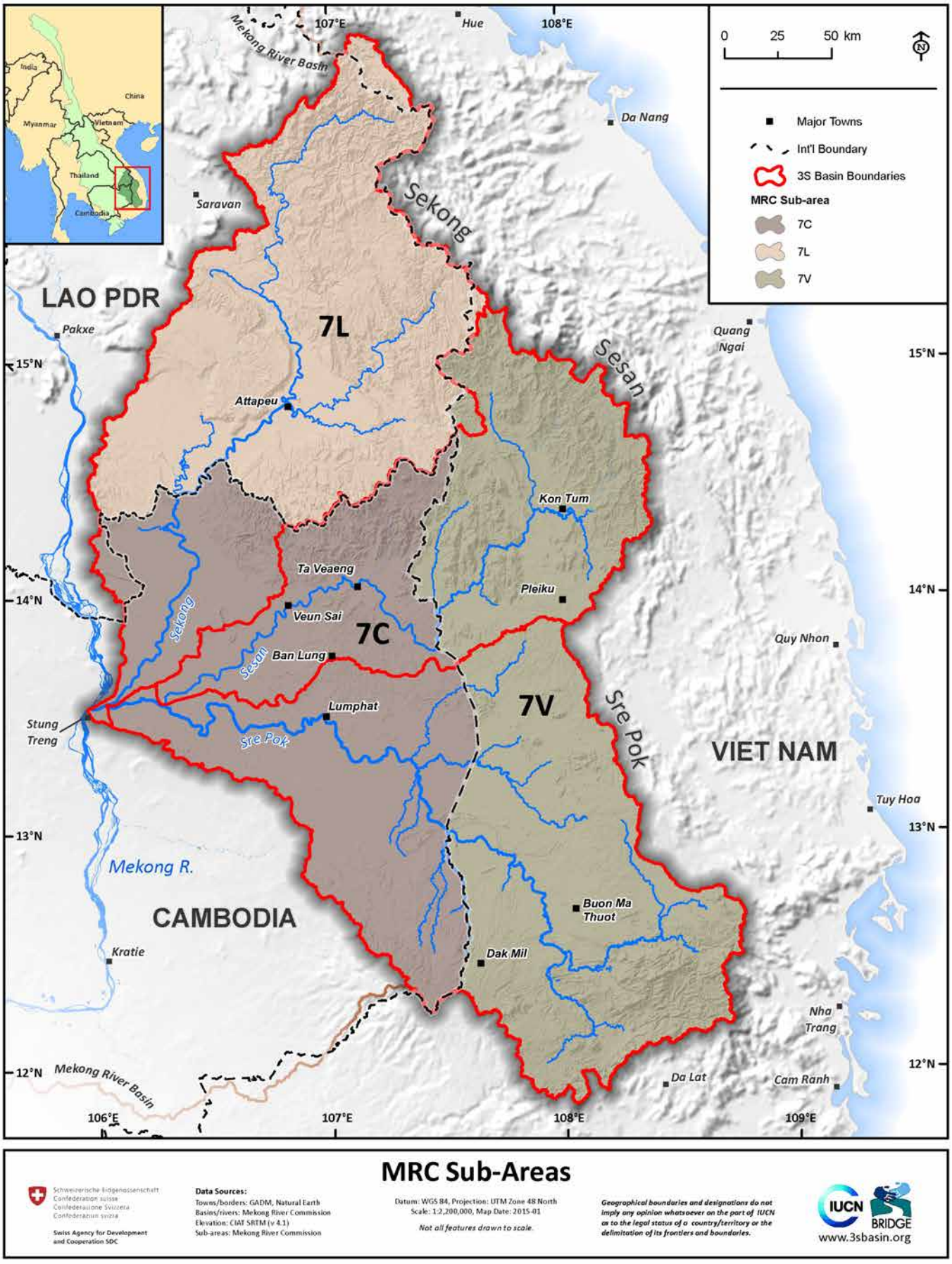
1.2. Mekong River Committee sub-areas

In 2002 the Mekong River Committee (MRC) delineated sub-areas for the Lower Mekong Basin (LMB) to help with development planning and reporting. Sub-areas approximately follow the intersection of a country with a defined sub-basin. Numbers increase from upstream to downstream, while the letter denotes the country in which the sub-area falls.

The 3S Basins are covered by sub-areas 7C (Cambodia), 7L (Lao PDR), and 7V (Viet Nam). However, the 3S sub-areas do not exactly coincide with country boundaries: parts of the Sekong overlapping with Cambodia and Viet Nam have been incorporated into area 7L, acknowledging the hydrological connections between these areas. Area 7L is the smallest (22,585 km^2), followed by 7C (26,377 km^2), and 7V (29,385 km^2).

National Mekong Committees (NMCs) for each country develop reports summarising the status of activities related to development in each sub-area. This provides a focused overview of an area, and allows for a bottom-up approach, integrating knowledge from those who know the area best. However, the statistics may be difficult to disaggregate by individual basins. For example, reports for sub-area 7C aggregate figures for the Sekong, Sesan, and Sre Pok. This is further complicated by the fact that national statistics are generally collected following sub-national administrative units, which do not align with sub-areas and often have part of their area outside of the 3S Basins.

Presenting data at the sub-level scale provides a pragmatic way to share information that is obtained at the national scale. However, this can also be augmented by analyses that focus on individual hydrologic basins.



MRC Sub-Areas

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Sub-areas: Mekong River Commission

Datum: WGS 84, Projection: UTM Zone 48 North
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1.3. Transportation network

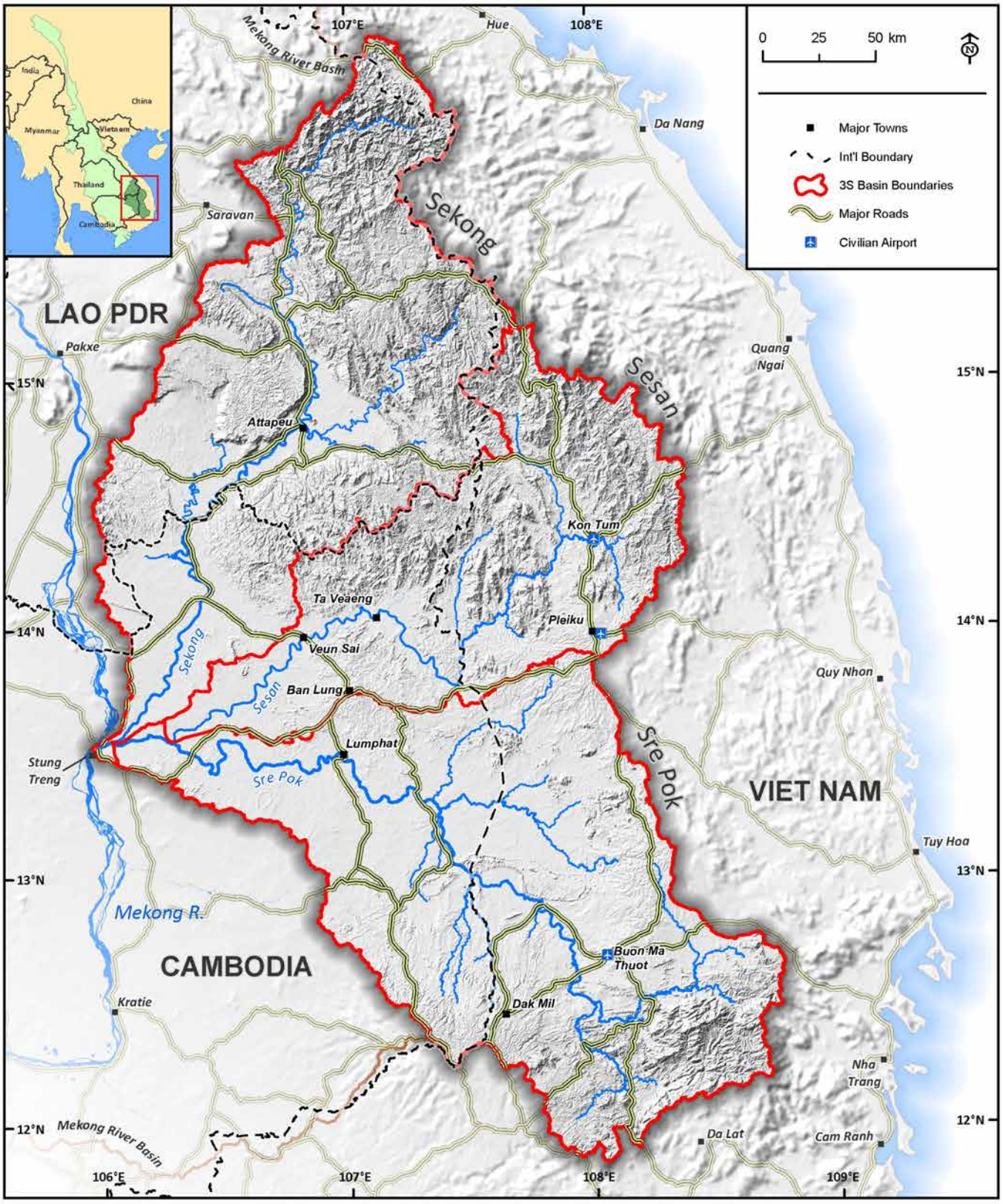
Transportation is important for economic development, supporting access to markets, tourism and links to areas outside of the basins. Transportation infrastructure is limited in the 3S Basins but is improving, and development plans for the Greater Mekong Sub-region (GMS) call for enhanced transportation corridors in this area. In this map “major road” is a relative term.

Although no major highways cross the 3S Basins, the roads denoted here are relatively larger and in better condition for vehicle traffic. The largest road connects Quy Nhon in Viet Nam and Stung Treng in Cambodia. This route has been identified as a key transport corridor and is made up of Highway 19 in Viet Nam and Highway 78 in Cambodia. The road approximately follows the border of the Sesan and Sre Pok Basins, passing through the town of Ban Lung. In 2008 a bridge was built from Stung Treng across the Mekong River to Thailand, improving access to the rest of the region.

In the Sekong, Highway 7 is the main paved road connecting the basin to Stung Treng. It follows the western basin boundary before veering off to travel along the Mekong River. Another three roads – 13, 16, and 18B – are paved and usable year round. Highway 18B links Attapeu in Cambodia to Viet Nam, while 18A connects to Highway 13, but is unpaved and can be impassable in the rainy season.

Several smaller roads connect cities within the upper basins in Viet Nam and in between provincial cities in Lao PDR. The road network is less developed in Cambodia. Here, the major roads include Highway 76, running north-south across the Sre Pok Basin and Road 301 running east-west through the Sekong.

Many of the smaller roads connecting minor towns and villages remain unpaved. During storm events roads and bridges can wash out or otherwise be damaged. Boats provide an especially important transportation method during the rainy season when roads are flooded and damaged. Waterways are also used for transport, but there is little established infrastructure, such as docks or ports, so no specific routes are noted on the map.



Transportation Network

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Major Roads: Natural Earth (2014)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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2. Geophysical characteristics

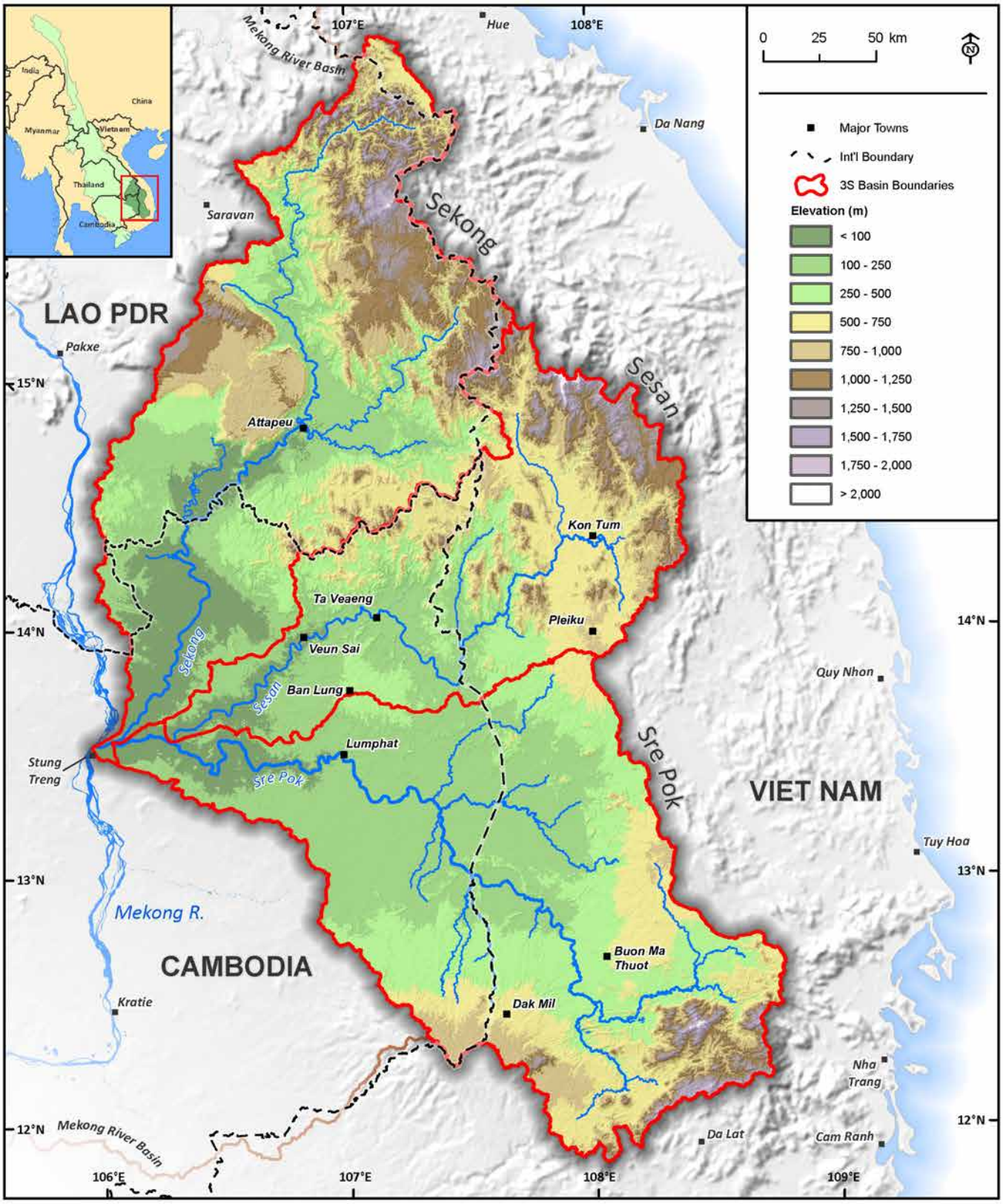
2.1. Elevation

The 3S Basins transition from steep, elevated mountainous areas in the east to low-lying, plains in the west and range from 2,409 meters above sea level (MASL) to around 50 MASL at the confluence with the Mekong River at Stung Treng. Geographically, the basins are bound by the Annamite Mountains, which run north-south and define the eastern boundary of the watershed. These mountains also contribute to the high level of precipitation that falls in the basin, by squeezing out moisture as weather patterns move across the region.

The Sesan Basin has the highest average elevation, at 558 meters (m), followed by the Sekong at 576 m, and the Sre Pok at 399 m. However, these averages do not reflect the large variations within the individual basins. Although the Sre Pok has the lowest average elevation, it also includes the highest peak, in the volcanic uplands southeast of Buon Ma Thuot.

Much of the lower Sre Pok is relatively flat with low elevation. These flat valleys are extensively cultivated, especially in Viet Nam. The topography of the Sesan represents a transition between the steep and rugged upper Sekong, and the relatively flatter Sre Pok. The upper Sesan is characterised by the Annamite Mountains above Kon Tum, while the area in Cambodia is relatively lower and flatter, except north of Ta Veang, along the Sekong-Sesan Basin divide, where the elevation reaches above 1,000 m.

The second largest of the 3S Basins, the Sekong, is characterised by rugged topography and high elevation peaks in its upper areas, a large plain in its central area, and flat valleys stretching from Attapeu down through Cambodia to the confluence with the Mekong River. A unique feature, the Bolaven Plateau, reaches above 1,300 m and provides a more temperate microclimate due to its elevation.



Elevation

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Data Sources:
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Basins/rivers: Mekong River Commission
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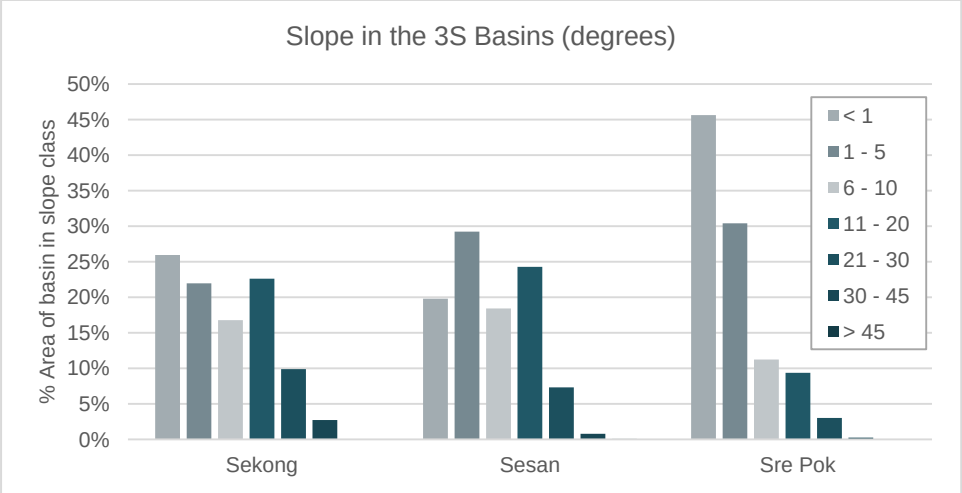
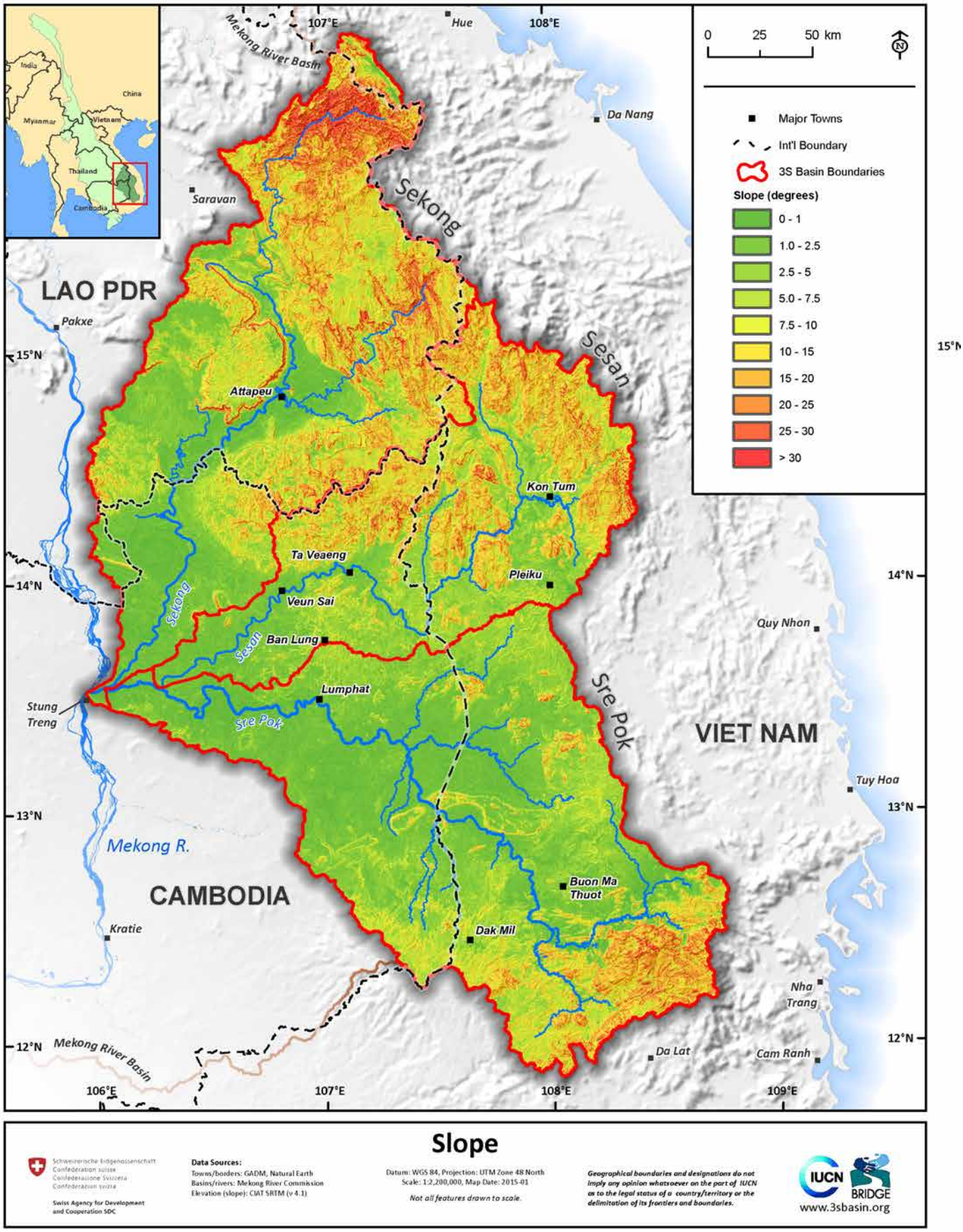
2.2. Slope

Slope is the change in elevation along a given horizontal distance. Steeper slopes, in combination with land use and human activities, are often more prone to erosion and influence human habitation patterns.

Slope in the 3S Basins differ between the upper and lower areas within basins, as well as between each basin. In the north, the Sekong and Sesan have the steepest slopes, with rugged topography in their upper reaches. The Sre Pok stands apart with a large per cent of its area in relatively low slope areas.

Figure 2: Slope in the 3S Basins




Slope
0 25 50 km
Major Towns
Int'l Boundary
3S Basin Boundaries
Slope (degrees)
0 - 1
1.0 - 2.5
2.5 - 5
5.0 - 7.5
7.5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
> 30
LAO PDR
CAMBODIA
VIET NAM
Mekong River Basin
Mekong R.
Sekong
Sesan
Sre Pok
Hue
Da Nang
Saravan
Pakxe
Attapeu
Kon Tum
Ta Veaeng
Pleiku
Veun Sai
Ban Lung
Lumphat
Stung Treng
Quy Nhon
Tuy Hoa
Buon Ma Thuot
Dak Mil
Kratie
Nha Trang
Da Lat
Cam Ranh
107°E
108°E
109°E
106°E
15°N
14°N
13°N
12°N
India
China
Myanmar
Vietnam
Thailand
Cambodia
Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation (slope): CIAT SRTM (v 4.1)
Datum: WGS 84, Projection: UTM Zone 48 North
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2.3. Land cover (2003)

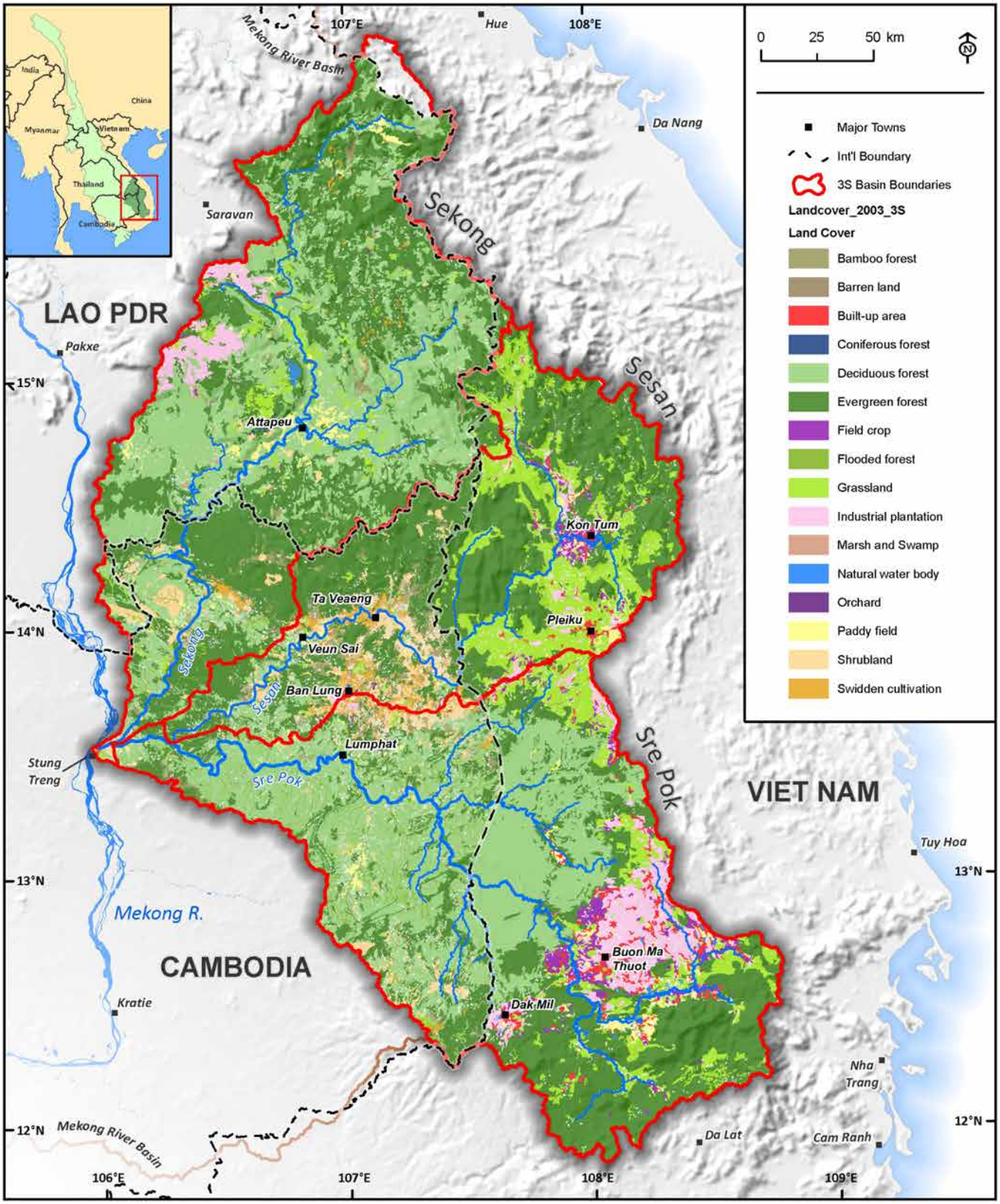
The most recent official land cover dataset from the MRC is for the year 2003. Although now outdated, it estimates that, at that time, 75% of the 3S Basins were forested. However, this figure includes both primary and secondary forests and does not differentiate between high quality and degraded forests (plantations are classified separately).

The 2003 land cover analysis was carried out by individual countries and compiled by the United Nations Food and Agriculture Organization (FAO). For unknown reasons the area of the Sekong Basin in Viet Nam was not included and some artefacts in the data have no value, therefore figures do not add to 100%. As of 2003, the Sekong was the portion of the 3S Basins with the highest proportion of forest cover, at 83% including a large area of deciduous forest.

The Sesan however had the highest percentage of evergreen forests. Forest cover in the Sre Pok is proportionally lower than the Sekong and Sesan, although in absolute numbers total forested area is as large as the Sekong. More recent satellite imagery is available from the MRC, but this has not yet been developed into an updated land cover map.

Table 1: Land cover in the 3S Basins

LAND COVER	SEKONG		SESAN		SRE POK		TOTAL	
	Area (km^2)	% of Basin	Area (km^2)	% of Basin	Area (km^2)	% of Basin	Area (km^2)	% of Total
Bamboo forest	466.0	1.6%	638.0	3.4%	407.5	1.3%	1,511.5	1.9%
Barren land	-	-	3.0	0.0%	-	-	-	-
Built-up area	18.8	0.1%	178.0	0.9%	656.9	2.1%	853.6	1.1%
Coniferous forest	15.4	0.1%		0.0%		0.0%	15.4	0.0%
Forest, Deciduous	11,472.3	39.8%	617.4	3.3%	11,342.8	36.7%	23,432.5	29.8%
Evergreen forest	12,546.5	43.5%	10,432.5	55.2%	10,006.2	32.3%	32,985.2	41.9%
Field crop	22.7	0.1%	263.2	1.4%	685.8	2.2%	971.7	1.2%
Flooded forest	122.2	0.4%	22.3	0.1%	858.9	2.8%	1,003.4	1.3%
Grassland	861.1	3.0%	3,831.0	20.3%	2,596.9	8.4%	7,289.0	9.3%
Industrial plantation	726.4	2.5%	230.1	1.2%	1,749.8	5.7%	2,706.3	3.4%
Marsh and Swamp	20.1	0.1%	9.0	0.0%	4.1	0.0%	33.2	0.0%
Natural Water body	111.1	0.4%	79.1	0.4%	180.8	0.6%	371.0	0.5%
Orchard	-	-	23.0	0.1%	17.3	0.1%	-	-
Paddy field	407.8	1.4%	204.7	1.1%	424.4	1.4%	1,036.9	1.3%
Shrubland	552.6	1.9%	772.8	4.1%	568.1	1.8%	1,893.5	2.4%
Swidden cultivation	173.7	0.6%	516.2	2.7%	149.9	0.5%	839.9	1.1%
TOTAL	**27,516.7**	**95.5%**	**17,820.4**	**94.3%**	**30,924.0**	**99.9%**	**76,261.1**	**97.0%**



Land Cover (2003)

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Land Cover: Mekong River Commission (2003)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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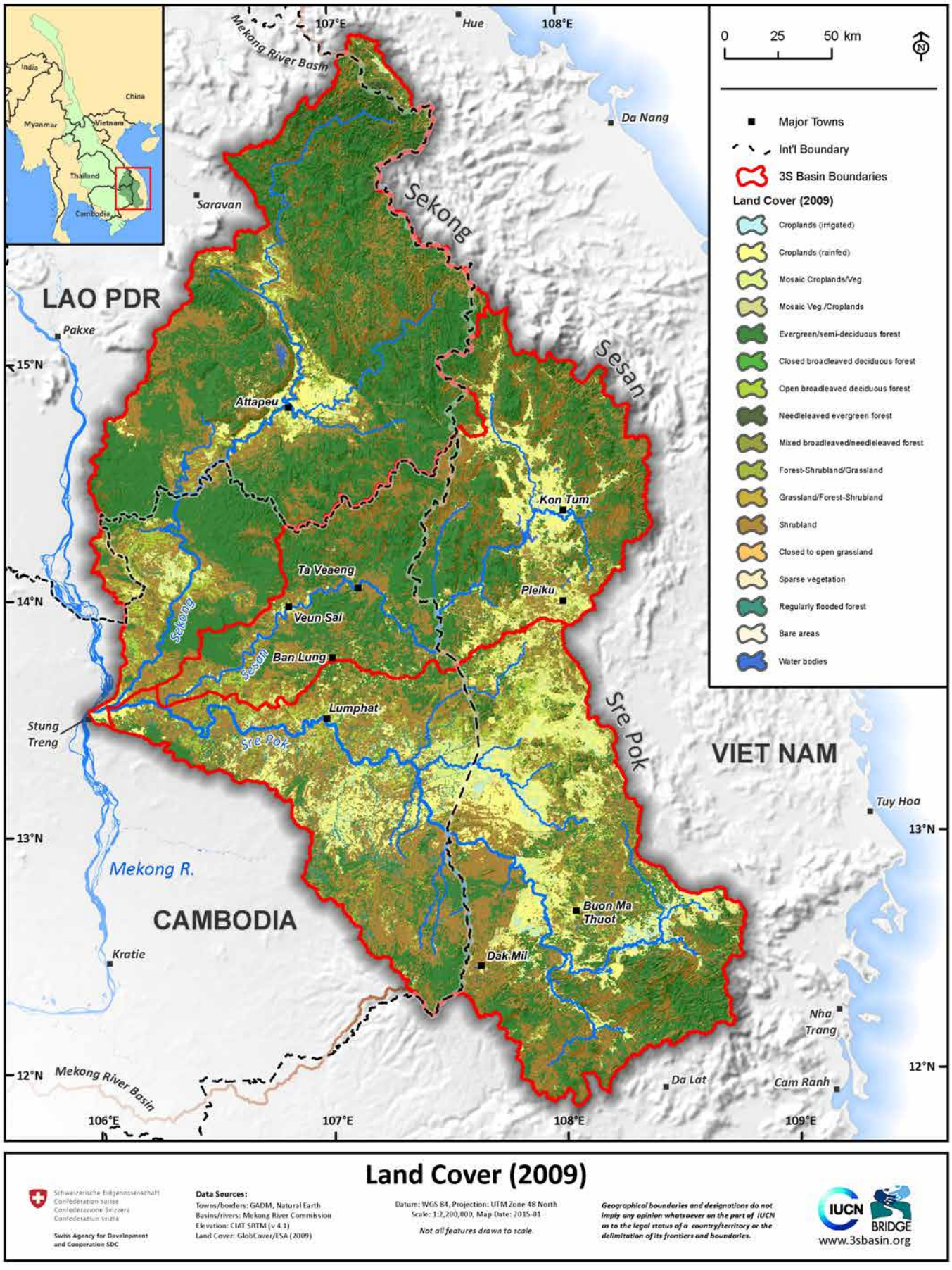
2.4. Land cover (2009)

Land cover, especially forest areas, in the 3S is thought to have dramatically changed over the past decade (Hansen et al. 2013). A recent land cover map focused on the Mekong and 3S Basins would yield a more accurate picture of the current state of the environment there. The MRC analysed satellite imagery in 2009, but this was not included in their 2011 basin-wide atlas and a land cover map has not been developed (MRC 2011).

The accompanying map is based on a global study of land cover conducted in the year 2009 by the European Space Agency (ESA). The data reveal that agricultural areas have expanded. However, the different methodologies and definitions of forest mean that the 2003 MRC and 2009 ESA datasets are not directly comparable.

In this map, large areas of cultivated land are visible around Attapeu, Kon Tum, and the upper Sre Pok Basin. More mountainous areas retain higher levels of forest cover, although this map does not denote forest health or level of intactness. While this dataset provides a rough picture of land cover as of the year 2009, it is not considered to be as accurate as a locally-focused study (Arino et al. 2009). A new analysis of land cover in the 3S Basins could provide up-to-date information for planning and addressing environmental concerns.



Land Cover (2009)

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Land Cover: GlobCover/ESA (2009)

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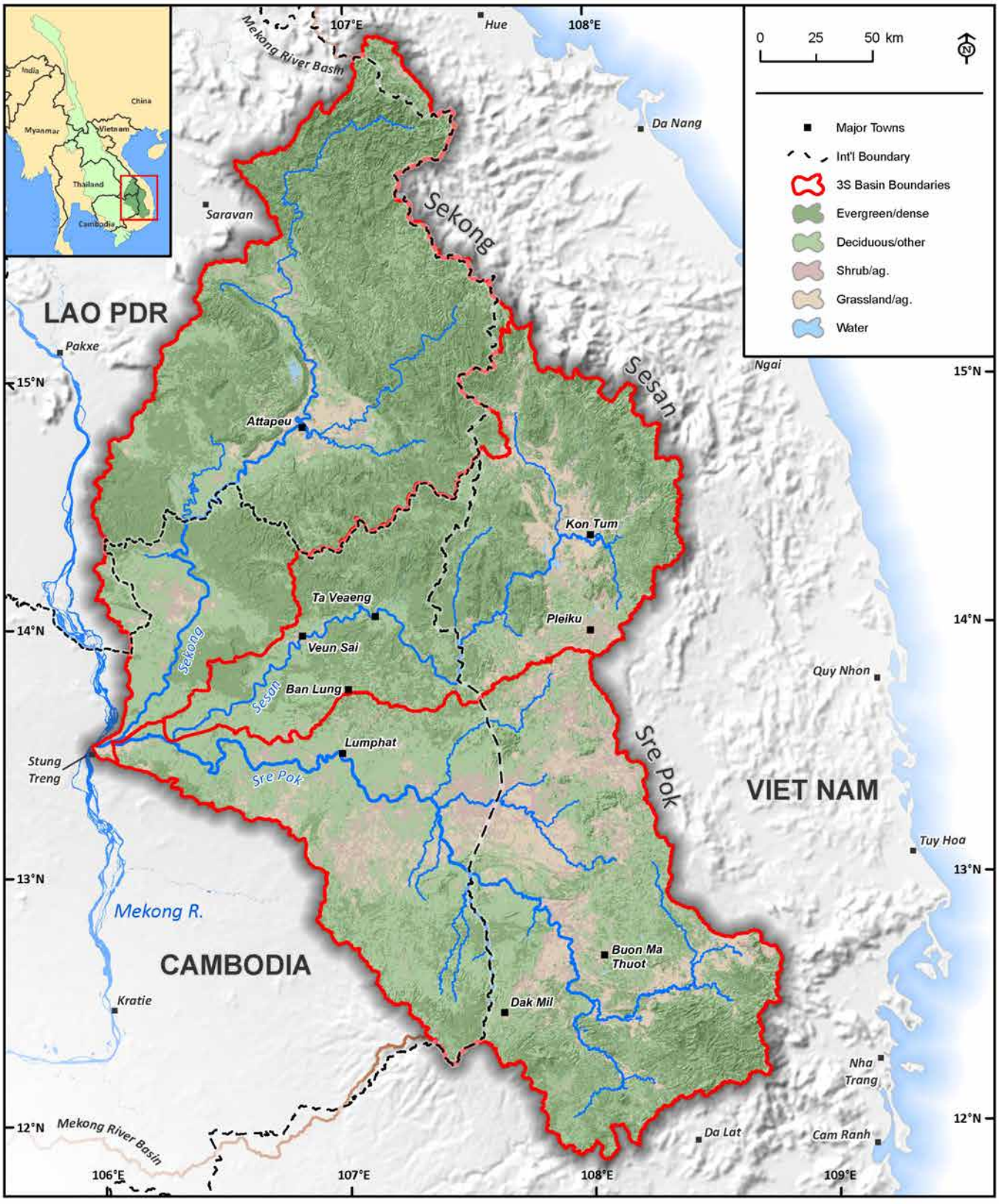
2.5. Forest cover (2009)

This map shows generalised forest cover in the year 2009. It was produced by the Environment Operations Centre of the Greater Mekong Sub-region (ADB), based on European Space Agency data (ESA/GlobCover 2009). No differentiation is made between natural and plantation forests.

From the map it is easy to see the dichotomy between large areas of forested land in mountainous areas, and agricultural and grassland areas in the valleys. Agricultural development surrounding Attapeu and Kon Tum is clearly visible, as is agricultural cultivation across much of the central Sre Pok Basin.



Forest Cover (2009)

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Forest Cover: GMS-EOC (2009)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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2.6. Soil Type

The predominant soil type in the 3S Basins is acrisols which covers more than 40% of the entire basin area. In the Sesan, the major soil types include acrisols and ferrasols. Both soil types have relatively lower value for agricultural cultivation, but nonetheless are capable of supporting many crops. Alluvial and fluvisol soils in the 3S are also of interest due to their association with floodplains and high productivity areas. Their presence can help identify potential floodplains and wetlands which often are important areas for crop cultivation and fisheries, and provide important natural habitat. An overview of selected major soil types and associated characteristics is given below.

Table 2: Characteristics of selected major soil types in the Sesan Basin.

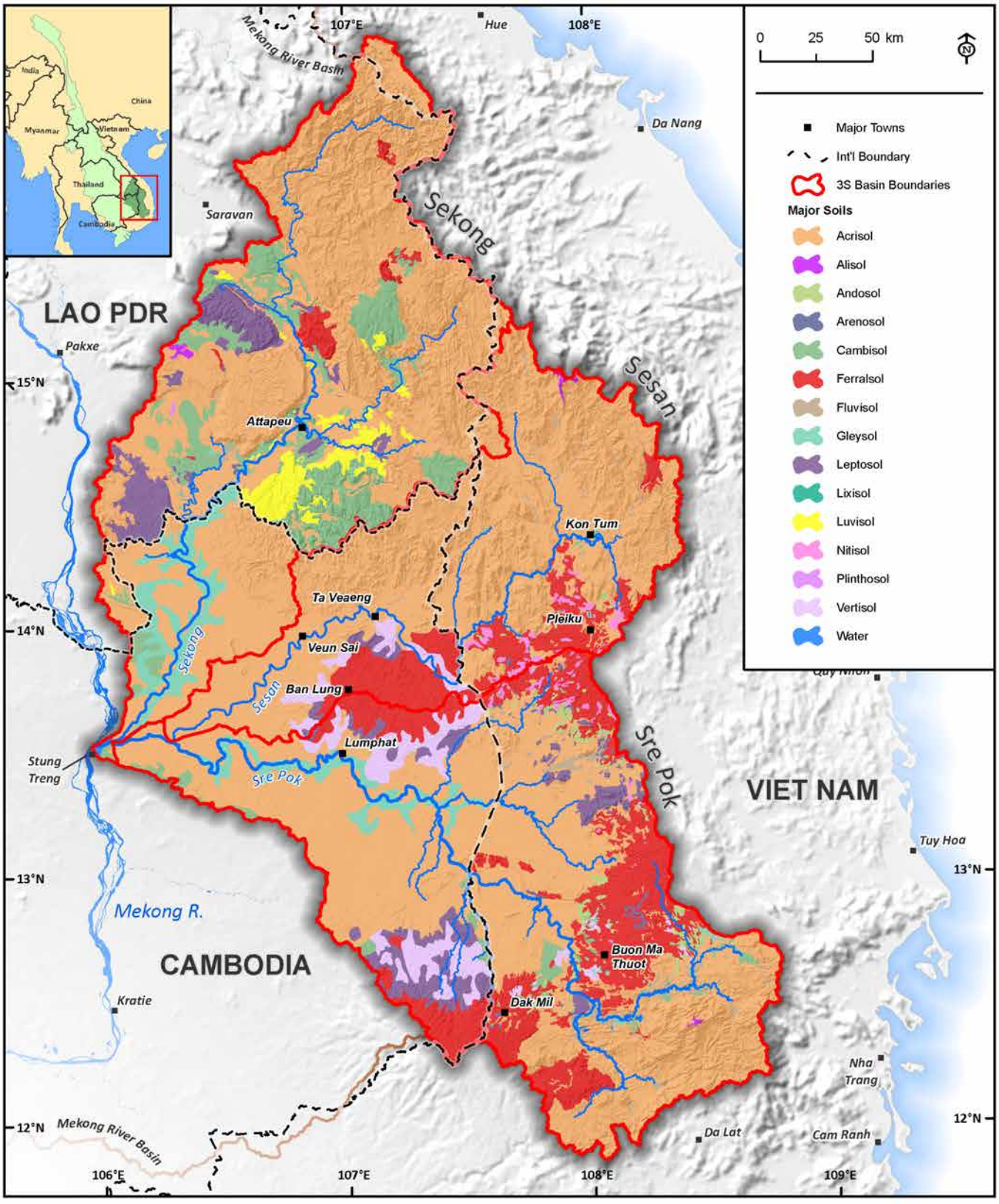
Soil Type	Characteristics
Acrisols	Relatively unproductive soil for agriculture, acidic and lacks key nutrients. Crops that can tolerate this soil type include cashew and pineapple. Acrisols are susceptible to erosion.
Ferrasols	Lack key nutrients, but with application of fertiliser they can be made more productive. Rubber trees can be grown on ferrasols.
Gleysols	Waterlogged soil often found in areas with shallow groundwater, they can be used for rice cultivation or for animal pasture.
Leptosols	Rocky soil with more limited potential for agriculture or tree crops.
Luvisols	Organic soil with silicate clay accumulation, often associated with lower elevation forested areas.
Vertisols	Productive agricultural soil with poor drainage, often used for crops tolerant of waterlogged soils.

Source: Modified from Someth et al. 2013.

The Sekong Basin has a slightly different soil composition compared to the 3S as a whole, with relatively more leptosols and luvisols. In the Sekong, luvisol areas remain mainly forested, with some clearing, but do not appear to be used for agriculture, possibly due to uneven and rocky terrain. The Sesan Basin is characterised by acrisol soils, which underlie around 80% of its area. Ferrasols are the next most common soil type here and make up almost 14% of the remaining area.

The Sre Pok Basin has a similar soil composition to the Sesan, but with a smaller area of acrisols (60%) and more ferrasols (20%). Gleysols are associated with the riparian corridors along the lower Sekong and Sre Pok. This soil type can be used for rice cultivation, but there is relatively little rice cultivated on these soils in the 3S Basins compared to the extensive rice paddy areas in the Mekong Delta.

Soil erosion is an emerging issue in some areas, and can be caused by changes land cover, such as from agricultural activities or surface mining. Riparian soil erosion can also be caused by changes in sediment loads associated with dams. As dams trap sediment, the water they release downstream erodes riverbanks as it seeks to return to a balanced sediment load (Someth et al. 2013). This has been an observed problem in the Sesan and could become more widespread with further hydropower development and changing land use.



Soils

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Soils: Mekong River Commission

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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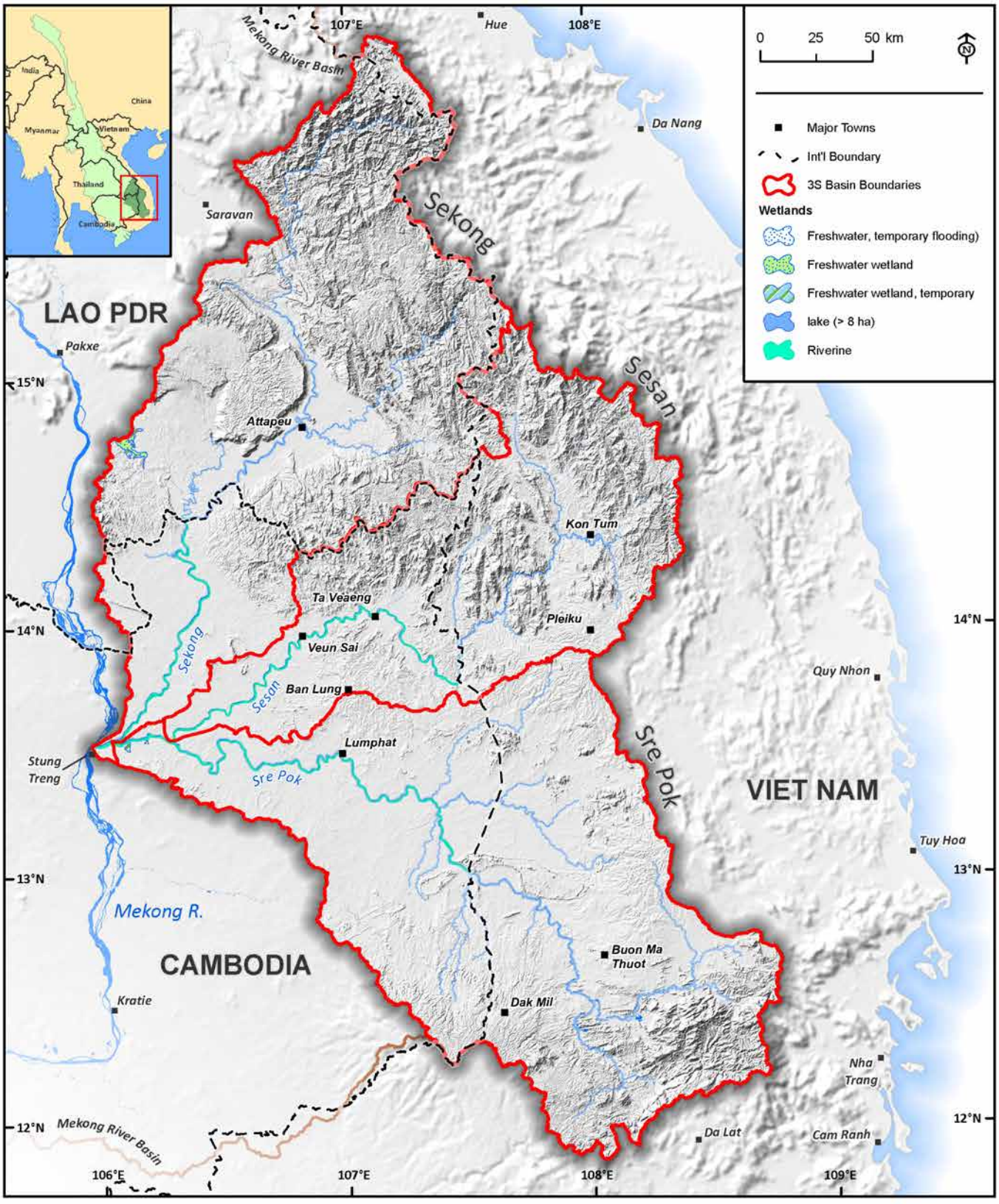
2.7. Wetlands

This map shows the location of wetlands within the 3S Basins as identified by the MRC. Wetlands provide important natural habitats for a variety of freshwater fish, birds, turtles, and other species. These areas are also recognised for their utility in lessening flood damage, providing clean water and as a source of food for local residents. In the LMB, the majority of wetlands are used for rice cultivation.

Most wetlands in the 3S Basins are classified as riverine and follow the lower reaches of the Sekong, Sesan, and Sre Pok Rivers. These ‘wetland’ areas are considered to approximately stretch from Cambodia to where the rivers meet the border with Lao PDR and Viet Nam in each basin. Two seasonal wetlands are also found on the left bank of the Sre Pok River, upstream of its confluence with the Sekong. A larger freshwater wetland, Beung Kiat Ngong Ramsar Site, is found on the western border of the Sekong Basin, southeast of Pakxe, Lao PDR.



Wetlands

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Wetlands: Mekong River Commission

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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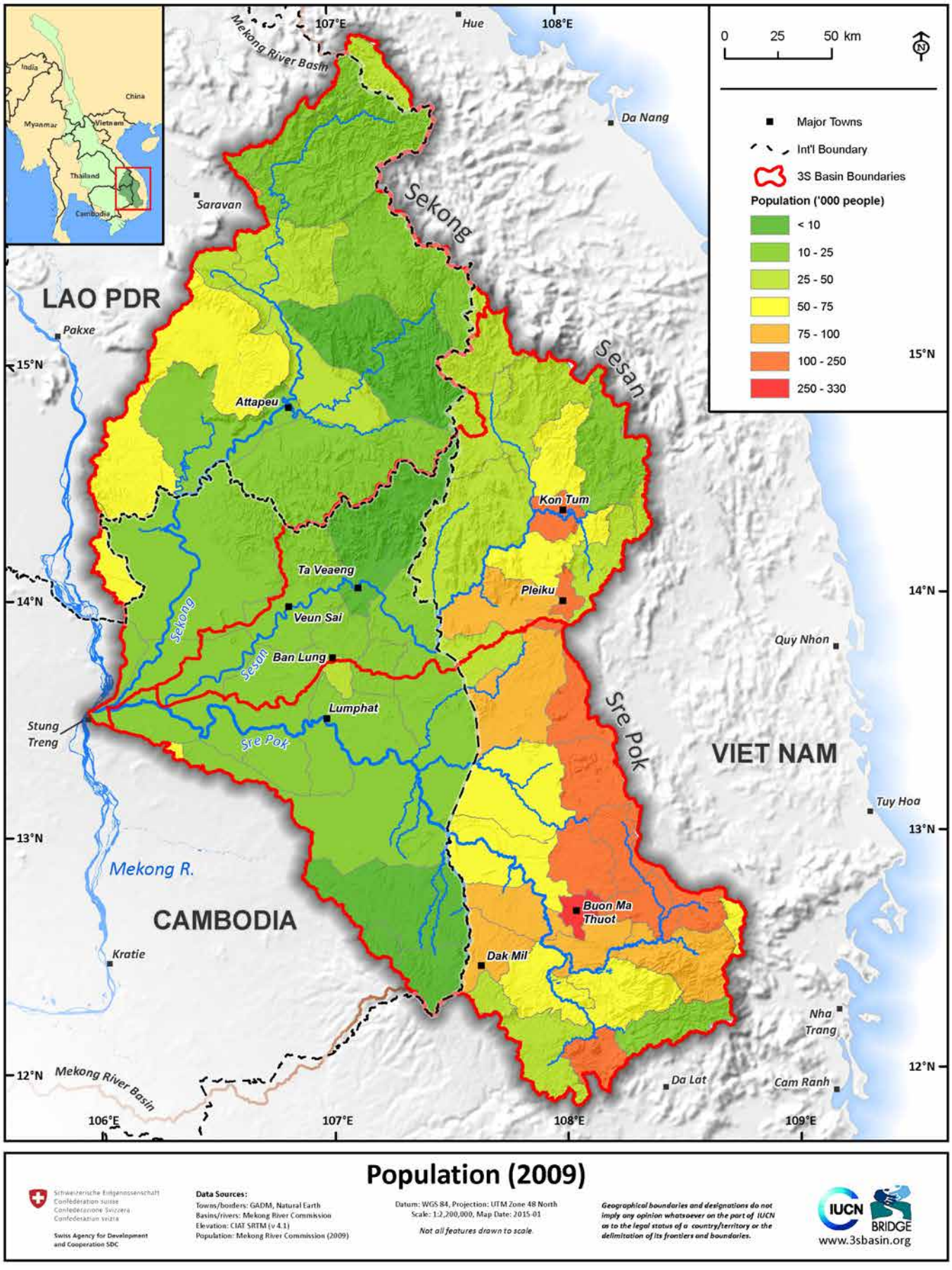
3. Population and socio-economics

3.1. Population

This map shows population distribution in the 3S Basins. Data was compiled by the MRC from national census data collected between 2005 and 2009. The population within the districts overlapping with the 3S Basins was reportedly 3.99 million in the year 2008. However, parts of some of these districts overlap with areas outside of the basins so the numbers may be overestimates. Projections from 2007 to 2015 estimated that the population would grow to 4.4 million – an increase of 11% from 2007 figures.

The lower area of the 3S Basins and the entire Sekong Basin are the least populated areas in the Mekong Basin. There are a few large cities, although some provincial towns have relatively high populations (for the area). The district of Buon Ma Thuot has the largest population at around 350,000 (if the surrounding areas are included). Other large population centres in the 3S Basins include Pleiku (220,000), Kon Tum (150,000) and Ban Lung (27,000). Population is concentrated in and around these towns and is notably higher in the parts of the 3S Basins located in Viet Nam, compared to the parts within Cambodia and Lao PDR.



Population (2009)

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Population: Mekong River Commission (2009)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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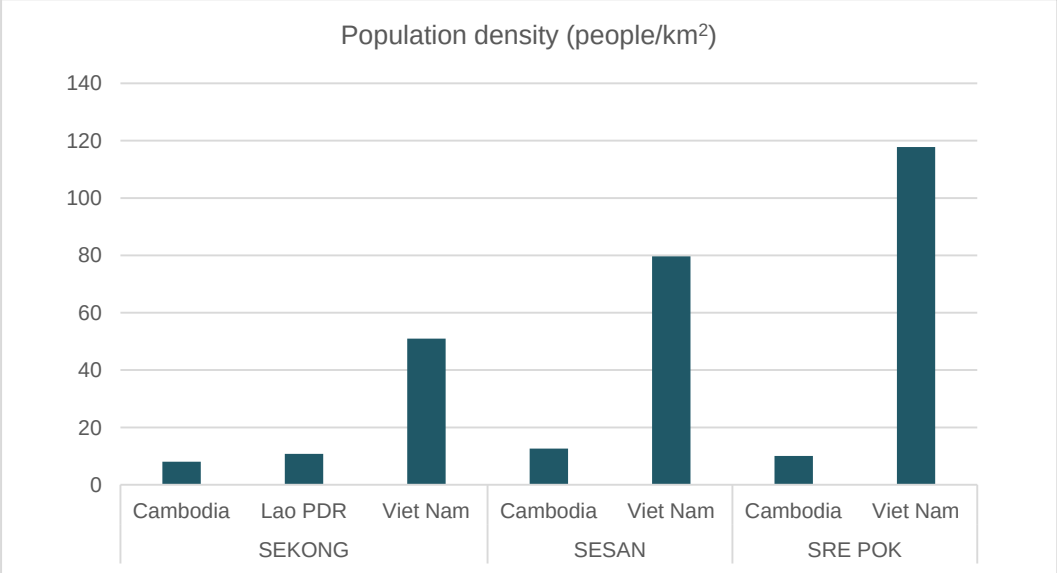
3.2. Population density

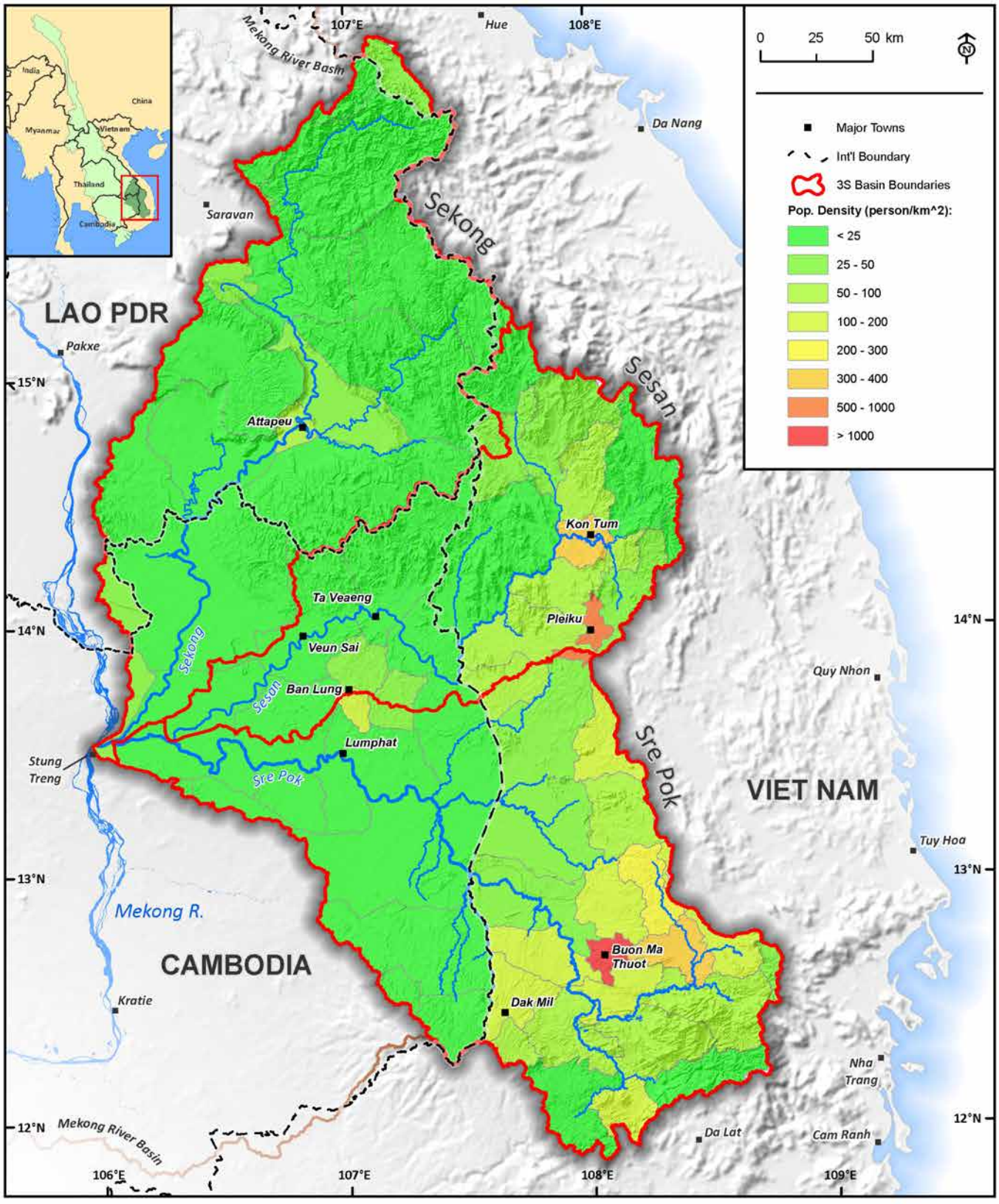
This map shows population density (the number of people per unit area) in the 3S Basins. Green areas denote lower density, while yellow, orange, and red represent areas with more people in a given area. The data is reported by district. Some larger districts have relatively low densities given their population, while smaller districts (such as the joint town/district of Kon Tum) have a high population density, a factor influenced by both their overall population and smaller land area. From the map it is clear that population density is generally low throughout the 3S Basins, but is higher in areas within Viet Nam.

Population density varies greatly, from 2.6 people per square kilometre (people/km$^{2)}$ in some districts in Ratanakiri Province, Cambodia, to nearly 1,200 people/km^2 in Buon Ma Thuot. The next densest areas are (as would be expected) other population centres, including Pleiku (714 people/km^2), Krong Pac District (347 people/km^2), and Kon Tum (310 people/km^2).

As noted above, population and population density vary greatly even within the same basin. In the 3S Basins population density is highest in the Sre Pok and Sesan Basins. Population density is also higher in the upper portions of all three basins, a fact influenced by higher population densities in Viet Nam.

Figure 3: Population density (year 2005) in the 3S Basins





Population Density (2009)

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Population Density: Mekong River Commission (2009)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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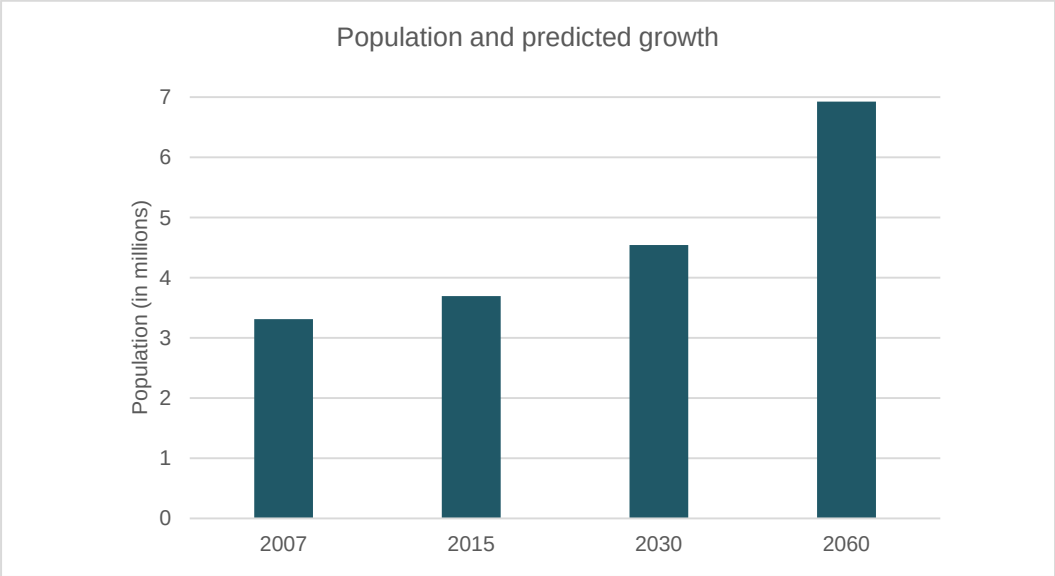
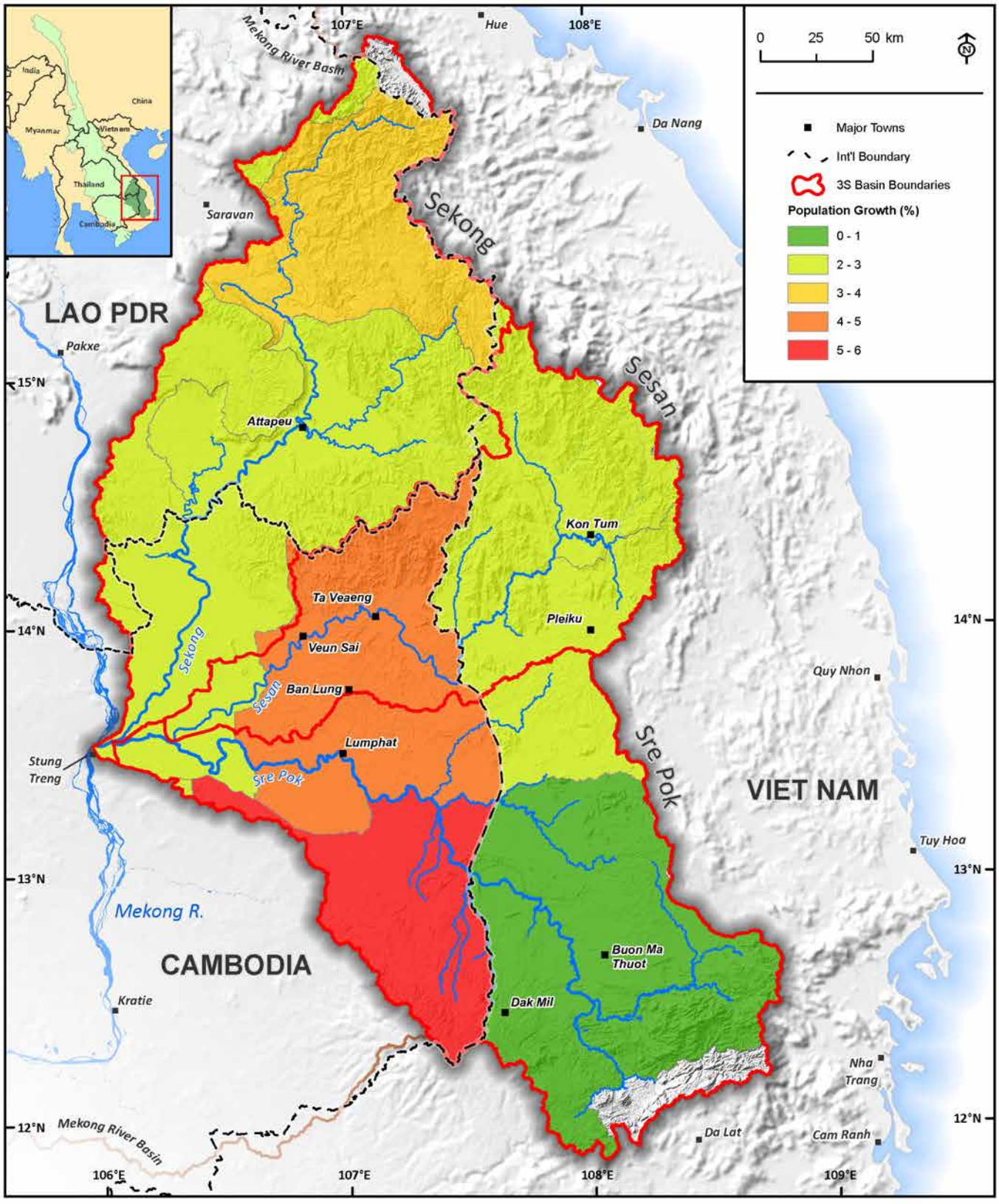
3.3. Population growth

This map shows predicted population growth in the 3S Basins. By the year 2060 the population is predicted to be roughly double that of 2007 levels, at almost seven million people. Some areas, such as the upper Sre Pok, are projected to see large increases in population. However, as a *proportion* of the current population, this growth will be lower than in areas in Cambodia where a lower population (in 2007) means a larger percentage increase year-on-year.

Population growth in the portions of the basins in Viet Nam may be partially driven by government policies incentivising migration and settlement of people in the Central Highlands, as well as the country's rapidly growing economy. There are some gaps in the current available data and these are left blank in this map.

Figure 4: 2012 Population growth projections in the 3S Basins





Population Growth Rate

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Population Growth: Mekong River Commission (2009).
Dates vary by country; approximately from 1999-2008.

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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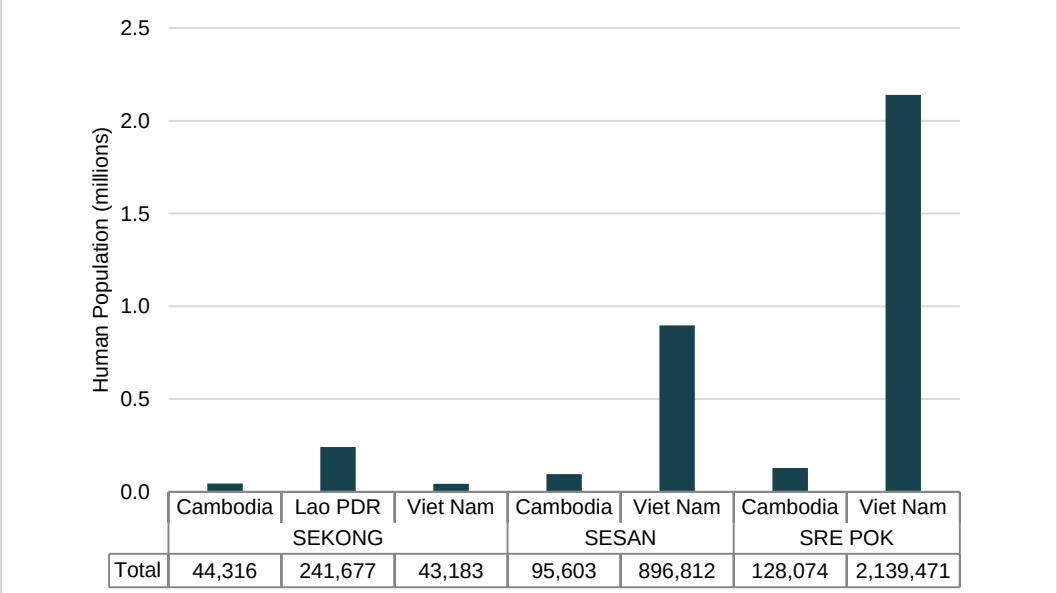
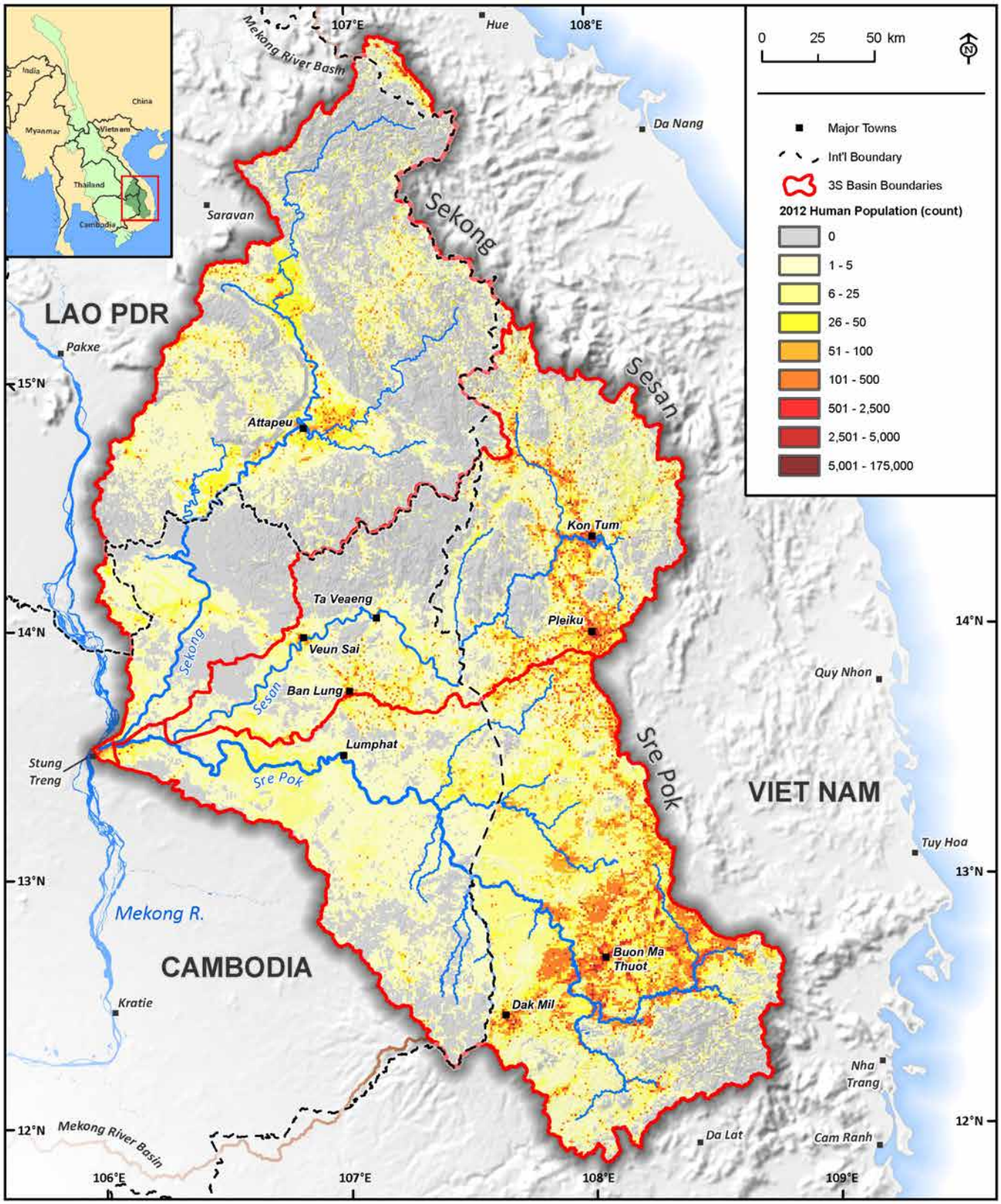
3.4. Population distribution (2012)

This map shows an estimate of population distribution in the 3S in the year 2012. Inhabited areas are modelled with the use of a complex technique developed by Oak Ridge National Laboratory in the US and which incorporates census data, land cover, slope, roads and the location of towns and villages, aside from other data. These datasets are indicators of population levels and can help in visualising the location of people more specifically compared to provincial aggregations. Such information can be useful for illustrating where population is concentrated, for example in relation to rivers, transportation corridors or protected areas. However, the numbers must be viewed as an estimate, not as an exact count.

The data estimates that, of the roughly 70 million residents in the Lower Mekong Basin (as of 2012), 4.7 million (7.7%) live in the 3S Basins. As similarly shown in the previous maps, the vast majority of people are located within Viet Nam. In general, population is concentrated in provincial towns, in valleys that allow for large-scale agricultural cultivation, and along riparian areas and transport corridors.

Figure 5: Population in the 3S Basins (2012)





Population Distribution (2012)

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Population Distribution: Landscan (2012)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale

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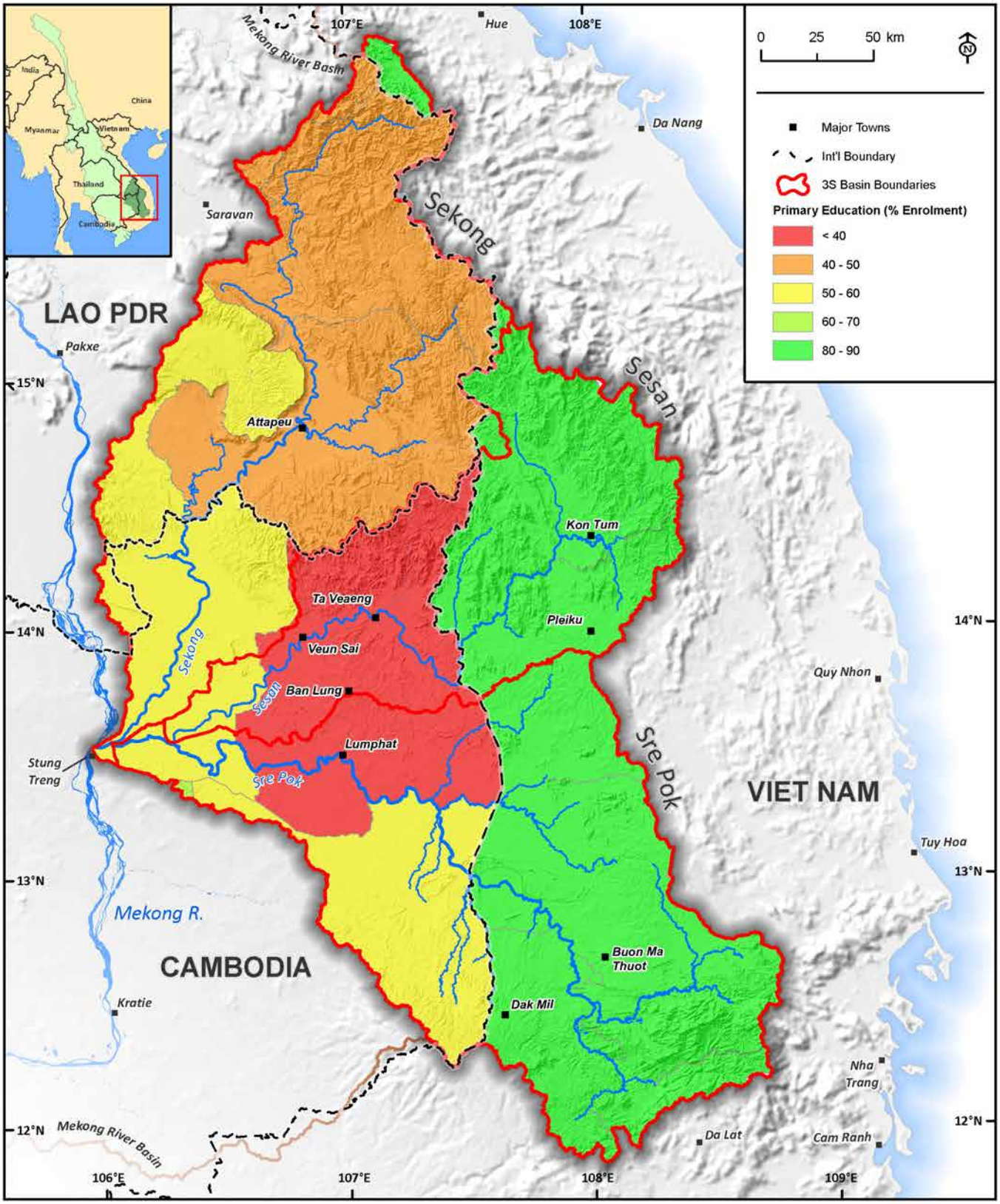
3.5. Primary school enrolment

This map illustrates primary school enrolment in the 3S Basins. Primary school enrolment is defined as the proportion of primary school-age children who attend school on a regular basis. As shown in the map, there is a stark difference in access to education among the three countries of the 3S Basins. However, data on Viet Nam as compiled by the MRC is only available as national averages and estimates. This national average shows that more than 80% of the primary school-age students in Viet Nam are enrolled (although, again, this figure does not represent the actual proportion in the 3S Basin).

In Cambodia provincial figures fall below 50% in much of the basin, and as low as 32% on average in Ratanakiri Province. Primary school enrolment is also low in Lao PDR, where less than 50% of students attend school on a regular basis, a proportion similar to the national average. This translates into low school completion rates: only one-third of students that enter the first grade in Lao PDR are estimated to complete all five grades of primary schooling.

More detailed data for all three countries could identify areas with lower access to education, which has wide-ranging implications for economic development, human health and other factors.



Primary Education Enrolment

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Education: Mekong River Commission (2009)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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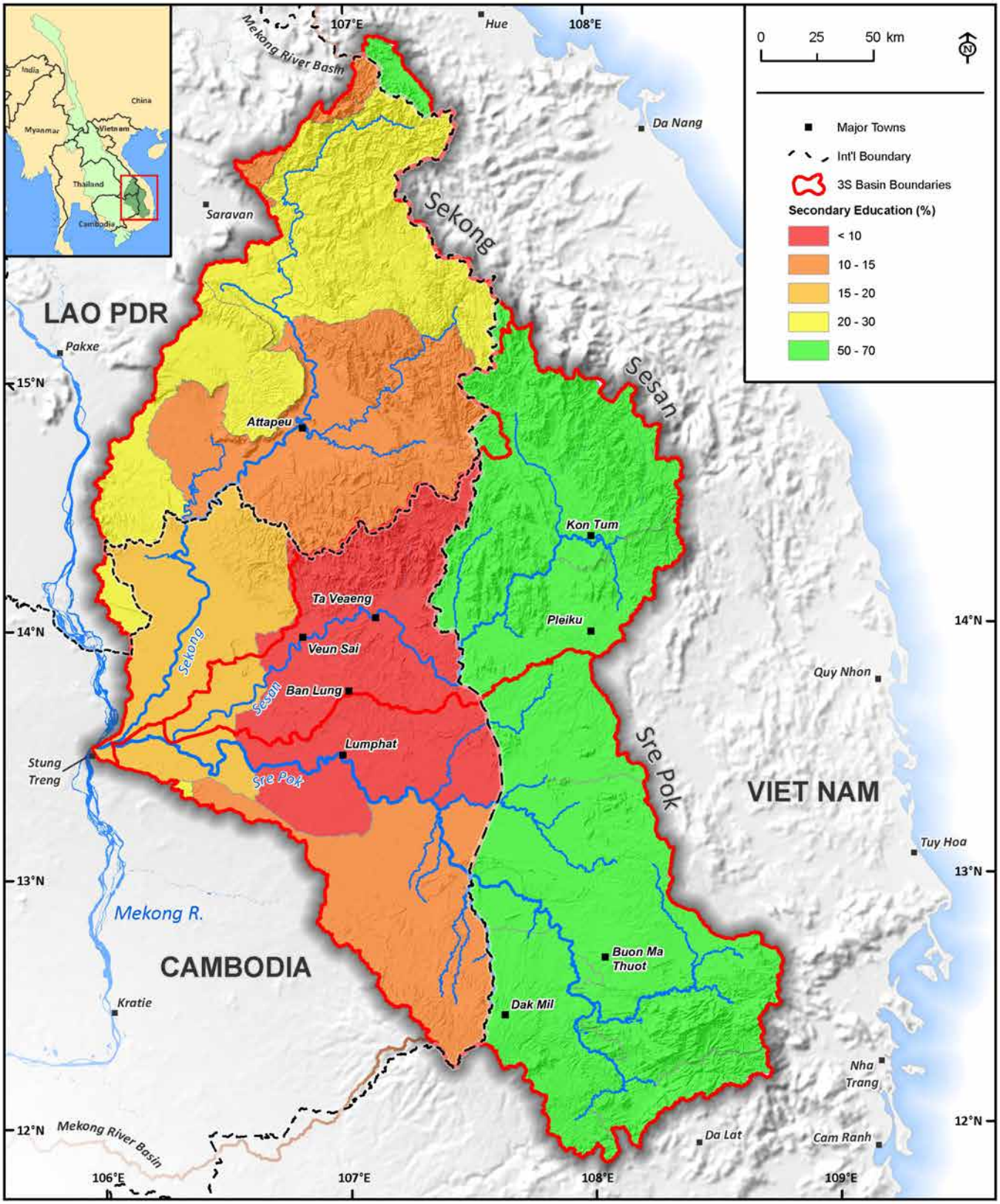
3.6. Secondary school enrolment

This map shows secondary school enrolment – the proportion of secondary school-age students attending school – in the 3S Basins. Data for Viet Nam is displayed at the national level, while data for Lao PDR and Cambodia have been aggregated by province.

Secondary school enrolment follows similar trends as primary school enrolment, although it is lower in all three countries. In Viet Nam at least 50% of all secondary school-age students are enrolled, although this is an average and is unlikely to accurately represent the situation in the 3S Basins. In Cambodia the figure is below 20% in Stung Treng province and is less than 10% in Ratanakiri. Figures for Lao PDR are similarly low. Potential reasons cited for lower educational attainment in Cambodia include distance to schools, instruction in Khmer (a second language for many), expense of books and materials, need for labour within the family and frequently absent teachers.



Secondary School Enrolment

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Education: Mekong River Commission (2009)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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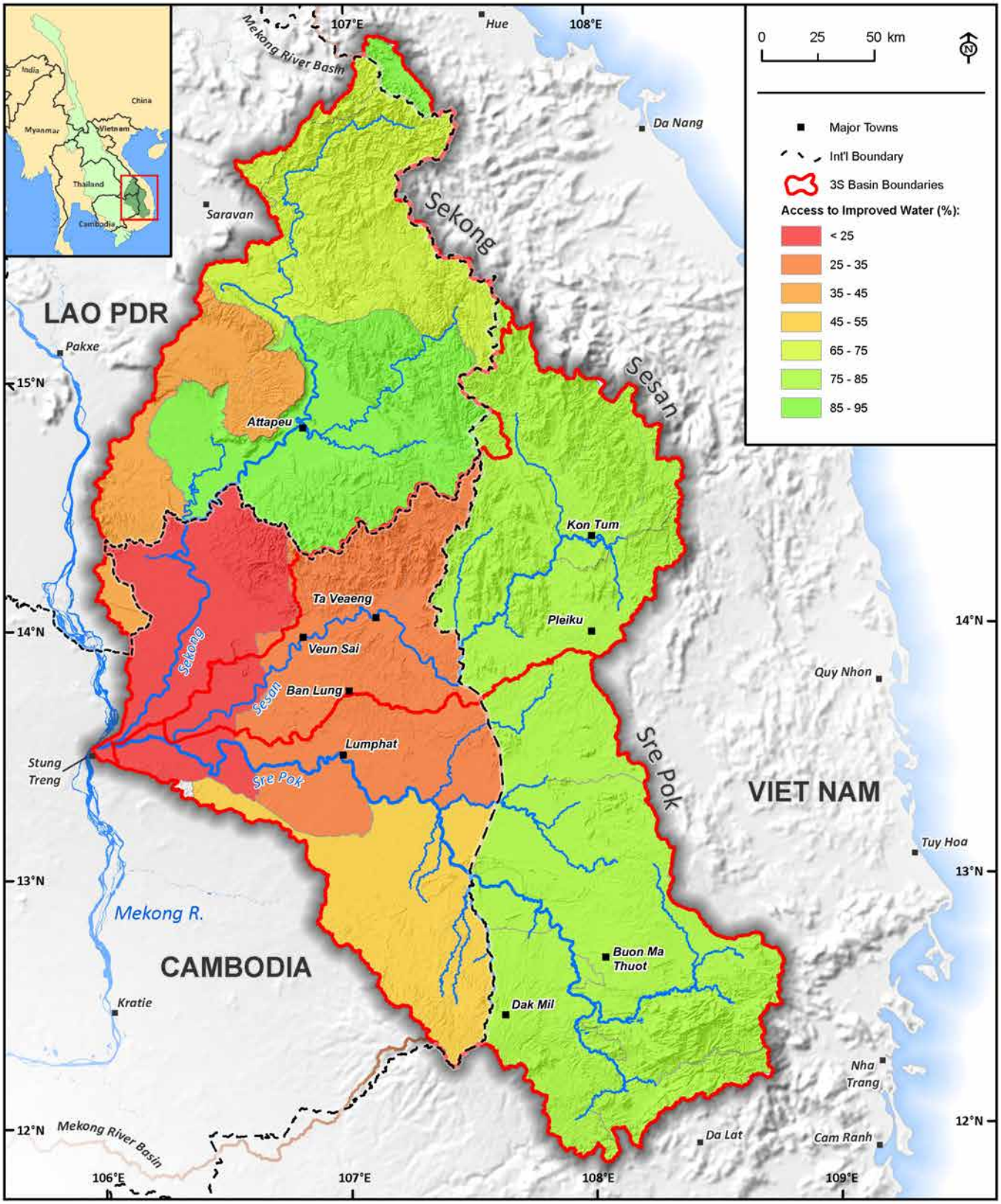
3.7. Access to improved water sources

Improved water sources have different definitions, but generally refer to reliable access to safe drinking water, such as from a protected spring, well or filtered or treated water sources. While not all national census surveys collect data according to World Health Organization (WHO) definitions of “improved” water sources, data collected, such as the proportion of a population with access to “safe” drinking water, are believed to be similar enough to be included here. This map shows access to such water sources, with data aggregated by province in Cambodia and Lao PDR, and by region (Central Highlands) in Viet Nam.

In Viet Nam, the proportion of the population with access to potable water supply is estimated at between 80 and 90%. In Ratanakiri and Stung Treng Provinces in Cambodia 61% of residents obtain water from natural springs or river streams. Another 32% use well water and only 5.5% use water that is treated (either purchased, piped or from tube wells).

As of 2005 the proportion of the population in Lao PDR with access to piped and treated water sources was also low, but varies greatly according to location. In general, residents of lowland areas here have greater access to improved water sources, reaching above 85% in areas around Attapeu. On the Bolaven Plateau this falls below 45%.



Access to Improved Water Source

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Water: Mekong River Commission (2009)
(% of population with access to improved water)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

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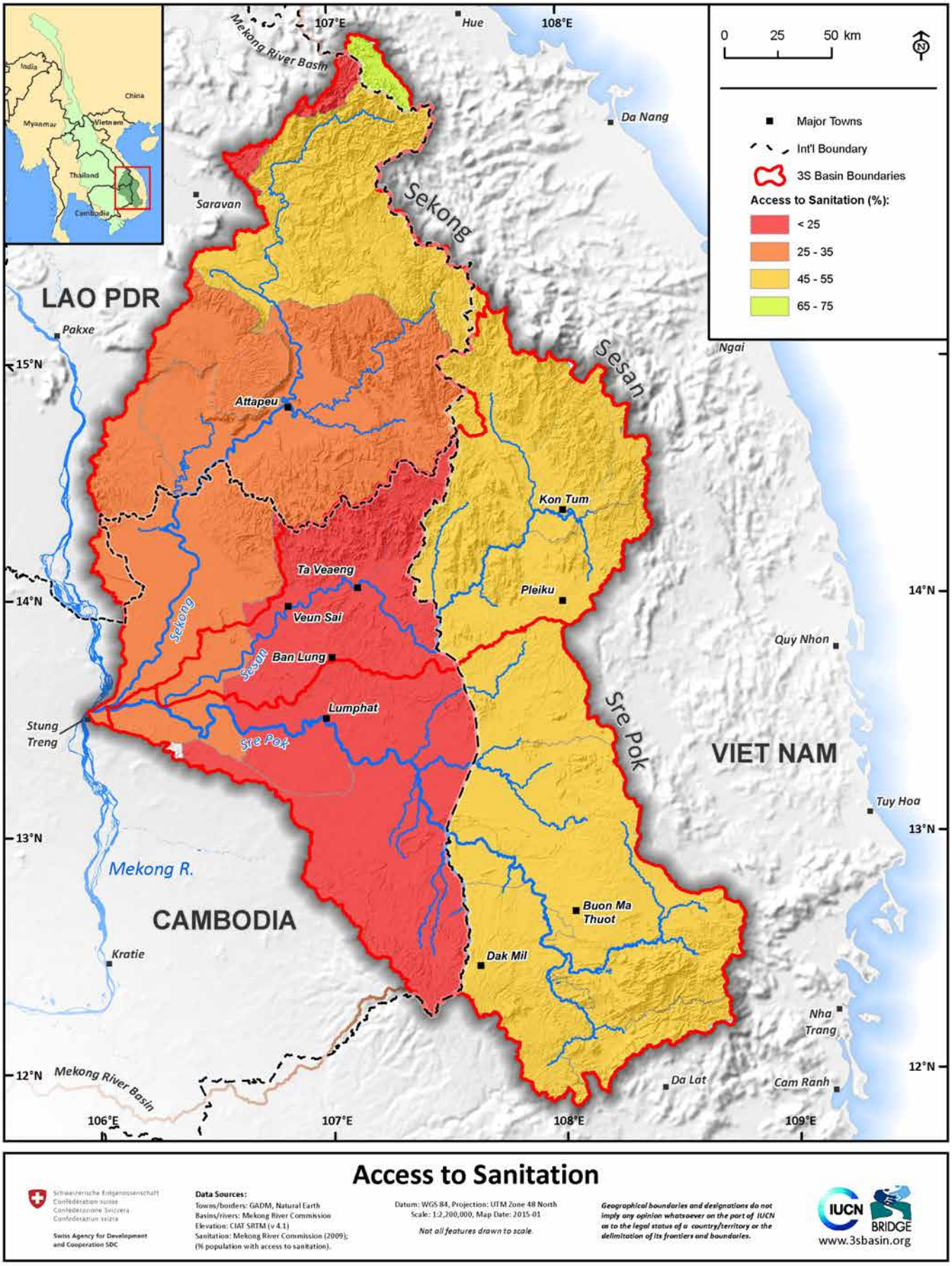
3.8. Access to Sanitation

This map shows sanitation access in the 3S Basins by province. The exact definition of sanitation varies by country, but it generally refers to access to a flush or non-flush toilet or latrine in a location convenient to the place of residence. Access to sanitation is an important metric because it is often correlated with health (better sanitation can mean less polluted water) and higher income (less time sick can mean more income earned).

Sanitation access has lagged behind access to improved water supply and other development metrics in the 3S Basins. Access is generally low: less than half of the population in all three countries have access to improved sanitation facilities. This proportion is lower in more rural areas.

Cambodia has one of the lowest rates of household sanitation in Southeast Asia. A survey conducted by the United Nations Children's Fund (UNICEF) found that among lower income Cambodians the rate falls below 5%, although the average is significantly higher. Sanitation access in Lao PDR is also low, with over half of the rural population practising open defecation. Viet Nam is estimated to have slightly higher access rates of up to 55%, but this figure may be affected by the larger urban population as sanitation rates in rural areas are closer to 20%.

Governments in the region have been trying to prioritise access to sanitation as an important issue. For example, in 2004, Cambodia formulated a *National Water Supply and Sanitation Sector Policy* which mandates that the government will provide improved water and sanitation facilities to 100% of the population by 2025. Initiatives in Lao PDR and Viet Nam have also shown some success in increasing access to sanitation.



Access to Sanitation

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Sanitation: Mekong River Commission (2009); (% population with access to sanitation).

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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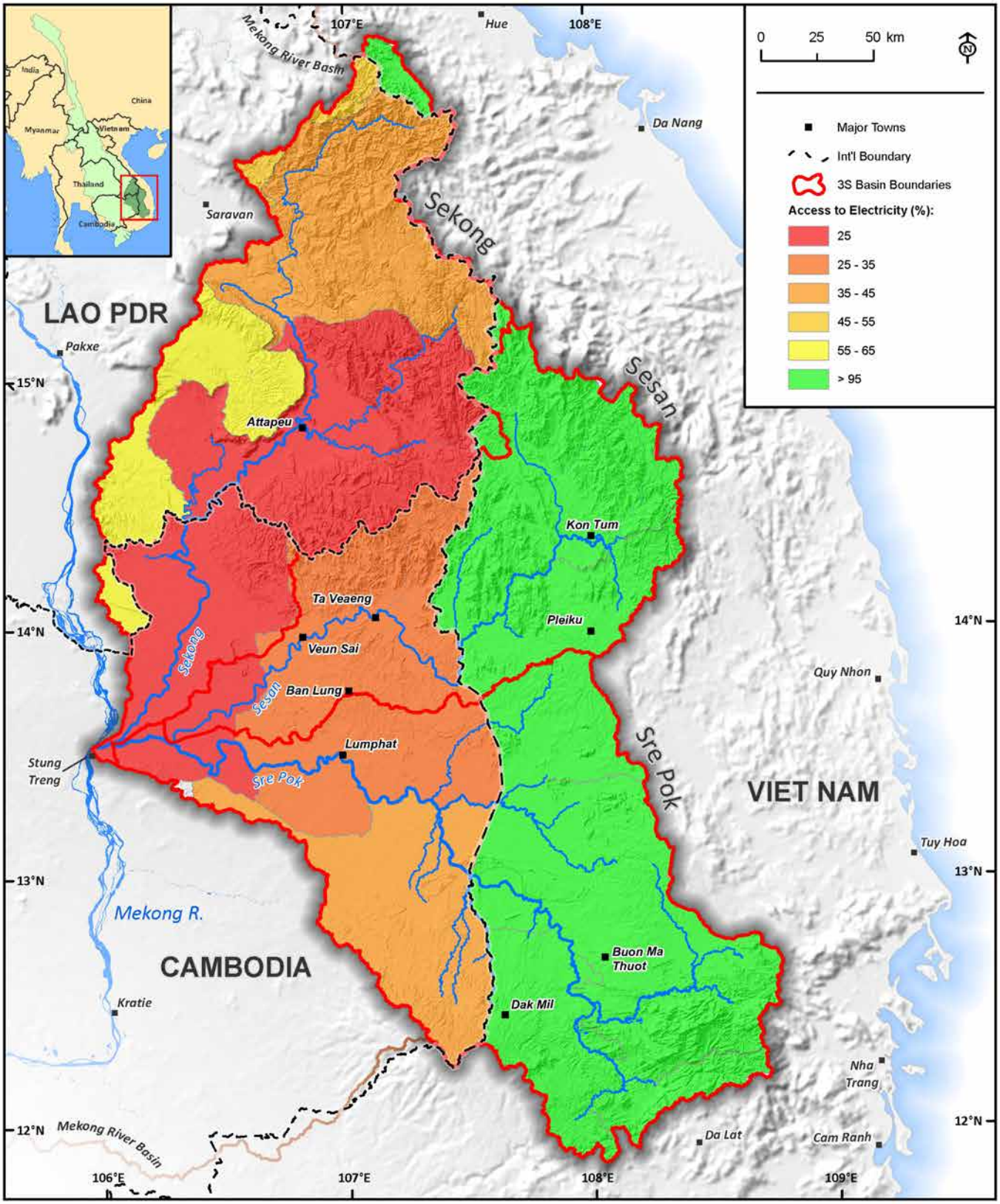
3.9. Access to electricity

The accompanying map illustrates electricity access in the 3S Basins. Data is displayed by province and shows the large differences in access among the three countries. Areas within the 3S Basins have experienced very high economic growth rates in recent years. This has helped raise many in the region out of extreme poverty and also increased demand for electricity.

In Viet Nam, power demand increased by 400% nationwide between 1990 and 2008, and it is expected to continue to grow at 10% per year through 2020. Cambodia faces acute power shortages – only one-quarter of the population has access to electricity from the grid. The portion of the Sekong Basin in Lao PDR has some of the lowest electrical power access rates in the region, for example reaching as low as 15% in Attapeu Province.



Access to Electricity

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Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Electricity: Mekong River Commission (2009); (% population with access to electricity)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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3.10. Consumption of fish and other aquatic animals

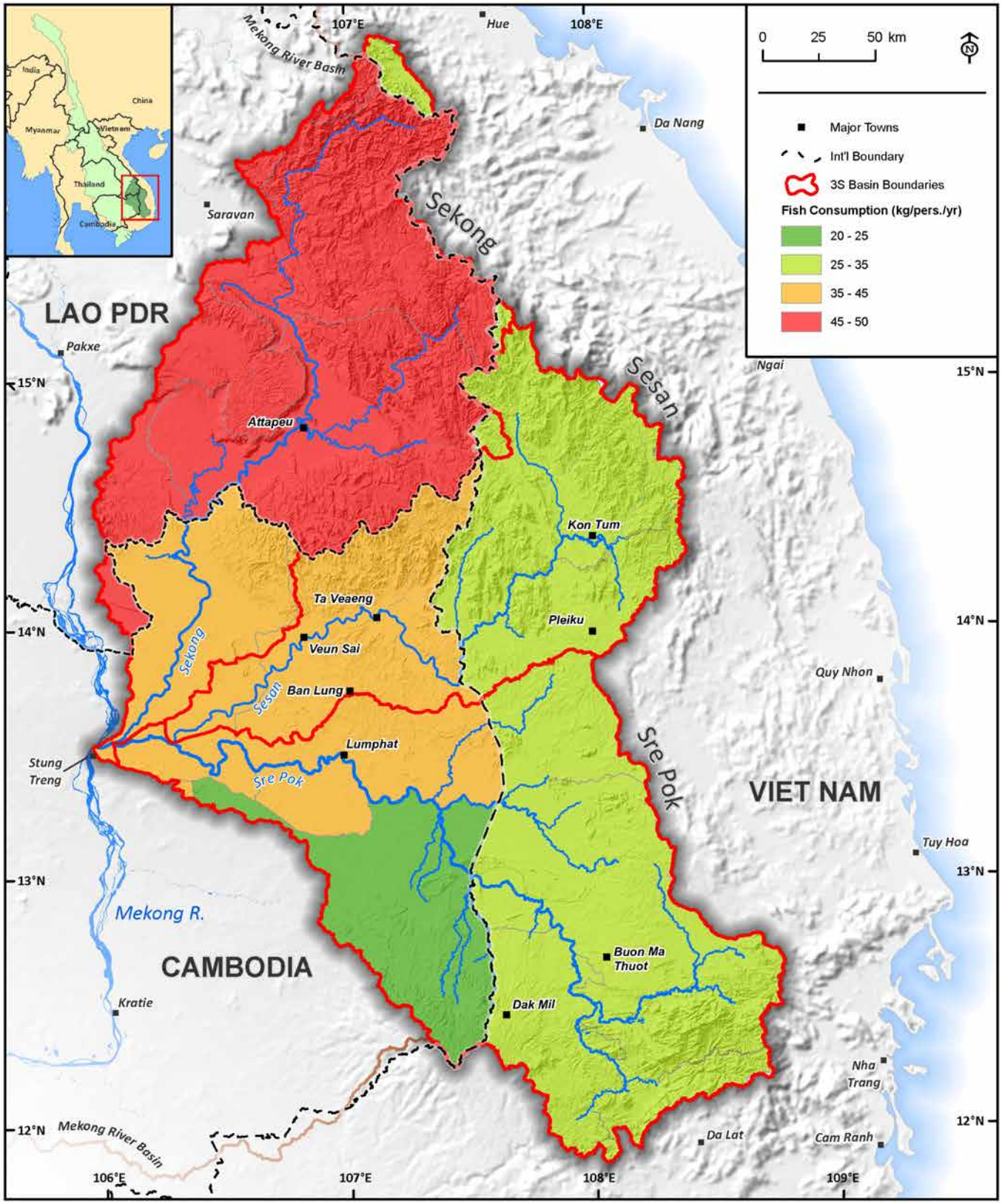
This map shows estimated annual per capita consumption of fish and other aquatic animals, by province. The latter includes all other freshwater animals which, along with fish, are an important part of the diet in the 3S Basins.

Mean per capita annual consumption is highest in the Sekong Basin, where it is around 45 kilograms (kg). Figures are similarly high in Cambodia, at between 35 and 45 kg/person/year, and lowest in Viet Nam where it is estimated at 25 to 35 kg/person/year.

Fish and aquatic animals are also important for the economy of the basins. In the Cambodian portion of the 3S, annual revenue related to water and associated resources reaches around USD10 million, of which 91% comes from freshwater fisheries (CNMC 2011).

However, fisheries here are facing a combination of threats. These include changes to the natural environment and flow patterns (Ziv et al. 2012), land cover change and modification of floodplains and overexploitation of fisheries resulting in decreased fish populations. Climate change has also been identified as a potential threat to fisheries and livelihoods, primarily through predicted changes to precipitation and runoff.

Of the 781 fish species recorded in the Lower Mekong Basin, 329 (42% of the total) are found in the 3S Basins. According to the IUCN Red List of Threatened Species™ 14 of these are Endangered or Critically Endangered.



Per Capita Fish Consumption

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Fish Consumption: Mekong River Commission; (annual average consumption, kg/pers./yr)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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4. Water resources and climate

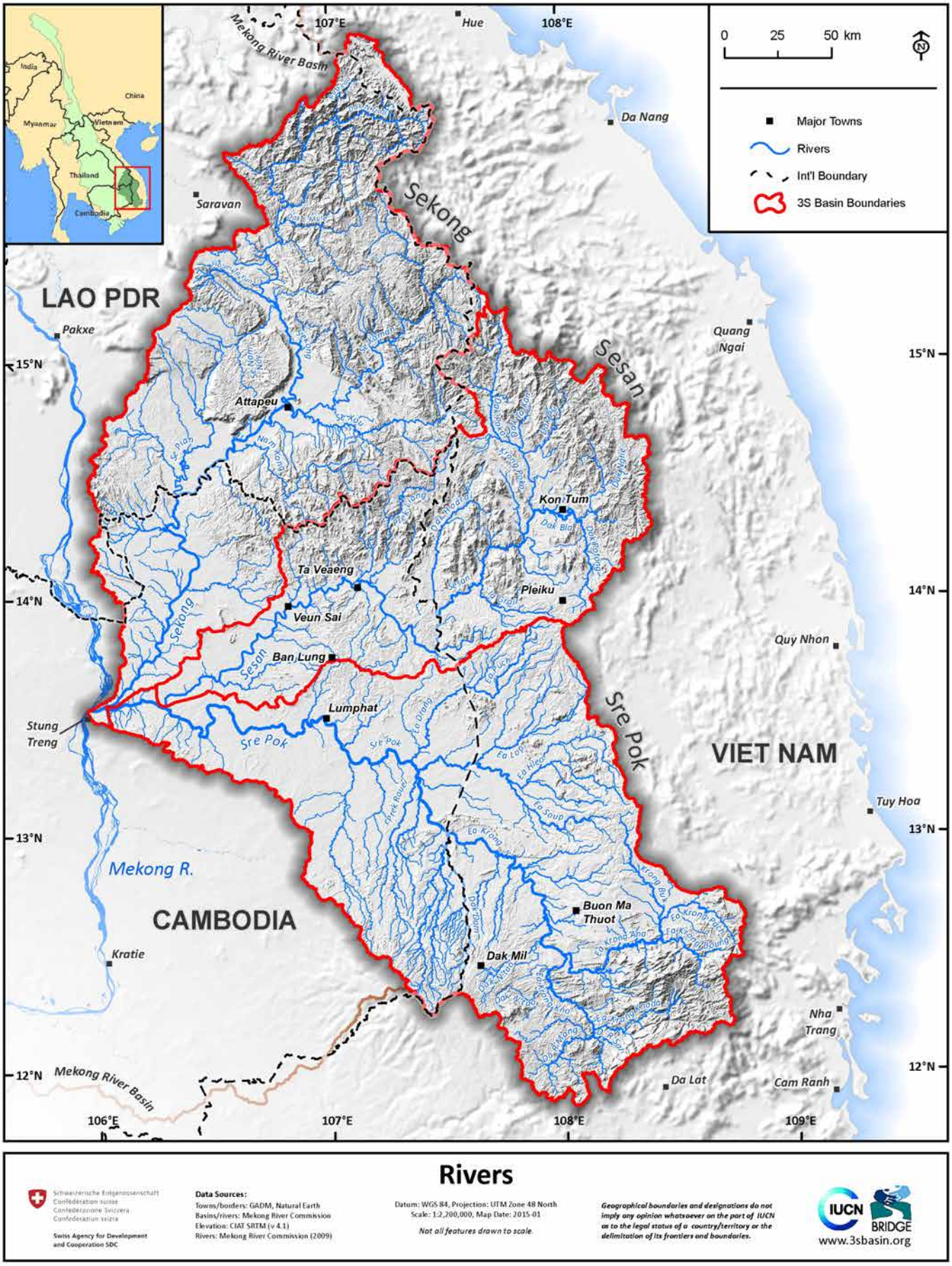
4.1. Rivers

This map shows the location of the three eponymous rivers in the 3S Basins – the Sekong, Sesan, and Sre Pok – as well as their tributaries. These rivers are shaped by precipitation patterns and the underlying topography and geology which cause them to flow generally westward, towards the mainstream of the Mekong River.

In the north of the Sekong Basin, the Rao Lao and Dak N'Troll Rivers cascade down steep terrain and join, later converging with the Dak E Mule and Houei Ta Yun Rivers. The Xe Nam Noy River joins after flowing off the Bolaven Plateau. This forms the beginning of the Sekong River above the town of Attapeu. From here, the Sekong River traverses relatively lower slopes and is joined by the Se Pian River at the Cambodian border. In Cambodia the Sekong continues to be joined by a network of smaller dendritic tributaries until it joins the Sesan and Sre Pok and discharges to the Mekong River.

The Sesan River is fed by two major tributaries that join above the Plei Krong Dam, near the town of Kon Tum in Viet Nam. The Dak Bla River flows to the west and is joined by the Krong Poko, which flows south. West of Pleiku, the Sesan River travels through areas where it is bound by natural topography, and is joined by the Dak Hodrai River at the Cambodian border. From here it forms the border between Cambodia and Viet Nam, and eventually it makes a 90 degree turn near the basin boundary with the Sre Pok. From there it travels northwest towards the town of Ta Veaeng. Downstream of Ta Vaeng, Cambodia the Sesan takes on a more meandering form as it traverses flatter terrain. After passing through a five km long rock-constricted channel it discharges into the larger Sre Pok River.

The Sre Pok River is fed by several tributaries that drain the highlands above the city of Buon Ma Thuot in Viet Nam. These come together to form the Ea Krong River, which is joined by the Dak Dam River to form the Sre Pok. The Sre Pok meanders through the lower Sre Pok Basin, passing the town of Lumphat and eventually converging with the Sesan and Sekong Rivers before discharging into the mainstream of the Mekong River.



Rivers

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Rivers: Mekong River Commission (2009)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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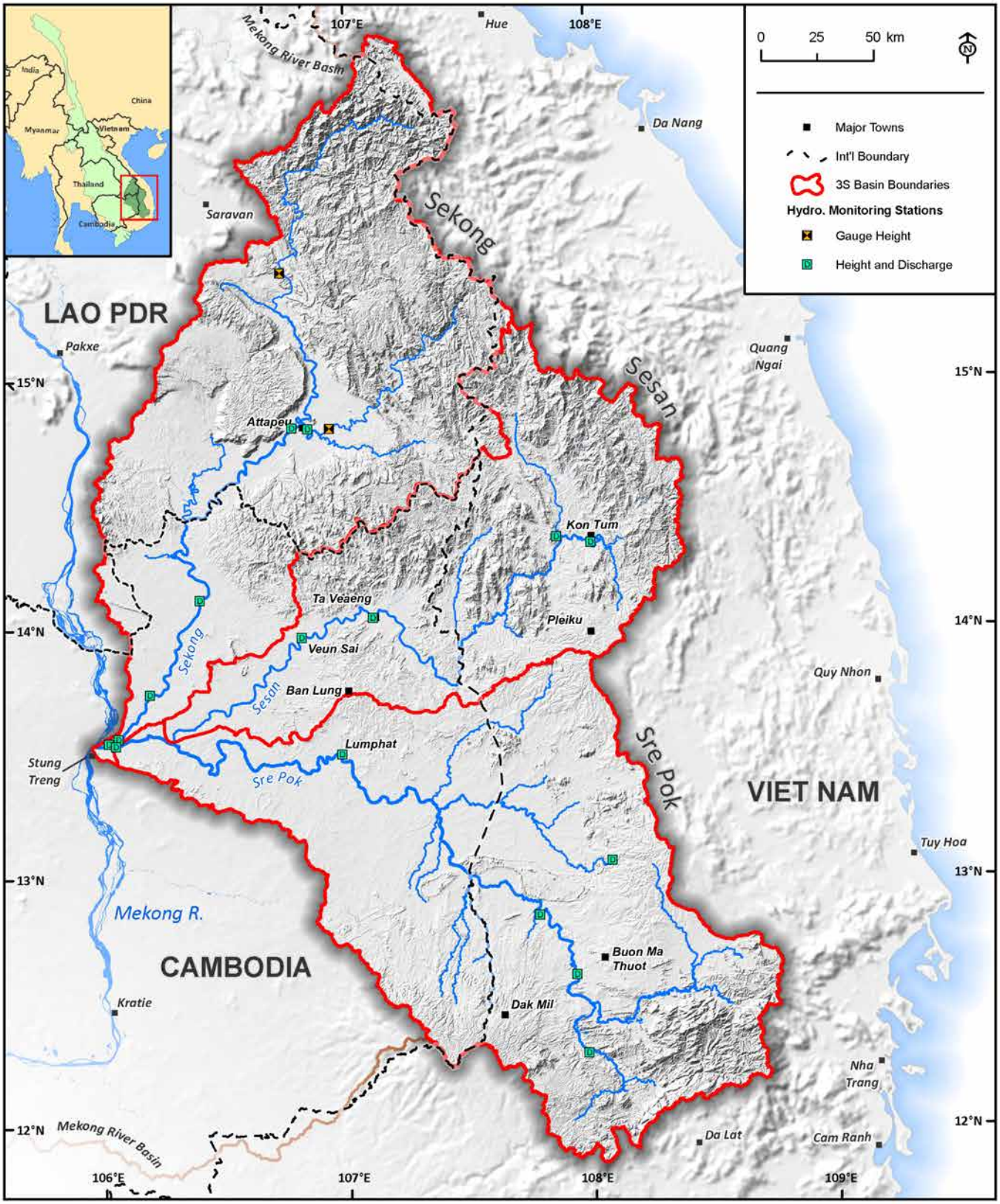
4.2. Hydrological monitoring stations

Hydrological stations measure water level, stream flow (discharge), and, in select locations, suspended sediment. In the 3S Basins, most stations measure discharge. Two long-term monitoring stations measure gauge height (water level) near the town of Attapeu. An additional 16 stations measure stream flow at six locations in Viet Nam, two in Lao PDR and eight in Cambodia. Measurements are also taken at hydropower plants, but these are not represented in this map.

Monitoring stations are run by each country and the data is provided to the MRC for inclusion in a master database. This data provides a useful baseline of discharge within the basin and can be used to compare changes over time.

Table 3: Hydrological stations in the 3S Basins Source: MRC 2010
Note: The dates in the two right-most columns indicate the years when data was available for a specific site.

Station name	Basin	River	Country	Parameter	Dates (water level)	Dates (discharge)
Stung Treng	Mekong	Mekong	Cambodia	Discharge	1910-70, 1991-06	1950-70, 1990-96
Ban Khmoun	Sekong	Sekong	Cambodia	Discharge	1961-70	1961-70
Siempang		Sekong	Cambodia	Discharge	1965-68, 2002-06	1965-68
Chantangoy		Sekong	Cambodia	Discharge	1960, 1992-2004, 2006	1960
M.May (Attapeu)		Sekong	Lao PDR	Discharge	1985,1987-96,1998-2006	1989-96,1998-2006
Veun Khene		Sekong	Lao PDR	Discharge	2001-06	2001-06
Khoueng Sekong		Sekong	Lao PDR	Gauge height	1994-2006	-
Ban Fang Deng (Attapeu)		Se Kaman	Lao PDR	Gauge height	1992, 2001-06	-
Voeun Sai	Sesan	Sesan	Cambodia	Discharge	1965-69, 2000-05	1965-69
Andaung Meas		Sesan	Cambodia	Discharge	2000-05	1965
Kontum		Dak Bla	Viet Nam	Discharge	1966-69,1973,1984-2006	1967-71,1974, 1984-2006
Trung Nghia		Krong Poko	Viet Nam	Discharge	1992-98	1992, 1993, 1995-98
Ban Kamphun	Sre Pok	Sesan	Cambodia	Discharge	1960-70, 1993-2006	1961-70
Lumphat		Sre Pok	Cambodia	Discharge	1965-70, 2000-2005	1965-69, 2000-2005
Duc Xuyen		Krong Kno	Viet Nam	Discharge	1985-2006	1985-2006
Cau 14 (Buon Bur)		Ea Krong	Viet Nam	Discharge	1966-69,1974,1984-87, 1989-2006	1967-69,1973, 1984, 1987
Ban Don		Vam Serepok	Viet Nam	Discharge	1992-94,1996-2006	1995-2006
Ia H'leo		Kinh Iahleo	Viet Nam	Discharge	1990, 1992-94	1990, 1992-94



Hydrological Monitoring Stations

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Hydro. Monitoring: Mekong River Commission; (data availability year differs by station)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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4.3. Meteorological monitoring stations

This map shows the location of monitoring stations for the historical hydrological monitoring database. The data gathered at these stations has established a baseline record for precipitation in the 3S Basins. In addition, monitoring stations at Ban Lung, and all stations in Viet Nam, record additional climatic variables such as temperature and evapotranspiration, among others.

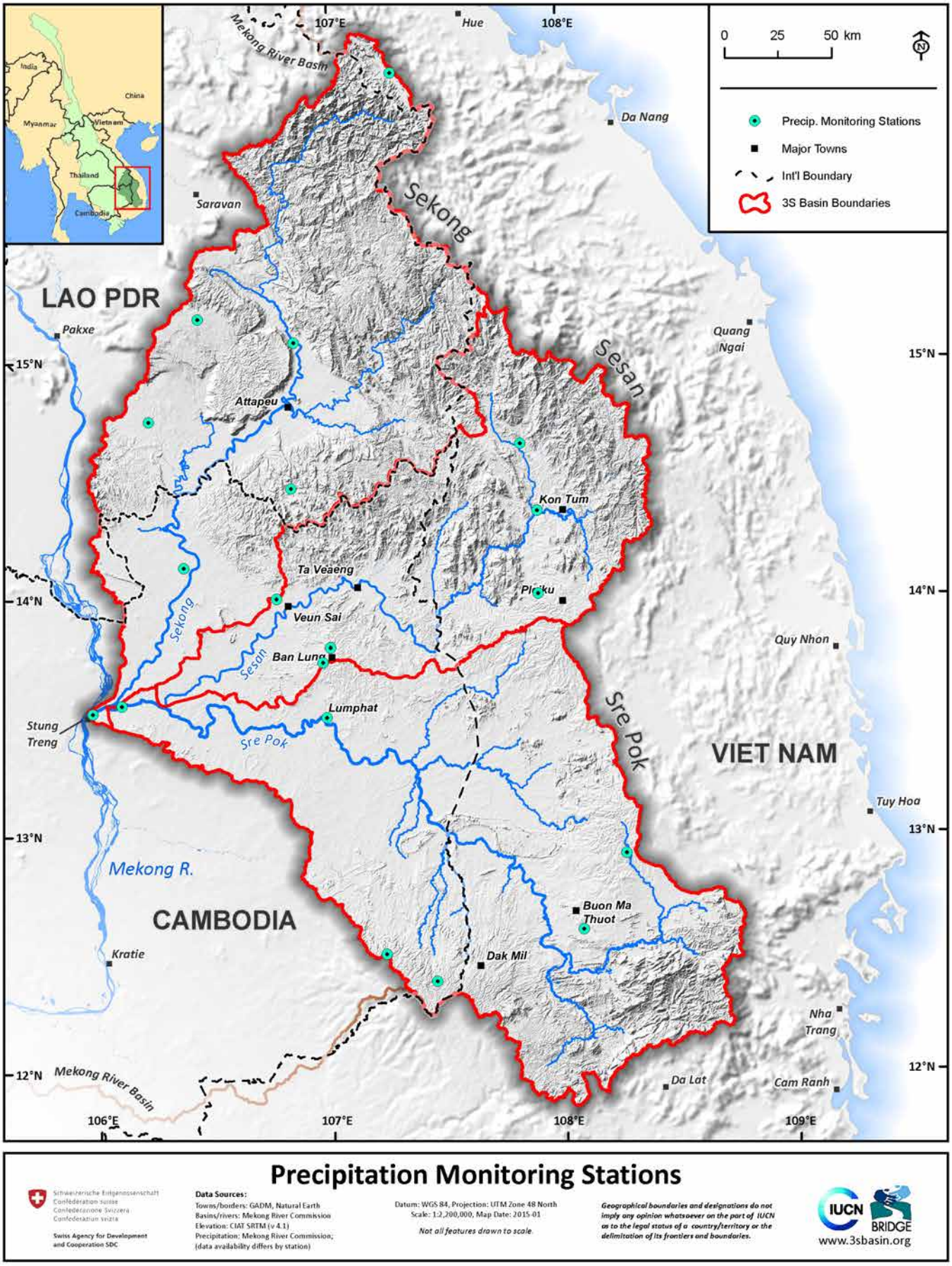
Long-term record reaches back to 1920 in some locations, such as at Stung Treng. However, only intermittent dates area available until more recent years. Stung Treng has the longest consistent record, starting in 1953.

In the Sekong Basin consistent data is available at most sites starting in the late 1980s to mid-1990s. In the Sesan the monitoring station at Voeun Sai has intermittent records reaching back to 1920, but regular records are only available from 1961-80, and again starting from the year 2000.

In the upper basin most sites started recording regular data in 2000, meaning a truly long-term record is not available. Records at Buon Ma Thuot start in 1927 but there are large gaps during periods of conflict.

Table 4: Hydrological monitoring stations

HYMOS station	Station name	Basin	Country	Years data recorded
130501	Stung Treng	Mekong	Cambodia	1920, ‘22-3, ‘25, ‘28, ‘30, ‘38-39, ‘43, ‘51, ‘53-present
140603	Seam Pang	Sekong	Cambodia	1925, ‘35, 1998-2002, 2004-06
140705	Attapeu		Lao PDR	1929-30, ‘32-33, ‘35-38, ‘43-44, 1988-2006
150605	Nonghine		Lao PDR	1980-2006
150607	Nikhom 34		Lao PDR	1991-94, 1996-2006
150609	Sekong		Lao PDR	1992-93, 1995-2006
160705	A Luoi		Viet Nam	2001-2006
130602	Ban Lung	Sesan	Cambodia	2000-02, 2004-06
130705	O Chum		Cambodia	2000-02, 2004-05
140602	Voeun Sai		Cambodia	1920, ‘22-25, ‘27-28, ‘30, ‘36-37, ‘54, ‘61-68, 2000
140703	Pleiku		Viet Nam	1927, ‘30-39, ‘56-59, ’61, ‘64-74, 1977-2006
140704	Kon Tum 2 (Lasan)		Viet Nam	1923, ‘25; ‘27-40, 42, ‘61-68, ‘71-74, ‘77-90, 1992-2006
140715	Dak To		Viet Nam	2001-06
120702	Sen Monorom	Sre Pok	Cambodia	1966
120703	O Raing		Cambodia	1958-65, 1967
130603	Lumphat		Cambodia	1961-65, ‘67, 2000-02, ‘04, ‘05
130605	Sesan		Cambodia	2001-02, 2004-06
120801	Buon Me Thuot		Viet Nam	1927-30, ‘51-56, ‘58-61, ‘63-74, ‘77-90, 1992-2006
120805	Buon Ho		Viet Nam	2001-06


Precipitation Monitoring Stations
0 25 50 km
Precip. Monitoring Stations
Major Towns
Int'l Boundary
3S Basin Boundaries
LAO PDR
VIET NAM
CAMBODIA
Mekong River Basin
Sekong
Sesan
Sre Pok
Mekong R.
Hue
Da Nang
Saravan
Pakxe
Attapeu
Kon Tum
Ta Veaeng
Veun Sai
Ban Lung
Lumphat
Stung Treng
Quang Ngai
Quy Nhon
Tuy Hoa
Buon Ma Thuot
Dak Mil
Kratie
Nha Trang
Da Lat
Cam Ranh
107°E
108°E
109°E
106°E
15°N
14°N
13°N
12°N
Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Precipitation: Mekong River Commission; (data availability differs by station)
Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01
Not all features drawn to scale.
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4.4. Mean annual precipitation

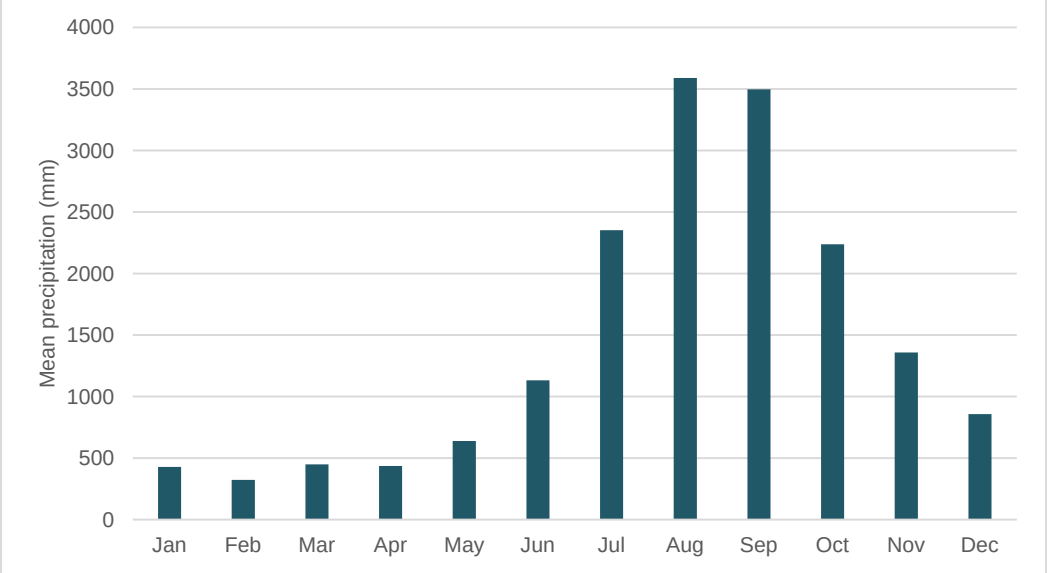
This map shows mean annual precipitation in the 3S Basins. Precipitation in the basins is influenced primarily by topography and the seasonal monsoon, with higher precipitation correlated with higher elevations.

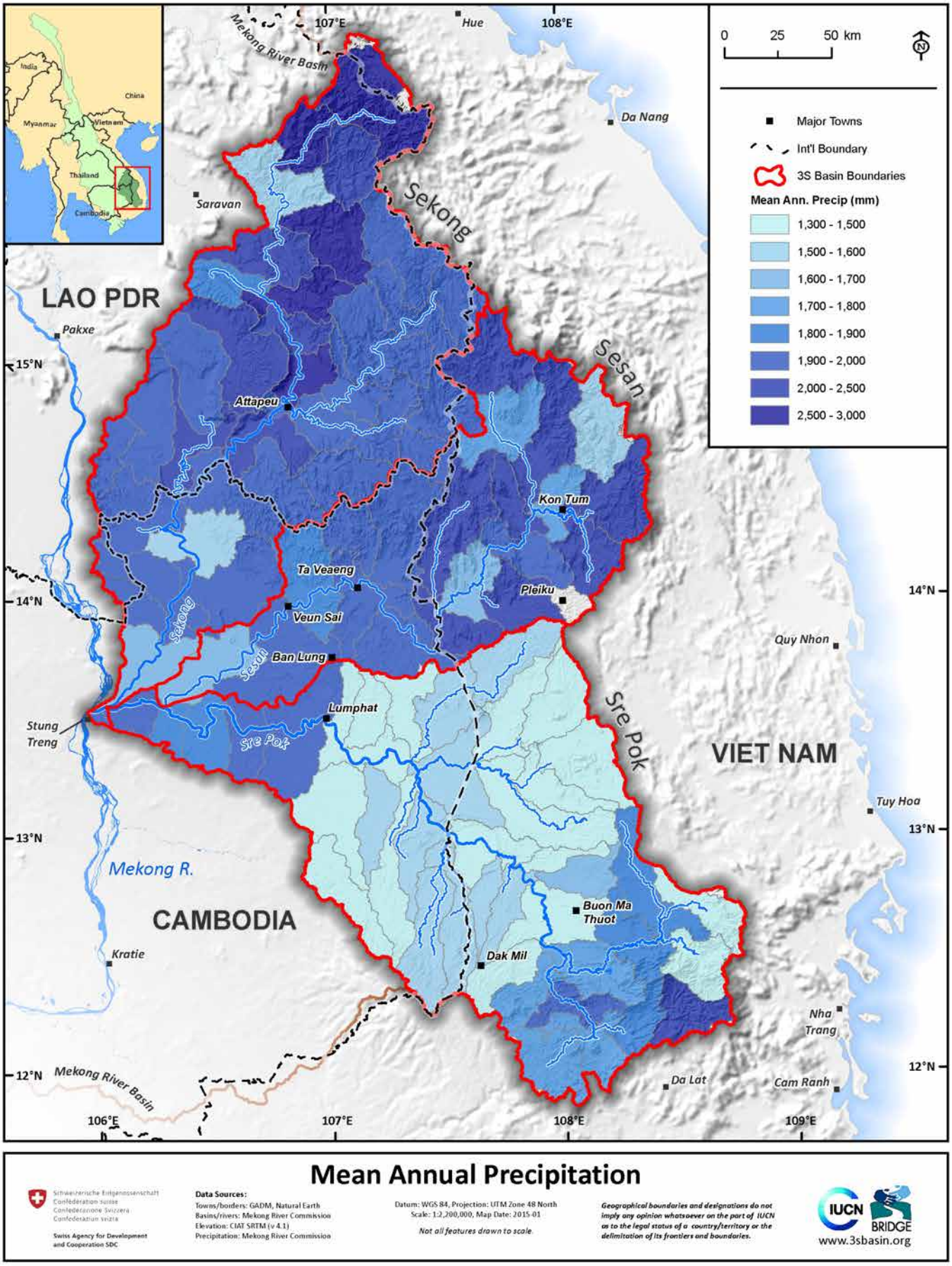
Due to its topography, the upper Sekong receives more precipitation and has slightly cooler average temperatures than the Sesan or Sre Pok. This is especially evident along the border between Lao PDR and Viet Nam, where average annual precipitation can exceed 2,800 millimetres (mm) per year.

Limited precipitation measurement locations and symbolisation by hydrologic basic imply stark changes in precipitation between adjacent areas. Although precipitation does differ throughout the basin, in reality it changes more continuously across the landscape.

Average precipitation in the Sre Pok Basin is significantly lower, although above Buon Ma Thuot this rises to above 2,500 mm per year. The chart below shows mean monthly precipitation as monitored by a station at Andaung Meas in the Sesan Basin, as measured between 1961 and 1968. The accompanying map shows precipitation by sub-basin, as interpolated from individual monitoring stations.

Figure 6: Mean monthly precipitation at Andaung Meas (Sesan Basin)




Mean Annual Precipitation
0 25 50 km
Major Towns
Int'l Boundary
3S Basin Boundaries
Mean Ann. Precip (mm)
1,300 - 1,500
1,500 - 1,600
1,600 - 1,700
1,700 - 1,800
1,800 - 1,900
1,900 - 2,000
2,000 - 2,500
2,500 - 3,000
LAO PDR
CAMBODIA
VIET NAM
Mekong River Basin
Sekong
Sesan
Sre Pok
Mekong R.
Hue
Da Nang
Saravan
Pakxe
Attapeu
Kon Tum
Ta Veaeng
Pleiku
Veun Sai
Ban Lung
Lumphat
Stung Treng
Quy Nhon
Tuy Hoa
Buon Ma Thuot
Dak Mil
Kratie
Nha Trang
Da Lat
Cam Ranh
107°E
108°E
109°E
106°E
15°N
14°N
13°N
12°N
India
China
Myanmar
Vietnam
Thailand
Cambodia
Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Precipitation: Mekong River Commission
Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01
Not all features drawn to scale.
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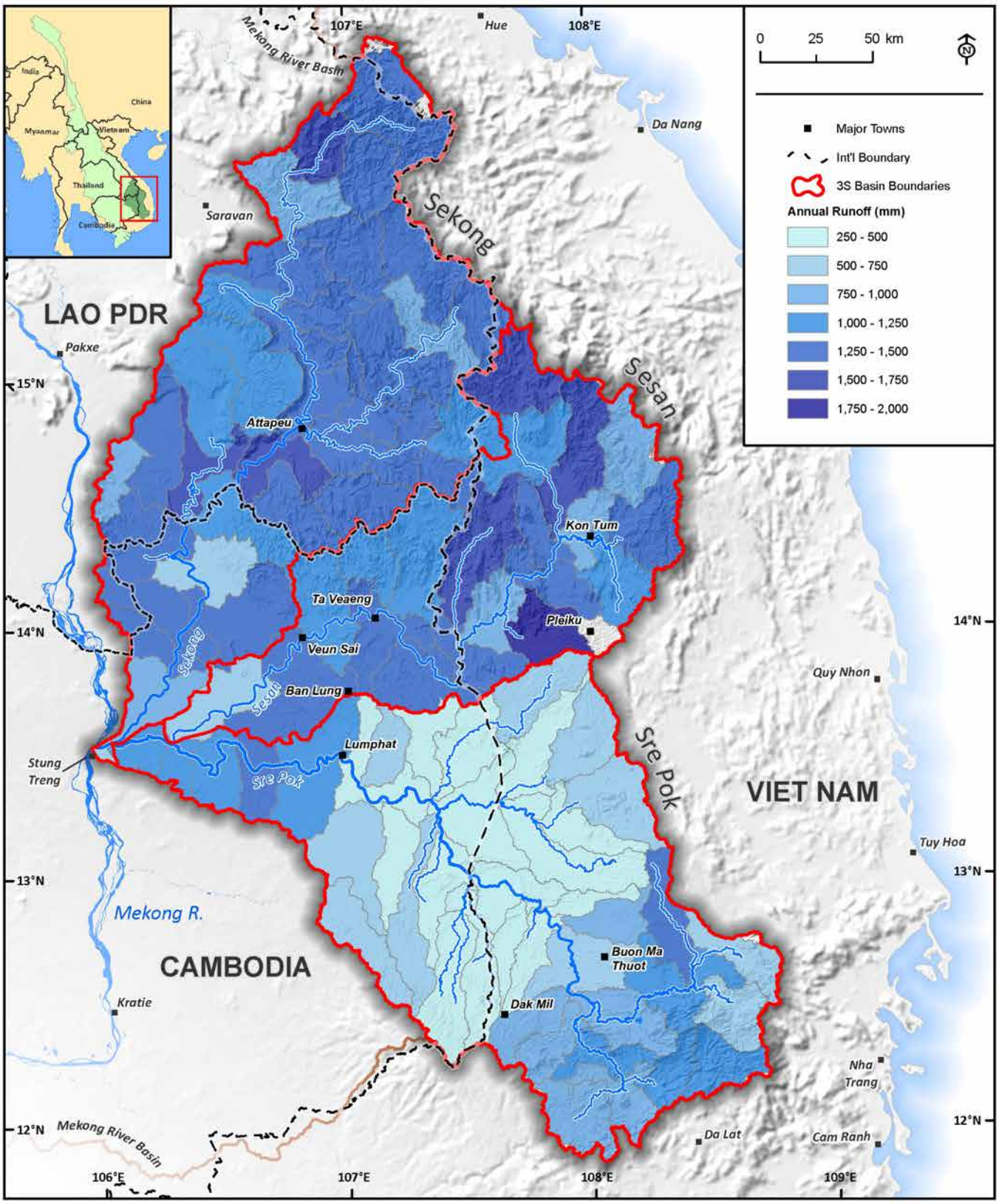
4.5. Mean annual runoff

Runoff can be defined as water not absorbed by the ground and which flows across the soil surface. This map illustrates runoff contribution per unit area, expressed in millimetres. Runoff values do not correspond exactly to precipitation because not all water that falls as rain into the basins becomes runoff (some evaporates, percolates into ground water or is otherwise stored).

However, the general trends are similar, with more runoff being generated in areas of high precipitation (chiefly in the Annamite Mountains). Similar to precipitation, runoff is seasonal and varies depending on the time of year. Due to high precipitation, the upper 3S Basins contribute around 18% of the Mekong River's total discharge even though they cover only 10% of the basin's total area.



Mean Annual Runoff

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Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Runoff: Mekong River Commission

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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5. Hydropower dams

5.1. Hydropower projects

This map shows hydropower dams in the 3S Basins which generate at least 10 megawatts (MW) of power. The mountainous topography of the upper basins provides a large elevation drop as rivers flow downstream. Taking advantage of this, numerous hydropower and irrigation dams have been constructed in these areas over the past decade, especially in the Sesan and Sre Pok. All three countries are eyeing hydropower development as a way to meet booming electricity demand.

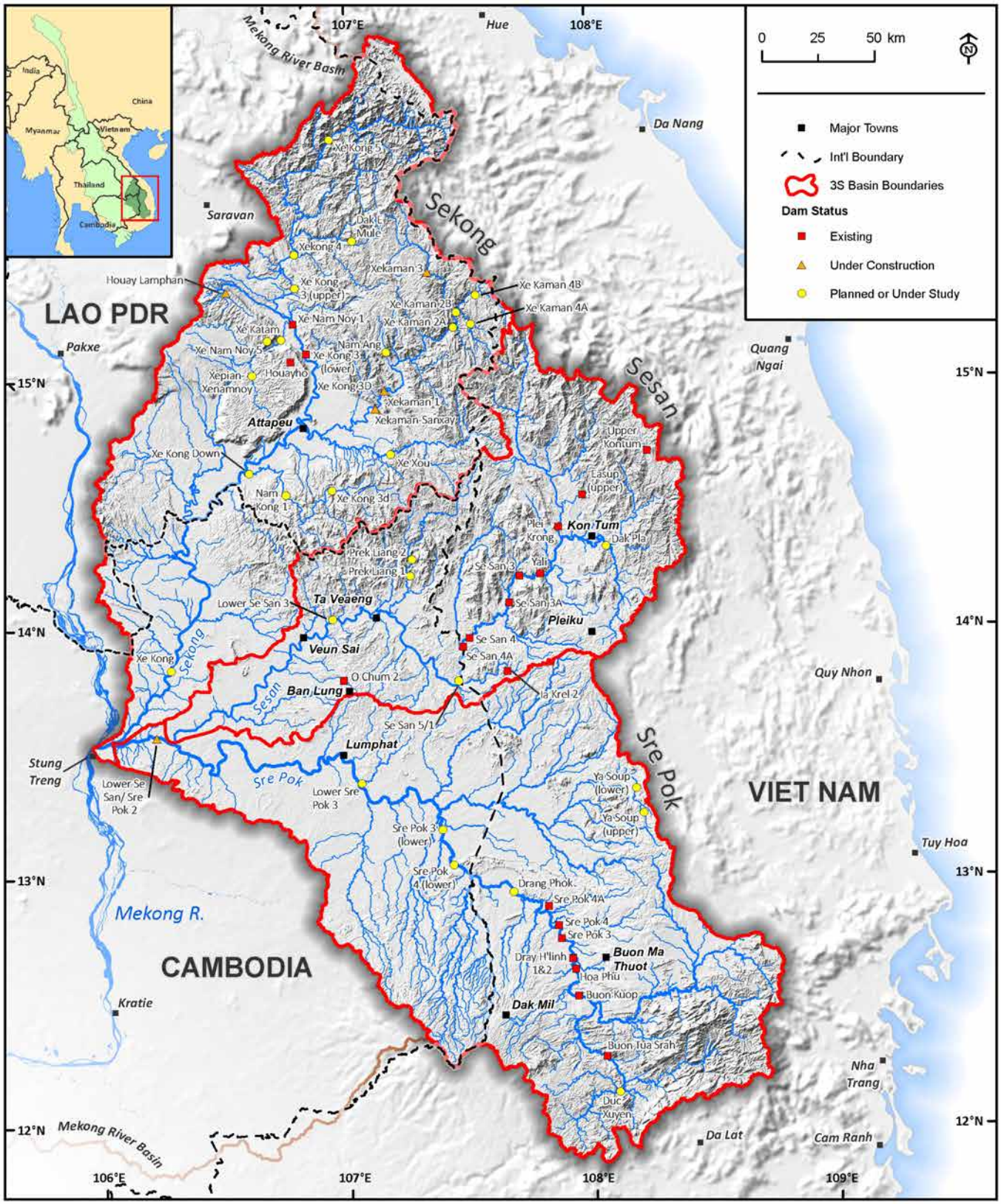
At present there are three major hydropower dams in the Sekong, eight in the Sesan, and seven in the Sre Pok. Many more are planned or are under consideration for the future.

A cascade of dams has been constructed in the upper reaches of the Sesan and Sre Pok Rivers, starting with Yali Falls, a 720 MW hydropower plant built in 1996. Most recently, the Sre Pok 4A and Hoa Phu Dams were completed in Viet Nam in 2013 and 2014, respectively. The Lower Sesan/Sre Pok 2 is currently under construction in Cambodia and is expected to provide up to an additional 400 MW of capacity when completed in 2017.

Although Lao PDR currently has fewer dams in the Sekong Basin, it aspires to become the 'battery' of Southeast Asia, supplying electricity to its neighbours while augmenting domestic supply. Plans within the basin may call for an additional 17 dams (16 in Lao PDR, and one in Cambodia) – although how many will actually be constructed is unknown. If all these plans were implemented the Sekong could have up to 24 hydropower dams, including three existing and four under construction.

Cambodia's National Strategic Development Plan (NSDP, 2014–2018) calls for increased energy supply and reliability, with an ambitious goal to bring electricity to 100% of villages by 2020. In practice, this has meant a strong focus on hydropower. If Cambodia meets this target, it is estimated that nearly 70% of the country's total power production will come from hydropower. Currently Cambodia has one dam planned in the Sekong Basin, three planned in the Sesan, and one under construction and three more in the pipeline in the Sre Pok.

Viet Nam already has a number of dams in both the Sesan and Sre Pok Basins. Viet Nam has placed a temporary moratorium on dam construction, but it is not known when this will be lifted.



Hydropower Projects

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Hydropower: Mekong River Commission (2009); updates from CPWF, research (2014).

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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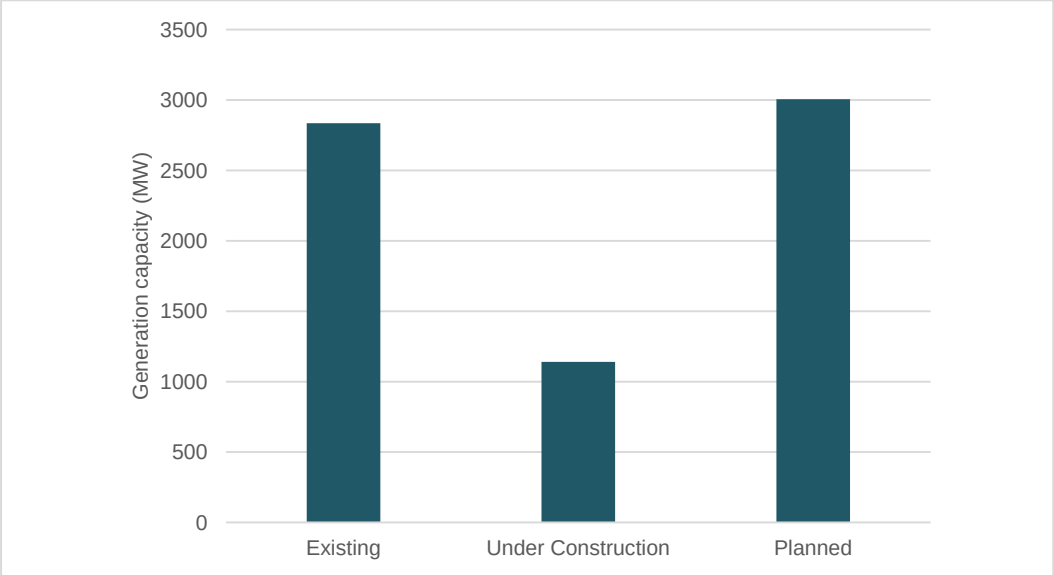
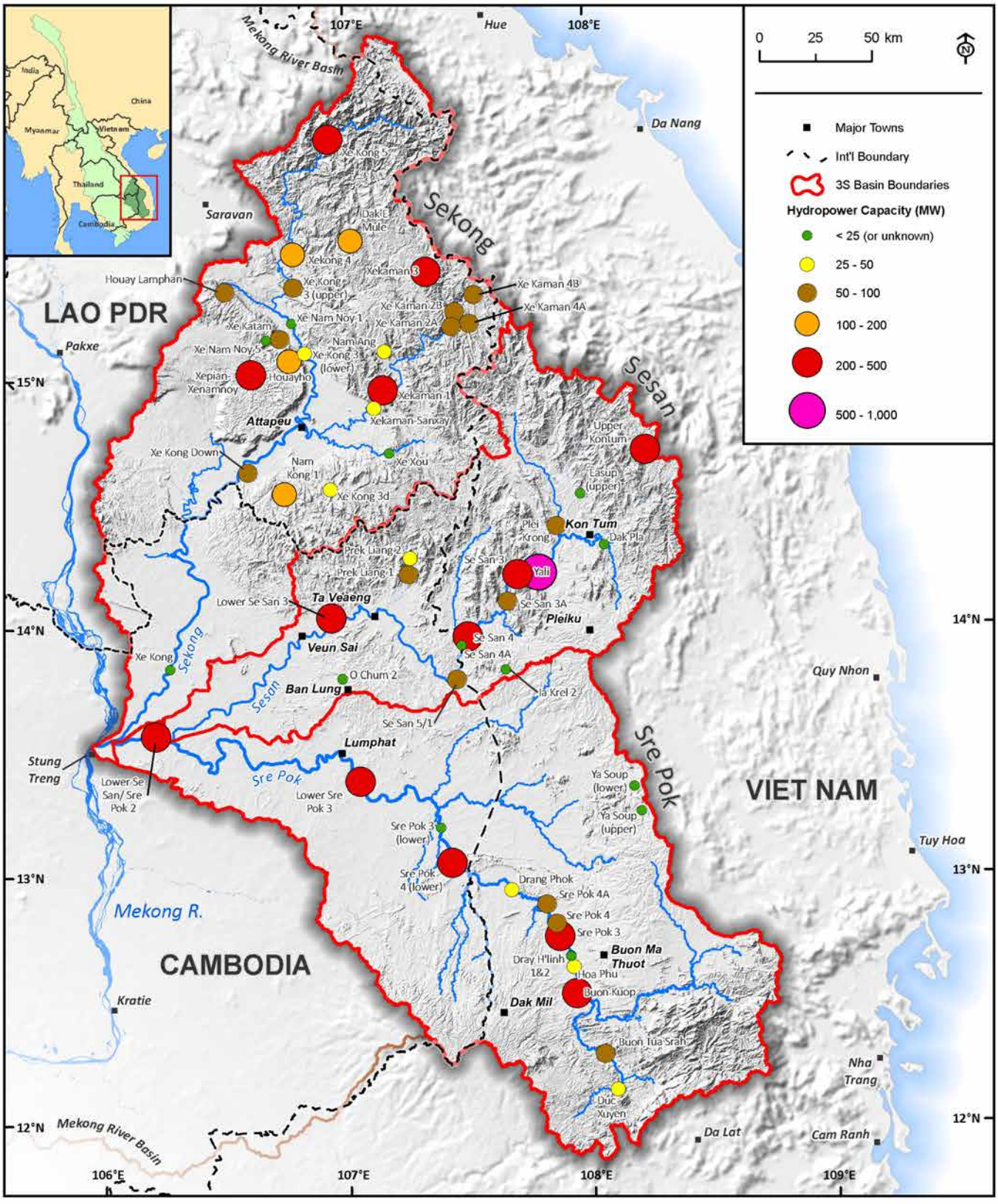
5.2. Hydropower capacity

This map illustrates the relative power generation capacity of hydropower dams, both existing and proposed or under construction. Dams in the 3S Basins currently provide 2,800 MW of installed capacity, most of which is for Viet Nam. Current expansion plans are expected to add at least 4,150 MW, of which 1,140 MW is already under construction. Most of the future capacity is planned for Lao PDR and Cambodia.

Figure 7: Existing, under construction, and planned hydropower capacity (as of late 2014)




Hydropower Capacity
0 25 50 km
Major Towns
Int'l Boundary
3S Basin Boundaries
Hydropower Capacity (MW)
< 25 (or unknown)
25 - 50
50 - 100
100 - 200
200 - 500
500 - 1,000
LAO PDR
VIET NAM
CAMBODIA
Mekong River Basin
Sekong
Sesan
Sre Pok
Mekong R.
Hue
Da Nang
Saravan
Pakxe
Attapeu
Stung Treng
Kratie
Kon Tum
Pleiku
Yali
Ta Veaeng
Veun Sai
Ban Lung
Lumphat
Dak Mil
Buon Ma Thuot
Quy Nhon
Tuy Hoa
Nha Trang
Da Lat
Cam Ranh
Xe Kong 5
Dak E Mule
Xekong 4
Xekaman 3
Xe Kong 3 (upper)
Xe Kaman 4B
Xe Kaman 4A
Xe Kaman 2B
Xe Kaman 2A
Houay Lamphan
Xe Nam Noy 1
Xe Katam
Xe Nam Noy 5
Nam Ang
Xe Kong 3 (lower)
Houaylho
Xepian-Xenamnoy
Xekaman 1
Xekaman-Sanxay
Xe Kong Down
Nam Kong 1
Xe Xou
Xe Kong 3d
Upper Kontum
Lasup (upper)
Plei Krong
Dak Pla
Se San 3
Prek Liang 2
Prek Liang 1
Lower Se San 3
Se San 3A
Se San 4
Se San 4A
Xe Kong
O Chum 2
Ia Krel 2
Se San 5/1
Lower Se San/ Sre Pok 2
Lower Sre Pok 3
Ya Soup (lower)
Ya Soup (upper)
Sre Pok 3 (lower)
Sre Pok 4 (lower)
Drang Phok
Sre Pok 4A
Sre Pok 4
Sre Pok 3
Dray H'linh 1&2
Hoa Phu
Buon Kuop
Buon Tua Srah
Duc Xuyen
106°E
107°E
108°E
109°E
12°N
13°N
14°N
15°N
Hydropower Capacity
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Agency for Development and Cooperation SDC
Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Hydropower: Mekong River Commission (2009); updates from CPWF, research (2014).
Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01
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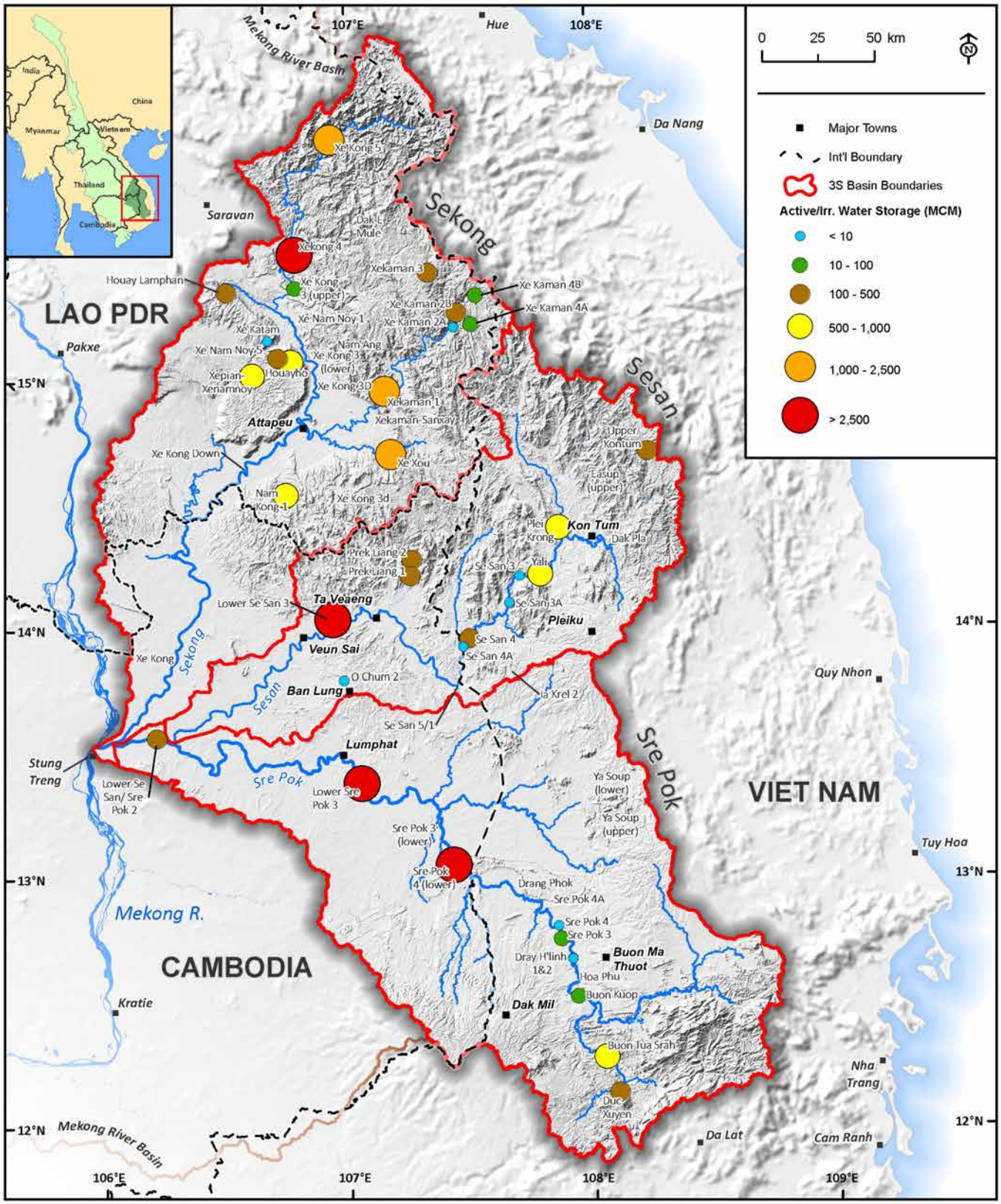
5.3. Hydropower storage capacity

This map illustrates relative active storage capacity of hydropower dams. Active storage capacity (also known as ‘live storage’ capacity) is the lowest volume of water stored in a reservoir under normal operating conditions. This metric is important because it is correlated with sediment levels downstream.

In general, the more live storage, the more sediment is trapped (due to slower water velocity in the reservoir, allowing sediment to settle). In flatter areas, live storage can also have a large impact on the amount of surface area covered by the reservoir, which in turn has implications on the number of people that might be displaced and on land cover changes as areas are covered, or otherwise influenced, by activities around a reservoir.


Water Storage Capacity
Mekong River Basin
Sekong
Sesan
Sre Pok
LAO PDR
CAMBODIA
VIET NAM
Mekong R.
Major Towns
Int'l Boundary
3S Basin Boundaries
Active/Irr. Water Storage (MCM)
< 10
10 - 100
100 - 500
500 - 1,000
1,000 - 2,500
> 2,500
0 25 50 km
Hue
Da Nang
Quy Nhon
Tuy Hoa
Nha Trang
Da Lat
Cam Ranh
Saravan
Houay Lamphan
Pakxe
Attapeu
Stung Treng
Kratie
Kon Tum
Pleiku
Buon Ma Thuot
Dak Mil
Ban Lung
Veun Sai
Lumphat
Ta Veaeng
Xe Kong 5
Xekong 4
Xe Kong 3 (upper)
Xe Nam Noy 1
Xe Katam
Xe Nam Noy 5
Xepian-Xenamnoy
Houayho
Nam Ang
Xe Kong 3A (lower)
Xe Kong 3D
Xekaman 3
Xe Kaman 4B
Xe Kaman 4A
Xe Kaman 2B
Xe Kaman 2A
Xekaman 1
Xekaman-Sanxay
Xe Kong Down
Xe Xou
Nam Kong-1
Xe Kong 3d
Upper Kontum
Lasup (upper)
Plei Krong
Dak Pla
Se San 3
Yali
Se San 3A
Prek Liang 2
Prek Liang 1
Lower Se San 3
Se San 4
Se San 4A
Xe Kong
O Chum 2
Ia Krel 2
Se San 5/1
Lower Se San/ Sre Pok 2
Lower Sre Pok 3
Ya Soup (lower)
Ya Soup (upper)
Sre Pok 3 (lower)
Sre Pok 4 (lower)
Drang Phok
Sre Pok 4A
Sre Pok 4
Sre Pok 3
Dray H'linh 1&2
Hoa Phu
Buon Kuop
Buon Tua Srah
Duc Xuyen
106°E
107°E
108°E
109°E
12°N
13°N
14°N
15°N
Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Hydropower: Mekong River Commission (2009); updates from CPWF, research (2014).
Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01
Not all features drawn to scale.
Geographical boundaries and designations do not imply any opinion whatsoever on the part of IUCN as to the legal status of a country/territory or the delimitation of its frontiers and boundaries.
Swiss Agency for Development and Cooperation SDC
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6. Natural resources and the environment

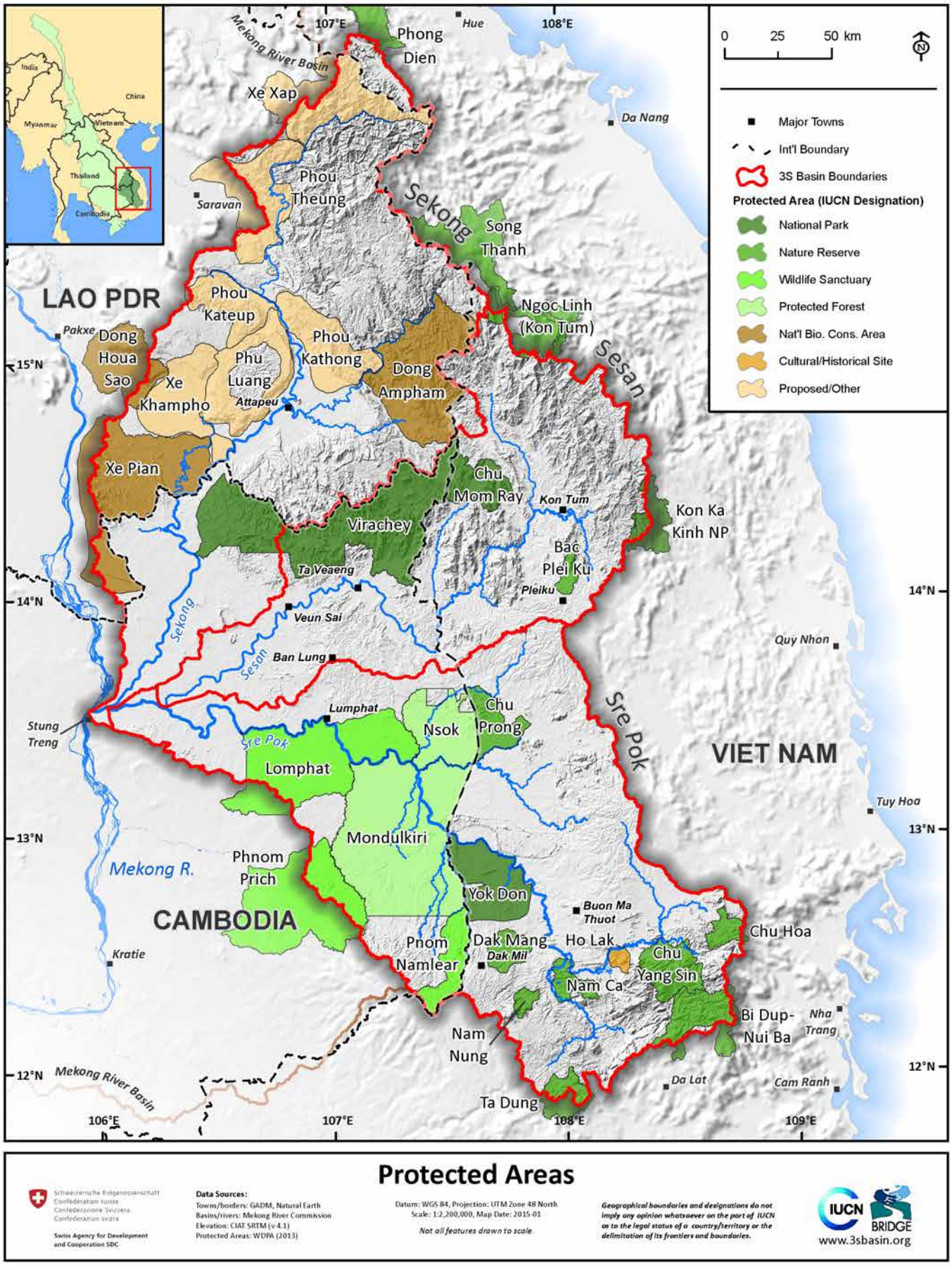
6.1. Protected areas (PAs)

The 3S Basins host a number of formally protected areas, including national parks, nature reserves, and protected forests, among others. Protected areas hold important natural resources and a diverse array of plants and wildlife. However, in some areas they have been impacted by development and resource extraction.

The Sekong overlaps with three national biodiversity conservation areas: Xe Pian, Dong Ampham, and Dong Houa Sao. Six protected areas have been proposed for areas of the basin within Lao PDR. However, some of these areas have already experienced significant forest loss and other impacts (see following section, “Protected Areas and Forest Loss”). In addition, 15 Key Biodiversity Areas (KBAs) and 13 Important Bird Areas (IBAs) fall within or are immediately adjacent to the Sekong. KBAs and IBAs are areas that are recognized as having exceptionally high biodiversity values or, for IBAs, high significance for bird species.

Protected areas in the Sesan include Chu Mom Ray and Virachey National Parks, Bac Plei Ku Nature Reserve, and small overlaps with Kon Ka Kinh National Park and Ngoc Linh (Kon Tum) Nature Reserve. Virachey is the largest protected area within the 3S Basins, covering 3,368 km^2, 2,240 km^2 of which is within the Sesan. Although all of Virachey is within Cambodia, the park is adjacent to Mom Ray Nature Reserve in Viet Nam and Dong Ampham protected area, in Lao PDR. Together these three form a contiguous protected area across all three countries. With the exception of Bac Plei Ku, all the aforementioned protected areas are also either KBAs or IBAs, or both. The portion of the Sesan River riparian corridor within Cambodia is also classified as an IBA.

The Sre Pok has the greatest number of protected areas within the 3S Basins. In Cambodia these include Mondulkiri and Nsok protected forests, and Lomphat, Phnom Prich, and Phnom Namlear wildlife sanctuaries. In Viet Nam these include seven nature reserves in the upper basin, a cultural/historic site at Ho Lak, and Yok Don National Park. Yok Don has been proposed as a potential site for tiger re-introduction and retains relatively pristine forests, although many animal species populations have been reduced.



Protected Areas

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Protected Areas: WDPA (2013)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

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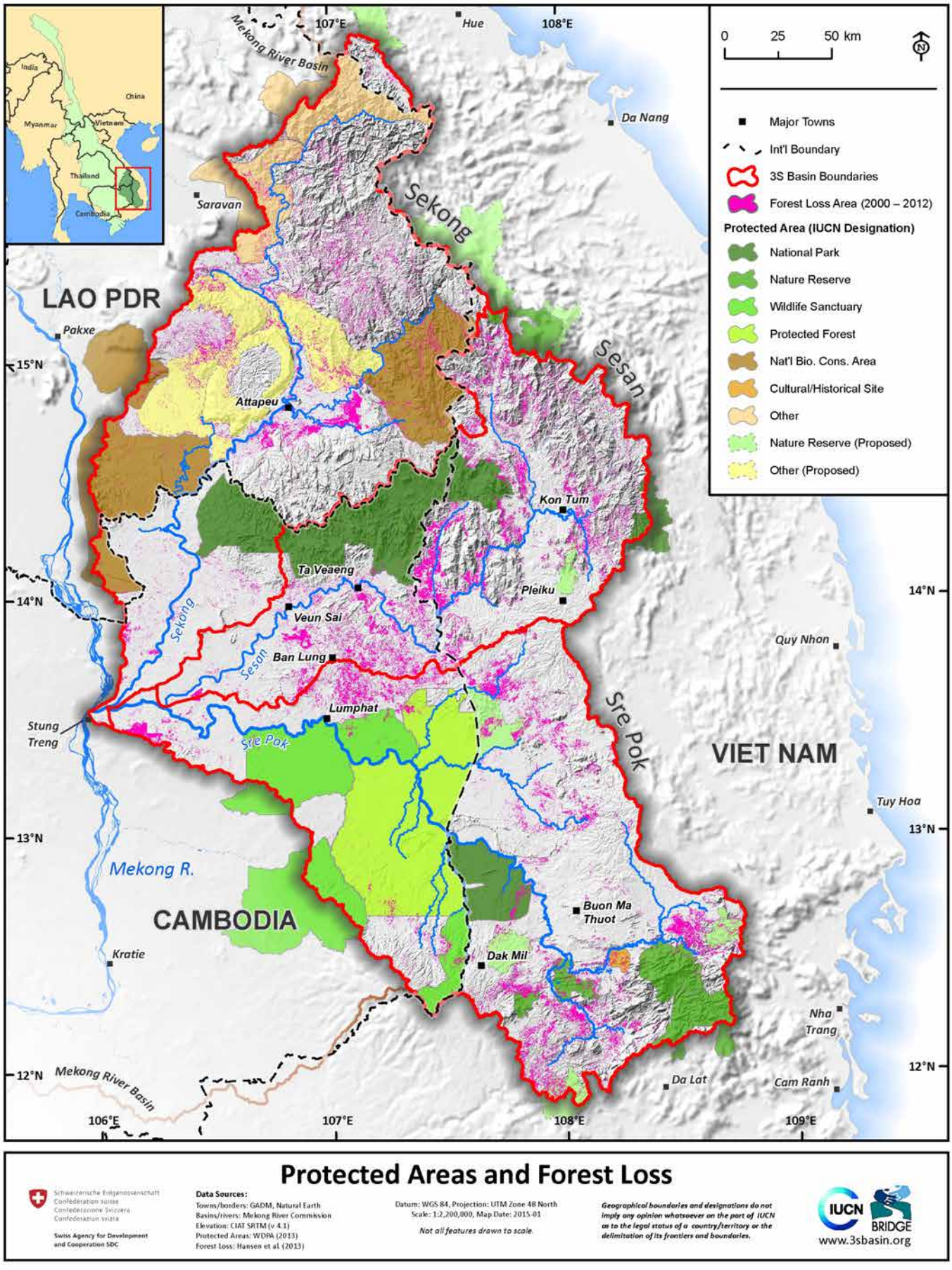
6.2. Protected areas and forest loss

This map shows estimated forest loss between 2000 and 2012, overlaid with existing and proposed protected areas. Forest loss was estimated based on a global forest cover study (Hansen et al. 2013) which identifies forested areas converted to other land use types during this time period. Although not focused on the 3S Basins, verification of the data indicates that it has correctly identified many locations where forest cover transitioned to another land cover type.

According to the MRC, the Sekong had the highest proportion of forest cover in the 3S Basins in the year 2003, at 83%. Between 2000 and 2012 as much as 1,400 km^2 of this forest (5.2% of the entire basin) was converted to other land uses. Much of this loss occurred in Lao PDR's portion of the basin, where roughly one third of the total area deforested (423 km^2) fell within existing or proposed protected areas. The largest contiguous clearings here have been for conversion to plantations, such as for an 8,000 hectare rubber plantation to the east of Attapeu.

Among the three basins, the Sesan has experienced the highest relative amount of deforestation, with an estimated 9.5% of its forests lost during this period of time. Similar to the Sekong, much of the land cover change appears to have been caused by logging for timber, conversion of natural forest areas to industrial plantations or expansion of agriculture. However, the creation of reservoirs for hydropower and irrigation purposes has also converted some previously forested areas into open water. The same forces are at work in the Sre Pok, where around 1,860 km^2 (6%) of the basin's forests were lost between 2000 and 2012.



Protected Areas and Forest Loss

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Protected Areas: WDPA (2013)
Forest Loss: Hansen et al (2013)

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

Geographical boundaries and designations do not imply any opinion whatsoever on the part of IUCN as to the legal status of a country/territory or the delimitation of its frontiers and boundaries.

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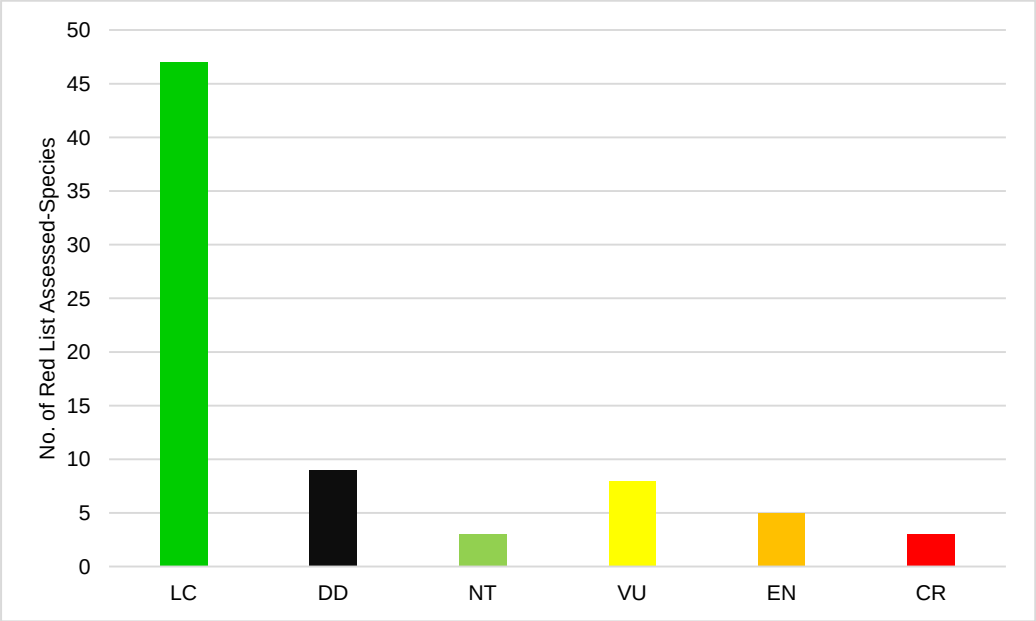
6.3. Migratory whitefish species

This map shows the distribution of migratory whitefish assessed by the IUCN Red List of Threatened Species™ (2014). Whitefish are important because they are a source of food, comprising 40–70% of the natural fish catch.

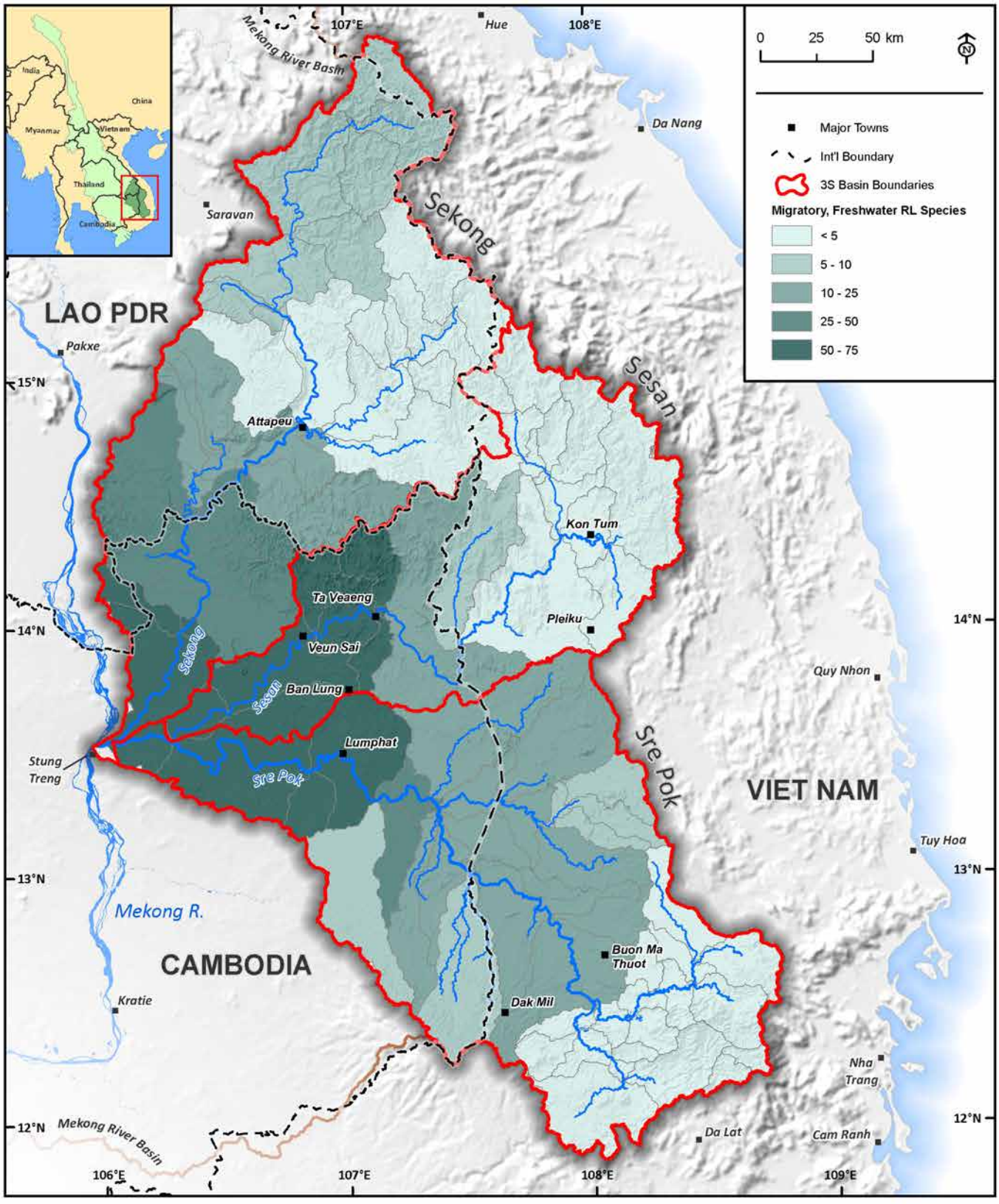
The map is based on a study conducted by Carrizo and Smith (2014) which looked at 102 species of freshwater, migratory fish present in the 3S Basins. Only 94 of the 102 species are considered here, as the eight species which have no record on the IUCN Red List cannot be further analysed. The 94 species were mapped according to sub-basin and analysed for potential impacts from dam construction within the 3S Basins.

The findings show that although most of the species are classified as Least Concern, endangered species could disappear in the basins if their migratory routes are blocked. As the map shows, the lowest reaches of the 3S Basins are home to the highest number of species, so development in this region could potentially have the biggest impact.

Figure 8: Number of migratory whitefish species in the 3S Basins
(as classified in the IUCN Red List)



Note: LC = Least Concern, DD = Data Deficient, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered. The study found that VU, EN, and CR species could be impacted by certain development activities in the basins.



Migratory Whitefish Species

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Data Sources:
Towns/borders: GADM, Natural Earth
Basins/rivers: Mekong River Commission
Elevation: CIAT SRTM (v 4.1)
Migratory Fish Species: IUCN Red List (2013, 3.1);
Number of assessed NT/VU/EN/CR species.

Datum: WGS 84, Projection: UTM Zone 48 North
Scale: 1:2,200,000, Map Date: 2015-01

Not all features drawn to scale.

Geographical boundaries and designations do not imply any opinion whatsoever on the part of IUCN as to the legal status of a country/territory or the delimitation of its frontiers and boundaries.

IUCN BRIDGE
www.3sbasin.org

Further reading and data sources

1. Location

1.1. Location and administrative boundaries

Further reading

- Cambodia National Mekong Committee (CNMC). (2011). Profile: Sub-area Sekong-Se San-Sre Pok Cambodia (SA-7C) (Unpublished draft: April 2011). Phnom Penh.
- Lao National Mekong Committee (LNMC). (2011). Final Report of Profile of Sub-area Sekong 7L in Lao PDR. Vientiane.
- Mekong River Commission. (2010). State of the Basin Report 2010. Vientiane, 232 pp.
- Viet Nam National Mekong Committee (VNMC). (2010). Update of Sub-Area Profile Sub-area 7V. Hanoi.

Data sources

Source	Year	Access
Global Administrative Areas Database (GADM)	2014	www.gadm.org
MRC: Basins	2000	9506000003818catchmentE01009of
MRC: Towns	2005	9506000003818___CitiesE01009og

1.2. Mekong river committee sub-areas

Further reading

- Asian Development Bank (ADB). (2010). Sesan, Sre Pok and Sekong River Basins Development Study in Kingdom of Cambodia, Lao People's Democratic Republic, and Socialist Republic of Viet Nam.
- Cambodia National Mekong Committee (CNMC). (2011). Profile: Sub-area Sekong-Se San-Sre Pok Cambodia (SA-7C) (Unpublished draft: April 2011). Phnom Penh.
- Lao National Mekong Committee (LNMC). (2011). Final Report of Profile of Sub-area Sekong 7L in Lao PDR. Vientiane.
- Viet Nam National Mekong Committee (VNMC). (2010). Update of Sub-Area Profile Sub-area 7V. Hanoi.

Data source

Source	Year	Access
MRC: Sub-areas	2002	http://portal.mrcmekong.org/

1.3. Transportation network

Further reading

- Asian Development Bank (ADB). (2014). *Initial Review of the Greater Mekong Sub-region Transport Sector Strategy 2006-2015*. Available from: <http://www.adb.org/documents/initial-review-gms-transport-sector-strategy-2006-2015>. [29 December 2014].

- MRC. (2011). Planning Atlas of the Lower Mekong River Basin. Phnom Penh and Vientiane, 101 pp.

Data sources

Source	Year	Access
MRC: Access roads	1998	9506000003818 roadE01009r2
Major Roads	2012	http://www.naturalearthdata.com/
MRC: Airports	2009	http://portal.mrcmekong.org/

2. Geophysical characteristics

2.1. Elevation

Further reading

- Cambodia National Mekong Committee (CNMC). (2011). Profile: Sub-area Sekong-Se San-Sre Pok Cambodia (SA-7C) (Unpublished draft: April 2011).

- MRC. (2011). Planning Atlas of the Lower Mekong River Basin. Phnom Penh and Vientiane, 101 pp.

Data source

Country	Source	Year	Access
ALL	SRTM	2008	http://srtm.csi.cgiar.org/

2.2. Slope

Further reading

- Mekong River Commission. (2010). State of the Basin Report 2010. Vientiane, 232 pp.
- Brookfield, M. E. (1998). The evolution of the great river systems of southern Asia during the Cenozoic India-Asia collision: rivers draining southwards. *Geomorphology*, *22*(3), 285–312.

Data source

Country	Source	Year	Access
ALL	SRTM	2008	http://srtm.csi.cgiar.org/

2.3. Land cover (2003)

Further reading

- Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850–853.
- Leinenkugel, P., Wolters, M. L., Oppelt, N., & Kuenzer, C. (2015). Tree cover and forest cover dynamics in the Mekong Basin from 2001 to 2011. *Remote Sensing of Environment*, 158, 376–392.
- MRC. (2011). Planning Atlas of the Lower Mekong River Basin. Phnom Penh and Vientiane, 101 pp.
- Rundel, P. W. (2009). Vegetation in the Mekong Basin. pp. 143–160. *In*: Campbell, I. C. ed. The Mekong: biophysical environment of an international river basin. London: Academic Press.

Data sources

Country	Source	Year	Access
ALL	FAO / MRC	2003	http://portal.mrcmekong.org/
Cambodia	Ministry of Public Works and Transportation	2003	-
Lao PDR	Ministry of Agriculture and Forestry	2004	-
Viet Nam	Sub-NIAPP	2003	-

2.4. Land cover (2009)

Further reading

- Arino, O., Perez, R., Julio, J., Kalogirou, V., Bontemps, S., Defourny, P., Van Bogaert, E. (2012). Global Land Cover Map for 2009 (GlobCover 2009). © European Space Agency (ESA) & Université catholique de Louvain (UCL), doi:10.1594/PANGAEA.787668.

- Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850–853.

- Rundel, P. W. (2009). Vegetation in the Mekong Basin. pp. 143–160. *In*: Campbell, I. C. ed. The Mekong: biophysical environment of an international river basin. London: Academic Press.

Data source

Country	Source	Year	Access
ALL	ESA/GlobCover 2009	2009	http://due.esrin.esa.int/globcover/

2.5. Forest cover

Further reading

- Mekong River Commission. (2010). State of the Basin Report 2010. Vientiane, 232 pp.

- Arino, O., Perez, R., Julio, J., Kalogirou, V., Bontemps, S., Defourny, P., Van Bogaert, E. (2012). Global Land Cover Map for 2009 (GlobCover 2009). © European Space Agency (ESA) & Université catholique de Louvain (UCL), doi:10.1594/PANGAEA.787668.

Data source

Country	Source	Year	Access
ALL	GMS-EOC	2009	www.gms-eoc.org

2.6. Soil type

Further reading

- Asian Development Bank (ADB). (2010). Sesan, Sre Pok, and Sekong River Basins Development Study in Kingdom of Cambodia, Lao People's Democratic Republic, and Socialist Republic of Viet Nam.
- Mekong River Commission. (2010). State of the Basin Report 2010. Vientiane, 232 pp.
- Someth, P. et al. (2013). Basin Profile of the Lower Sekong, Sesan and Srepok (3S) Rivers in Cambodia. Project report: Challenge Program on Water & Food Mekong project MK3 "Optimizing the management of a cascade of reservoirs at the catchment level". ICEM – International Centre for Environmental Management, Hanoi.

Data source

Source	Year	Access
MRC: Soil Type	2002	9506000003818_____soilE01009r7

2.7. Wetlands

Further reading

- Mekong River Commission. (2010). State of the Basin Report 2010. Vientiane, 232 pp.

Data source

Country	Source	Year	Access
ALL	MRC: Wetlands	2003	http://portal.mrcmekong.org/

3. Population and socio-economics

3.1. Population

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

Data source

Source	Year	Access
MRC: Population	2008	http://portal.mrcmekong.org/

3.2. Population density

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

Data source

Source	Year	Access
MRC: Population Density	2008	http://portal.mrcmekong.org/

3.3. Population growth

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

Data sources

Country	Source	Year	Access
ALL	MRC: Population Growth	2009	http://portal.mrcmekong.org/
Cambodia	Census	2008	-
Lao PDR	Census	2005	-
Viet Nam	Census	2009	-

3.4. Population distribution

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.
- LandScan Documentation. Available from: <web.ornl.gov/sci/landscan/landscan_documentation.shtml>. [29 December 2014].
- Vijayaraj V., Bright, E. A., Bhaduri ,B. L., "High Resolution Urban Feature Extraction for Global Population Mapping using High Performance Computing", *Proceedings of 2007 IEEE International geosciences and remote sensing symposium, IGARSS 2007.*

Data source

Country	Source	Year	Access
ALL	LandScan	2012	http://web.ornl.gov/sci/landscan/

3.5. Primary school enrolment

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.
- MRC. (2011). Planning Atlas of the Lower Mekong River Basin. Phnom Penh and Vientiane, 101 pp.

Data sources

Country	Source	Year	Access
ALL	MRC	2009	9506000003818___socioE01009r6
Cambodia	Census	2008	http://www.decide.la/
Lao PDR	Census	2005	http://www.nis.gov.kh/index.php/en/
Viet Nam	UNICEF	2005	http://www.unicef.org/infobycountry/vietnam_statistics.html

3.6. Secondary school enrolment

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

- MRC. (2011). Planning Atlas of the Lower Mekong River Basin. Phnom Penh and Vientiane, 101 pp.

Data sources

Country	Source	Year	Access
ALL	MRC	2009	9506000003818____socioE01009r6
Cambodia	Census	2008	http://www.nis.gov.kh/index.php/en/
Lao PDR	Census	2005	http://www.decide.la/
Viet Nam	Household Living Standards Survey	2008	http://www.gso.gov.vn/default_en.aspx?tabid=515&idmid=5&ItemID=12426

3.7. Access to improved water sources

Further reading

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

- WHO and UNICEF. (2014). *WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation*. Available from: <http://www.wssinfo.org/>. [29 December 2014].

Data sources

Country	Source	Year	Access
ALL	MRC: Improved Water	2009	9506000003818____socioE01009r6
Cambodia	Census	2008	http://www.nis.gov.kh/index.php/en/
Lao PDR	Census	2005	http://www.decide.la/
Viet Nam	Household Living Standards Survey	2008	http://www.gso.gov.vn/default_en.aspx?tabid=515&idmid=5&ItemID=12426

3.8. Access to sanitation

Further reading

- Hook, J., Novak, S.,Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

- WHO and UNICEF. (2014). *WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation*. Available from: <http://www.wssinfo.org/>. [29 December 2014].

Data sources

Country	Source	Year	Access
ALL	MRC: Sanitation Access	2009	9506000003818____socioE01009r6
Cambodia	Census	2008	http://www.nis.gov.kh/index.php/en/
Lao PDR	Census	2005	http://www.decide.la/
Viet Nam	Household Living Standards Survey	2008	http://www.gso.gov.vn/default_en.aspx?tabid=515&idmid=5&ItemID=12426

3.9. Access to electricity

Further reading

- International Energy Agency. (2013). *Southeast Asia Energy Outlook.* Available from: <http://www.worldenergyoutlook.org/southeastasiaenergyoutlook/>. [29 December 2014].

- Hook, J., Novak, S., Johnson, R. (2003). Social Atlas of the Lower Mekong Basin. Mekong River Commission, Phnom Penh. 154 pp.

Data sources

Country	Source	Year	Access
ALL	MRC	2009	9506000003818____socioE01009r6
Cambodia	Census	2008	http://www.nis.gov.kh/index.php/en/
Lao PDR	Census	2005	http://www.decide.la/
Viet Nam	Household Living Standards Survey	2008	http://www.gso.gov.vn/default_en.aspx?tabid=515&idmid=5&ItemID=12426

3.10. Consumption of fish and other aquatic animals

Further reading

- Baran, E., Saray S., Teoh S. J., & Tran T. C. (2011). Fish and fisheries in the Sesan River Basin - Catchment baseline, fisheries section. Project report. Mekong Challenge Program project MK3 “Optimizing the management of a cascade of reservoirs at the catchment level”. WorldFish Center, Phnom Penh, Cambodia. 61 pp.

- Cambodia National Mekong Committee (CNMC). (2011). Profile: Sub-area Sekong-Se San-Sre Pok Cambodia (SA-7C) (Unpublished draft: April 2011).

- Hortle, K.G. (2007). Consumption and the yield of fish and other aquatic animals form the lower Mekong Basin.” MRC Technical Paper No 16, Vientiane, Mekong River Commission, 87 pp.

- IUCN 2014. *The IUCN Red List of Threatened Species. Version 2014.3*. http://www.iucnredlist.org.

Data source

Country	Source	Year	Access
ALL	Fishery Program, MRCS	2009	http://portal.mrcmekong.org/

4. Water resources and climate

4.1. Rivers

Further reading

- Brookfield, M. E. (1998). The evolution of the great river systems of southern Asia during the Cenozoic India-Asia collision: rivers draining southwards. *Geomorphology*, *22*(3), 285–312.

- Hong, T. et al. (2013). Basin Profile of the Upper Sesan River. Project report: Challenge Program on Water & Food Mekong project MK3 “Optimizing the management of a cascade of reservoirs at the catchment level”. ICEM – International Centre for Environmental Management, Hanoi Vietnam, 2013.

- Mekong River Commission. (2005). Overview of the Hydrology of the Mekong River Basin. Mekong River Commission, Vientiane, 73 pp.

- Twidale, C. R. (2004). River patterns and their meaning. *Earth-Science Reviews*, *67*(3), 159–218.

Data sources

Country	Source	Year	Access
ALL	MRC: Major Rivers	2001	http://portal.mrcmekong.org/
ALL	MRC: All Rivers	2001	http://portal.mrcmekong.org/

4.2. Hydrological monitoring stations

Further reading

- Mekong River Commission. (2005). Overview of the Hydrology of the Mekong River Basin. Mekong River Commission, Vientiane, 73 pp.

Data source

Country	Source	Year	Access
ALL	MRC: Hydrological Stations	2010	9506000003818_____E0200hvv

4.3. Meteorological monitoring stations

Further reading

- Mekong River Commission. (2005). Overview of the Hydrology of the Mekong River Basin. Mekong River Commission, Vientiane, 73 pp.

Data source

Country	Source	Year	Access
ALL	MRCS	2002	9506000003818_____E0200hvv

4.4. Mean annual precipitation

Further reading

- Cambodia National Mekong Committee (CNMC). (2009). Profile of Sub-area 7C (Cambodia).
- Mekong River Commission. (2005). Overview of the Hydrology of the Mekong River Basin. Mekong River Commission, Vientiane, 73 pp.
- Someth, P. et al. (2013). Basin Profile of the Lower Sekong, Sesan and Srepok (3S) Rivers in Cambodia. Project report: Challenge Program on Water & Food Mekong project MK3 “Optimizing the management of a cascade of reservoirs at the catchment level”. ICEM – International Centre for Environmental Management, Hanoi Vietnam, 2013.

Data source

Country	Source	Year	Access
ALL	MRC: Rainfall	2010	9506000003818_____PHE0100j4c

4.5. Mean annual runoff

Further reading

- MRC. (2005). Overview of the Hydrology of the Mekong River Basin. Mekong River Commission, Vientiane, 73 pp.
- MRC. (2011). Annual Mekong Flood Report 2010, Mekong River Commission, 76 pp.

Data source

Country	Source	Year	Access
ALL	MRC: Runoff	2011	http://portal.mrcmekong.org/

5. Hydropower dams

5.1. Hydropower projects

Further reading

- Baran E., Saray, S, Teoh, S. J., & Tran, T. C. (2011). Fish and fisheries in the Sesan River Basin - Catchment baseline, fisheries section. Project report. Mekong Challenge Program project MK3 “Optimizing the management of a cascade of reservoirs at the catchment level”. WorldFish Center, Phnom Penh, 61 pp.
- CPWF. (2014). *Mapped Research Repository*. Available from: <http://wle-mekong.cgiar.org/gis-hydropower-mekong/>. [15 September 2014].
- MRC. (2009). Lower Mekong Basin Hydropower Database. Mekong River Commission, Vientiane.
- Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I., & Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences*, *109*(15), 5609-5614.

Data source

Country	Source	Year	Access
ALL	MRC	2009	9506000003818__hydropwE01009p4

5.2. Hydropower capacity

Further reading

- CPWF. *Mapped Research Repository*. Available from: <http://wle-mekong.cgiar.org/gis-hydropower-mekong/>. [15 September 2014].
- Baran E., Saray, S, Teoh, S. J., & Tran, T. C. (2011). Fish and fisheries in the Sesan River Basin - Catchment baseline, fisheries section. Project report. Mekong Challenge Program project MK3 “Optimizing the management of a cascade of reservoirs at the catchment level”. WorldFish Center, Phnom Penh, 61 pp.
- MRC. (2009). Lower Mekong Basin Hydropower Database. Mekong River Commission, Vientiane.
- Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I., & Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences*, *109*(15), 5609-5614.

Data source

Country	Source	Year	Access
ALL	MRC: Hydropower Dams*	2009	9506000003818__hydropwE01009p4

**The link listed above is from the year 2003. The data displayed here represents an unpublished version, updated with external references.*

5.3. Hydropower storage capacity

Further reading

- Cochrane, T. A., Arias, M. E., Teasley, R. L., and Killeen, T. J. (2010). Simulated changes in water flows of the Mekong River from potential dam development and operations on the Se San and Sre Pok tributaries.
- CPWF. *Mapped Research Repository*. Available from: <http://wle-mekong.cgiar.org/gis-hydropower-mekong/>. [15 September 2014].
- MRC. (2009). Lower Mekong Basin Hydropower Database. Mekong River Commission, Vientiane.
- Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I., & Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences*, *109*(15), 5609-5614.

Data source

Country	Source	Year	Access
ALL	MRC: Hydropower Dams*	2009	9506000003818__hydropwE01009p4

**The link listed above is from the year 2003. The data displayed here represents an unreleased version, updated with external references.*

6. Natural resources and the environment

6.1. Protected areas (PAs)

Further reading

- IUCN and UNEP 2013. *The World Database on Protected Areas (WDPA)*. Cambridge, UK. Available from: <www.protectedplanet.net>. [25 October 2013].

- Tordoff, A. W., Timmins, R. J., Maxwell, A., Keavuth, H., Vuthy, Lic., Eang, K. H., & Walston, J. (2005) Biological assessment of the Lower Mekong Dry Forests Ecoregion. Phnom Penh: WWF Cambodia Program.

Data source

Country	Source	Year	Access
ALL	World Database of Protected Areas	2014	www.protectedplanet.net

6.2. Protected areas and forest loss

Further reading

- Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850-853.

Data source

Country	Source	Year	Access
ALL	Hansen et al. 2013	2013	http://earthenginepartners.appspot.com/science-2013-global-forest

6.3. Migratory whitefish species

Further reading

- Carrizo, S., Smith, K. (2014). Estimating change in extinction risk for “White Fish” based on six dam development scenarios in the Lower Mekong Basin. IUCN (unpublished research).
- IUCN 2014. *The IUCN Red List of Threatened Species. Version 2014.3*. http://www.iucnredlist.org.
- Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I., & Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences*, *109*(15), 5609-5614.

Data source

Source	Year	Access
IUCN Freshwater Biodiversity Unit	2014	www.iucn.org/species/freshwater/

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Asian Development Bank (ADB). (2010a). Sesan, Sre Pok, and Sekong River Basins Development Study in Kingdom of Cambodia, Lao People's Democratic Republic, and Socialist Republic of Viet Nam.

Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara. (2008). *Hole-filled SRTM for the globe Version 4*. Available from: <http://srtm.csi.cgiar.org>.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, *342*(6160), 850–853.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International journal of climatology*, *25*(15), 1965–1978.

Hong, T. et al. (2013). Basin Profile of the Upper Sesan River. Project report: Challenge Program on Water & Food Mekong project MK3 "Optimizing the management of a cascade of reservoirs at the catchment level". ICEM – International Centre for Environmental Management, Hanoi Vietnam, 2013.

MRC (Mekong River Commission). *Data and Information Services.* Available from: <http://portal.mrcmekong.org/>. [Note: multiple access dates. Actual data obtained in person.]

MRC (Mekong River Commission). (2011). Planning Atlas of the Lower Mekong River Basin. Phnom Penh and Vientiane, 101 pp.

Rundel, P. W. (2009). Vegetation in the Mekong Basin. pp. 143–160. *In*: Campbell, I. C. ed. The Mekong: biophysical environment of an international river basin. London: Academic Press.

Someth, P. et al. (2013). Basin Profile of the Lower Sekong, Sesan and Srepok (3S) Rivers in Cambodia. Project report: Challenge Program on Water & Food Mekong project MK3 "Optimizing the management of a cascade of reservoirs at the catchment level". ICEM – International Centre for Environmental Management, Hanoi Vietnam, 2013.

WorldClim [database]. Available from: <www.worldclim.org>. [18 February 2014].

Annex A: Detailed list of data sources

The following table lists relevant spatial datasets which have been compiled into a geodatabase and used in this atlas. The majority of the source data has been developed by the MRC. Additional data sources were included when data was not available from the MRC or when an open-access dataset was identified. All data, with the exception of LandScan, is available at no cost, although MRC charges a fee of USD15 per online 'checkout'. Additionally, some datasets require a license agreement. The majority do not allow redistribution, and must be acquired from the original data provider. When possible, the direct URL for the data source is included. For data available through the MRC, a unique ID is specified. On electronic versions of this atlas you may click on the ID/URL to access the original online data reference. If you are viewing a hardcopy you may visit http://portal.mrcmekong.org/ and type the ID from this atlas into the search box in the upper right corner of the webpage.

- **Access restrictions:** "Registration" (registration required); "License" (license agreement required); "None" (direct download, no registration).
- **Redistribution:** "Restricted" (no redistribution, or written approval required); "Allowed" (allowed, with attribution, see link for more information); "Limited" (Redistribution allowed in some cases for non-commercial use).

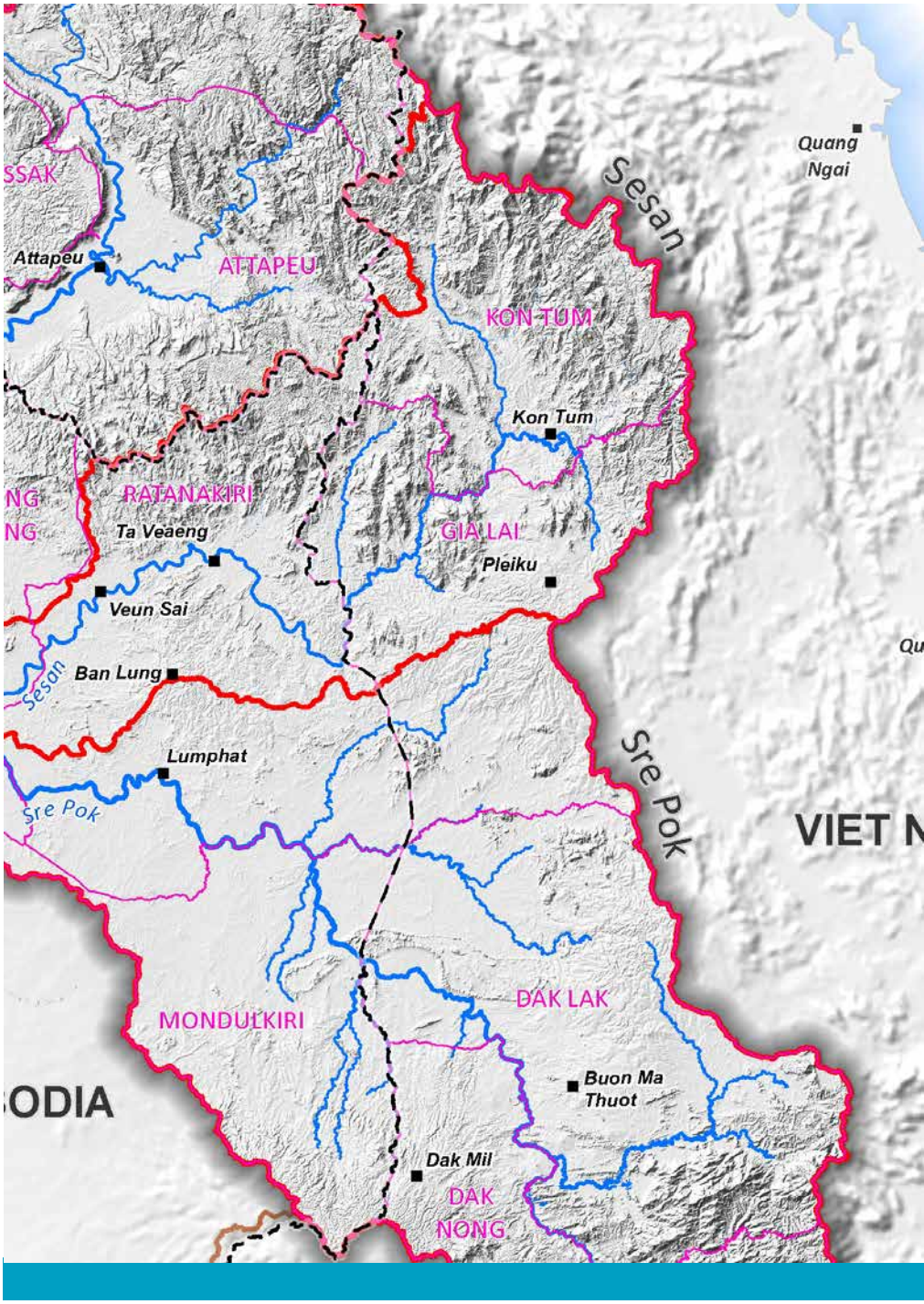
Theme	Dataset	Year	Source	Link / MRCS GIAI	Access restrictions	Redistribution	Notes
Adm. Boundaries & Protected Areas	Levels 0-4 (country-commune)	2013	GADM	www.gadm.org	Registration	Limited	Also available from MRC (restricted).
	MRC sub-areas	2009	MRC	http://portal.mrcmekong.org/	Registration	Restricted	
	Protected areas	2013	WDPA	http://www.protectedplanet.net/	Registration	Restricted	
	Important Bird Areas	2014	BirdLife	http://www.birdlife.org/datazone/info/ibadownload	By request	Restricted	IBA data is restricted access.
	Key Biodiversity Areas	2012	CI	data@conservation.org	By request	Restricted	KBA data is restricted access. Inclusion does not imply endorsement by CI.
Basemap	Buffers and annotation	2014	IUCN	www.3sbasin.org	None	Allowed	Not currently uploaded
	Mekong river	2001	MRC	9506000003818_riverpolE01009r1	Registration	Restricted	
	Towns	2005	MRC	9506000003818___CitiesE01009og	Registration	Restricted	With modifications.
	Countries (overview location map)	2012	Natural Earth	http://www.naturalearthdata.com/	None	Allowed	Public domain
	Terrain (hillshade) (900 m)	2009	NOAA	http://www.ngdc.noaa.gov/mgg/global/global.html	Registration	Restricted	
	Elevation and slope (90 m)	2008	USGS/NASA	http://srtm.csi.cgiar.org/	None	Restricted	Also available from: http://dwtkns.com/srtm/; www.gms-eoc.org
	Elevation and slope (30 m)	2011	USGS/NASA	http://asterweb.jpl.nasa.gov/gdem.asp	Registration	Restricted	ASTER is a product of METI and NASA.
Bio-geophysical	Land cover (2003)	2003	MRC	http://portal.mrcmekong.org/	License	Restricted	
	Land cover (2009)	2009	GlobCover	http://due.esrin.esa.int/globcover/	None	Allowed	
	Forest cover (2009)	2009	GMS-EOC	www.gms-eoc.org	None	Allowed	Aggregated from GlobCover (2009) data.

Theme	Dataset	Year	Source	Link / MRCS GIAI	Access restrictions	Redistribution	Notes
	Forest loss	2001-2012	Hansen et al. 2013	http://www.globalforestwatch.org/	None	Allowed	Direct download at: http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.1.html
	Red List-assessed white fish species	2012	IUCN Red List	http://www.iucnredlist.org/technical-documents/spatial-data	None	Limited	http://www.iucnredlist.org/technical-documents/spatial-data
	Soil type	2002	MRC	9506000003818____soilE01009r7	Registration	Restricted	
	Wetlands	2003	MRC	9506000003818wetland03E0100hvw	Registration	Restricted	
	Temperature (min/mean/max)	2005	WorldClim	www.worldclim.org/	None	Limited	Based on 1951–2000 data. Also available from IUCN; further distribution limited.
	BIOCLIM (multiple variables)	2005	BioClim	http://www.worldclim.org/bioclim	None	Limited	Interpolated; global extent
Demographic	Population distribution	2012	LandScan	http://web.ornl.gov/sci/landscan/	Purchase	Restricted	
	Population	2008	MRC	http://portal.mrcmekong.org/	Registration	Restricted	
	Population density	2008	MRC	http://portal.mrcmekong.org/	Registration	Restricted	
	Population growth	~1999-2008	MRC	http://portal.mrcmekong.org/	Registration	Restricted	Year range varies by country. Please see MRC atlas (2011).
	Population / density	1990, '95, '00	SEDAC	http://sedac.ciesin.columbia.edu/data/collection/gpw-v3/sets/browse	Registration	Restricted	
	Future pop. / density estimates	2005, '10, '15	SEDAC	http://sedac.ciesin.columbia.edu/data/collection/gpw-v3/sets/browse	Registration	Restricted	

Theme	Dataset	Year	Source	Link / MRCS GIAI	Access restrictions	Redistribution	Notes
Hydrological	Basins	2000	MRC	giai=9506000003818catchmentE01009of	Registration	Restricted	
	Hydropower dams	2009	MRC	9506000003818__hydropwE01009p4	License	Restricted	Link is to 2003 dataset, updated in 2009; project updates by IUCN.
	Rivers	2001	MRC	9506000003818_riverpolE01009r1	Registration	Restricted	
	Rivers (detailed)	2001	MRC	9506000003818____riverE01009r0	Registration	Restricted	
	Monitoring stations (meteorological)	2010	MRC	9506000003818_____E0200hvv	Registration	Restricted	
	Monitoring stations (hydrological)	2008	MRC	9506000003818_____E0200hvv	Registration	Restricted	
	Monitoring stations (water qual.)	2011	MRC	9506000003818_____E0100eil	License	Restricted	More recent data now available on a regular basis.
	Precipitation (annual/monthly)	2011	MRC	http://portal.mrcmekong.org/	License	Restricted	
	Precipitation (annual/monthly)	2005	WorldClim	http://www.worldclim.org/	None	Limited	Interpolated; global extent. Also available from IUCN; further distribution limited.
	Runoff (annual average)	2011	MRC	http://portal.mrcmekong.org/	Registration	Restricted	
	Sub-watersheds (4k)	2012	MRC	9506000003818_catmb_4kE0100jxj	Registration	Restricted	
	Sub-watersheds (1k)	2012	MRC	9506000003818_catmb_1kE0100jxi	Registration	Restricted	
	Sub-watersheds (3S)	--	MRC	http://portal.mrcmekong.org/	Registration	Restricted	Similar to HydroBasins level 8.
	Sub-watersheds	2012	HydroBasins	http://hydrosheds.org/page/hydrobasins	Registration	Restricted	Levels 1-12 available; level 8 corresponds most similarly to MRC sub-basins.

Theme	Dataset	Year	Source	Link / MRCS GIAI	Access restrictions	Redistribution	Notes
Socio-economic	Access to electricity	2008	MRC	9506000003818___socioE01009r6	Registration	Restricted	Using updated data, covering up to year 2008.
	Access to sanitation	2008	MRC	9506000003818___socioE01009r6	Registration	Restricted	Using updated data, covering up to year 2008.
	Access to improved water sources	2008	MRC	9506000003818___socioE01009r6	Registration	Restricted	Using updated data, covering up to year 2008.
	Primary school enrolment	2008	MRC	9506000003818___socioE01009r6	Registration	Restricted	Using updated data, covering up to year 2008.
	Secondary school enrolment	2008	MRC	9506000003818___socioE01009r6	Registration	Restricted	Using updated data, covering up to year 2008.
	Fish consumption	2009	MRC	http://portal.mrcmekong.org/	Registration	Restricted	
Transportation	Roads (access)	1998	MRC	9506000003818____roadE01009r2	Registration	Restricted	
	Airports	2009	MRC	http://portal.mrcmekong.org/	Registration	Restricted	
	Roads (major)	2012	Natural Earth	http://www.naturalearthdata.com/	None	Allowed	
Other	Landsat imagery	2013	USGS/NASA	http://earthexplorer.usgs.gov/	Registration	Allowed	Also available from IUCN

CI - Conservation International
GADM - Global Administrative Areas
GMS-EOC - Greater Mekong Sub region - Environment Operations Center
NOAA - National Oceanic and Atmospheric Administration
SEDAC - Socioeconomic Data and Applications Center
USGS/NASA - US Geological Survey/ National Aeronautics and Space Administration
WDPA - World Database on Protected Areas



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