Measuring, understanding and adapting to nexus trade-offs in the Sekong, Sesan and Srepok Transboundary River Basins

Jake Brunner, Jeremy Carew-Reid, Raphael Glemet
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EXECUTIVE SUMMARY

The Lower Mekong Initiative (LMI) is a multi-donor, country-directed platform to coordinate and address development challenges in three of the four Lower Mekong countries: Cambodia, Laos, and Vietnam. The LMI is founded on the assumption that development challenges in the Lower Mekong require stronger regional cooperation.[1] One of LMI's components is an Environment and Water Pillar. This component aims to advance sustainable economic development through regional dialogue and capacity-building. It promotes cross-cutting strategies to achieve water, energy, food and environmental security.

The LMI nexus Futures Program (NFP) is a subset of the LMI. It was created by merging LMI's water, energy, food, and environment pillars. Its goals are:

- the advancement of sustainable economic development;
- strengthened regional integration; and
- Resilience to the impacts of climate change.

A consortium comprising IUCN (International Union for Conservation of Nature), IWMI (International Water Management Institute) and ICEM (International Centre for Environmental Management) was engaged to assist the NFP by preparing a nexus assessment of the Sekong, Sesan, and Srepok (3S) sub-basins in Cambodia, Laos, and Vietnam.

This report comprises a building block of the consortium's first deliverable which is:

> *"A nexus assessment produced in collaboration/partnership with key regional stakeholders to facilitate improved understanding within existing local, national, and/or regional dialogues, planning, and/or investments on the opportunities and risks from conjunctively managing water, food, energy, and the environment".*

The term "nexus assessment" refers to an integrated assessment of current and future trends of water, energy, food, and environmental conditions to support integrated planning and development decision-making at the regional level. The assessment also provides recommendations to overcome data, technology, and capacity, institutional and financial barriers.

This report includes five sections and three annexes. *Section 1* summarizes the key challenges in the 3S. These include:

- Rapid, unregulated land use change characterized by widespread deforestation.
- Degradation of terrestrial and aquatic habitats, resulting in reduced biomass that provides crucial nutritional value and livelihoods for the rural poor.
- Poverty and malnutrition, especially among ethnic minorities.
- Domestic immigration leading to unsustainable land use pressure, especially in Vietnam.
- Squandering of water on economically low-value uses, resulting in declining basin welfare.

Global experience shows that the existing siloed approaches to water, food and energy will result in continued degradation of the natural environment and with the poorest communities paying the highest price. Hence the importance of the NFP dialogue, which seeks cross-sectoral and integrated solutions.

To understand how a nexus approach can help avoid the problems of silo-based approaches to water, food, energy and environment, it is necessary to know what is planned for these sectors in each country. *Section 2* therefore examines the policy and planning frameworks in Cambodia, Laos, and Vietnam. It does this by consolidating the objectives in these frameworks into a set of generalized objectives for each country. Redundancies are removed by further consolidation into 18 unique objectives of which:

- Seven are concerned with water resources

[1] https://www.lowermekong.org/

- Three are concerned with food
- Three are concerned with energy
- Five are concerned with the environment

A nexus assessment applied to these objectives reveals a range of various threats that an initiative in one sector might pose to another. We call these “red flags”.

Many of these threats could be addressed by appropriate implementation of a nexus approach within and among each country. These are identified in *Section 3*. Seven nexus solutions are identified of which two comprise of built and five are natural infrastructure. In addition, eight non-nexus solutions are identified as complementary measures that would add value to a nexus approach. The major threats and nexus solutions were then consolidated into the typology shown in Table 1, which shows the potential of natural infrastructure to address the threats.

NEXUS SOLUTIONS
1. Multi-purpose dams or new operating rules
2. Large-scale groundwater recharge infrastructure
3. Natural infrastructure 1: Seepage troughs
4. Natural infrastructure 2: Wetlands
5. Natural infrastructure 3: Use of paddy fields
6. Natural infrastructure 4: Use of floodplains
7. Natural infrastructure 5: Other

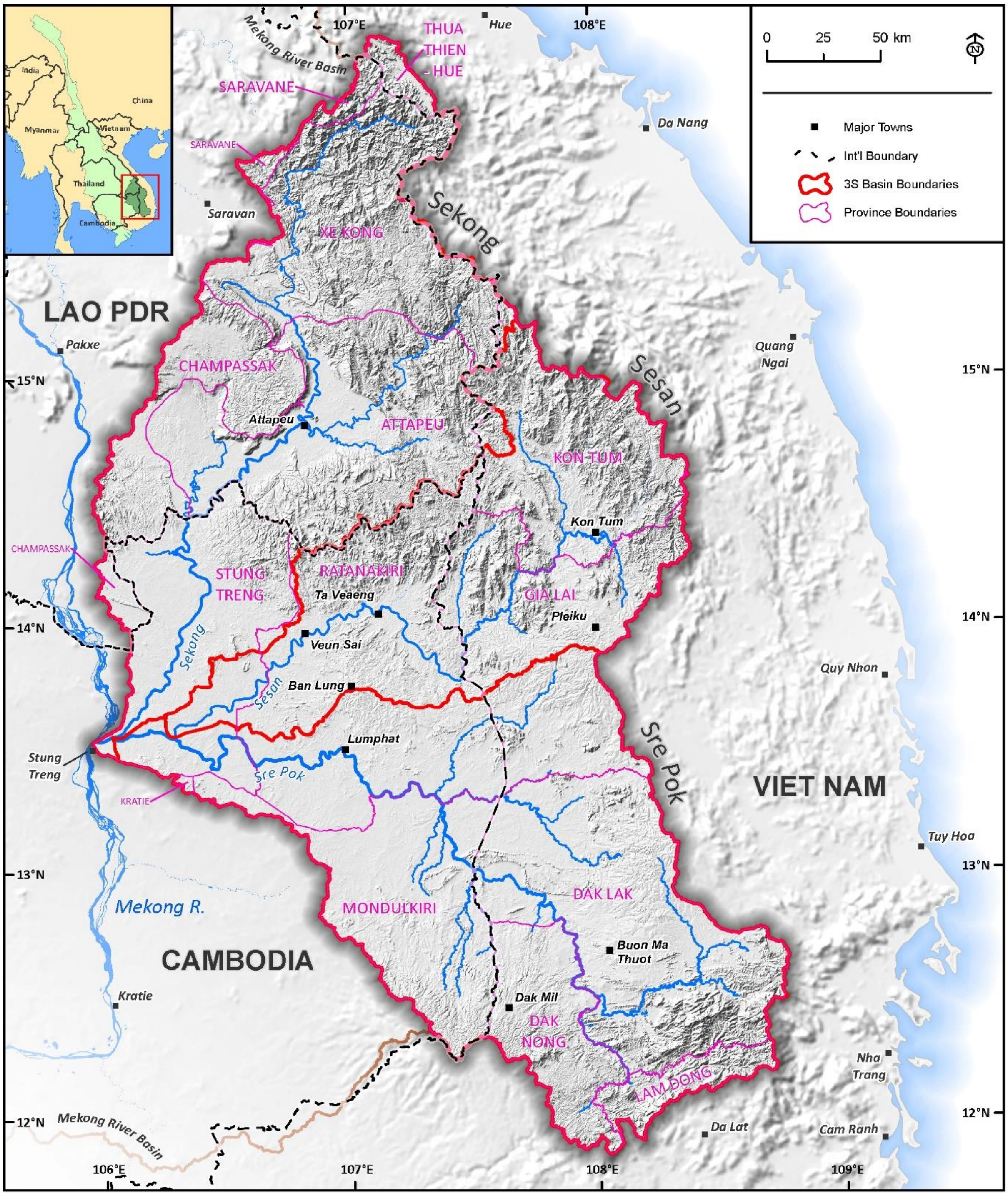
THREAT	**NEXUS SOLUTIONS**							**AVAILABLE SOLUTIONS**
	1	**4**	**7**	**3**	**6**	**5**	**2**	
1. Over-pumping groundwater for irrigation	1	1	1	1	1	1	1	**7**
2. Location-specific flood management infrastructure	1	1	1		1	1		**5**
3. Increased irrigation diversions	1	1	1	1			1	**5**
4. Over-exploitation of fishery and other aquatic organisms	1	1	1		1			**4**
5. Intensified smallholder agriculture and agrochemicals	1	1		1				**3**
6. Mineral processing impacts on water quality	1	1		1				**3**
7. Increased industrialization in upper Sesan and Srepok	1	1						**2**
8. Maximizing hydropower, increased dams and reservoir area	1							**1**
9. Deforestation			1					**1**
Potential number of threats that could be addressed	**8**	**7**	**5**	**4**	**3**	**2**	**2**	

Table 1: nexus solutions ranked by applicable threats (horizontal) and solutions per threat (vertical)

The remainder of Section 3 describes each of the nexus and non-nexus solutions.

Section 4 addresses the benefits, risks, and challenges that have emerged from the assessment.

Section 5 addresses challenges in implementing a nexus approach in the 3S.



The 3S Basins

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)

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. BACKGROUND

1.1 Sustainable development challenges in the 3S

Globally, demands for water, energy, and food are increasing rapidly while available natural resources are increasingly degraded and in scarce supply. This challenge is particularly acute in developing countries experiencing rapid economic growth such as Cambodia, Laos, and Vietnam (CLV).

Within CLV, the Sesan, Srepok, and Sekong, or 3S river basins, are of special interest from a nexus perspective of water, energy, food and environmental trade-offs and solutions. This sparsely populated region, often referred to as the last frontier of development in CLV, is rich in natural resources, which governments are seeking to harness to drive national development. The process has gone furthest in Vietnam where large-scale state investment in agriculture, mining, hydropower, and transport in the Central Highlands started in the 1990s. In Cambodia, investments in roads, hydropower, and land development started in the 2000s and in Laos more recently.

Box 1.1: Development of the Central Highlands

The Central Highlands is dominated by basalt-derived soils, which are suitable for perennial crops such as coffee, rubber, tea, pepper, cashew nut, and mulberry. Today, it produces 75% of Vietnam's rubber and 80% of its coffee. Coffee exports from Dak Lak alone were worth $1.26 billion in 2018. The region is also rich in bauxite and gold.

Before 1976, ethnic minorities made up 70% of the population. As more and more Kinh people—the largest ethnicity in Vietnam—arrived, the ethnic minority population declined to 44% in 1993 and 25% in 2004. Most of the immigration was state-organized as the government brought in labor to work new state-owned logging and industrial crop enterprises and to reduce population pressure on the densely-populated Red River Delta in the north.

Rapid Kinh immigration resulted in the large-scale transfer of land to state-owned farms and conflicts with ethnic minorities who were pushed deeper into the forests. The area of coffee grew from 207,000 hectares in 1996 to 573,000 hectares in 2014 while the area under rubber grew five-fold over the same period (Figure 1.6). In 2018, the area of coffee in Dak Lak alone was 204,000 hectares.

Unregulated logging and land conversion resulted in rapid deforestation. Nationwide, annual timber production fell from 600,000-700,000 m^3 in the late 1980s and early 1990s to 200,000-300,000 m^3 today. Forest cover fell from 67% in 1976 to 50% in 2012 and has continued to decline.

The government has invested heavily in infrastructure in the Central Highlands. Hundreds of small (<5 MW) hydropower plants have been built, every commune now has electricity, and the region is now connected to the rest of the country through a dense road network.

Rapidly growing populations and agriculture (especially irrigated robusta coffee) production have hugely increased water demand, resulting in rapidly falling groundwater tables during the dry season, while forest clearing has reduced water retention and groundwater recharge.

Globally, the pattern of investment and growth expanding into a less developed periphery is typical. What justifies a focus on the 3S for this nexus assessment is the pace and scale of change, and its globally-important biodiversity. Parts of the 3S have experienced dramatic changes, particularly in Vietnam through coffee and hydropower, and the 3S typify the challenges that confront natural resources management in fast-growing economies. Box 1.1 describes the human and environmental transformation of the Central Highlands over the last 40 years.

There have been several nexus studies of the Lower Mekong as a whole. Pittock et al. (2016) propose a model showing how increased hydropower and irrigation could drive further river modification through a feedback loop (Figure 1.1). Increased modification of rivers results in reduced food supply that drives agricultural intensification that requires further river modification.

This feedback loop is apparent in the Mekong Delta where the construction of high dikes in the 2000s to grow a third rice crop blocked the delivery of nutrient-rich sediment, which requires the increased application of fertilizer and pesticide, whose production further increases energy use (which in the delta is being increasingly met by coal power stations).

Such a feedback loop can have positive outcomes. More power can support increased industrialization, urbanization, and higher paying non-agricultural jobs (e.g., construction, garments) that allow food requirements to be met through a combination of increased productivity from land consolidation (as the rural population falls) and/or increased imports.

However, this model entails risks.

From Vietnam's perspective, sediment-trapping dams pose an existential threat to the Mekong Delta, source of 90% of the country's rice exports and 20% of its GDP. No amount of industrialization could offset the loss of the delta's economic importance. In 2018, the Communist Party of Vietnam designated the sustainability of the Mekong Delta a matter of national security. In 2014, to encourage greater regional cooperation over the Mekong, Vietnam ratified the UN Watercourses Convention.

The loss of capture fisheries affects the landless who depend on fishing for their livelihoods and food security. This risk is high in the 3S because over half the Lower Mekong fish catch is from long-range migrant fish species that are particularly susceptible to dams, dikes, and other barriers. The impacts of dams on fisheries and food security therefore extend far beyond the 3S itself.

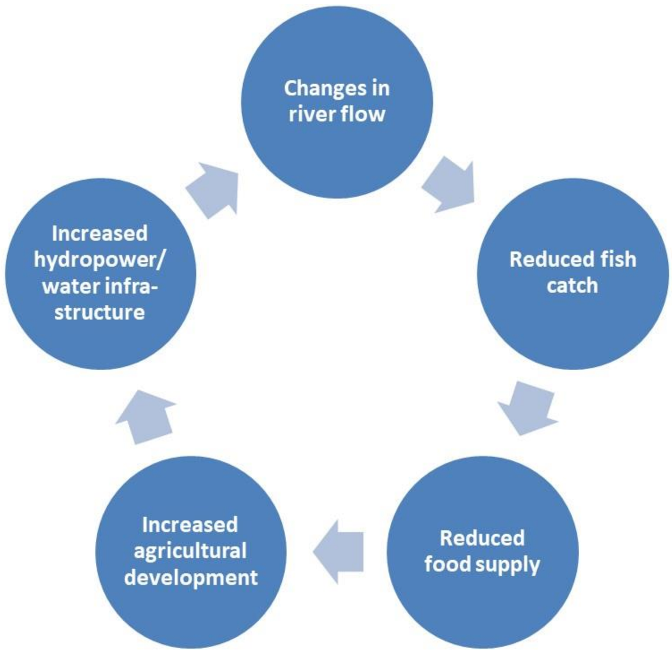


Figure 1.1: Nexus feedback loop in the Lower Mekong adapted from Pittock et al. (2016)

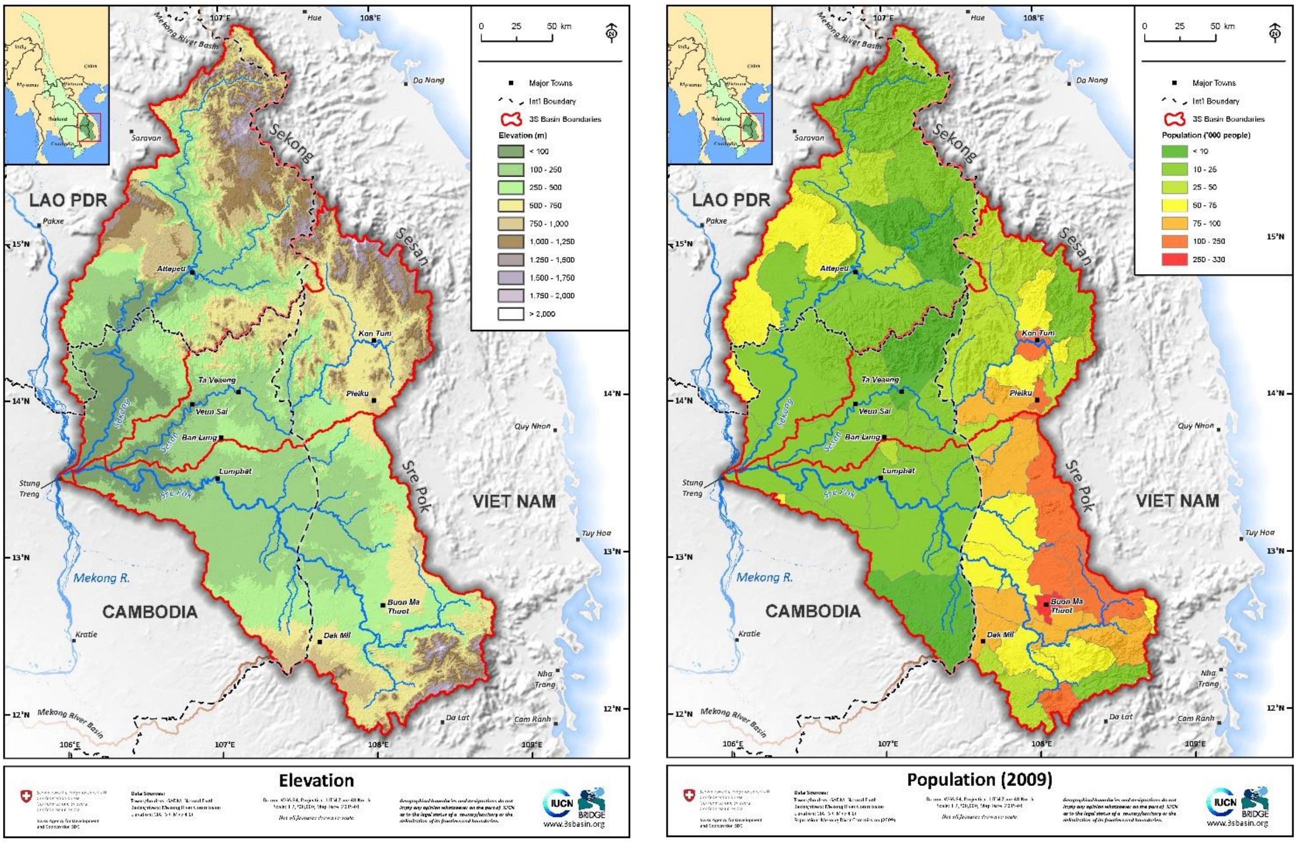
The 3S merge just upstream of their confluence with the Mekong and combined form the Mekong's single largest tributary basin (78,579 km^2). All three rivers are transboundary. The Sekong originates in central Vietnam and flows into southeast Laos, and then into northeast Cambodia. The Sesan and Srepok originate in the Central Highlands before they too flow into northeast Cambodia (Figure 1.2).

While often referred to as a single unit, the three rivers basins are physically, socially, and economically diverse (Table 1.1). The Sekong is the least developed in terms of population, commercial agriculture, and hydropower. It has the highest proportion of ethnic minorities, the largest remaining area of forest, and the largest number of endemic fish species.

	SEKONG				SESAN			SREPOK		
	C	**L**	**V**	**Total**	**C**	**V**	**Total**	**C**	**V**	**Total**
BIOPHYSICAL										
Catchment area (km^2)	5,520	22,448	848	28,816	7,566	11,255	18,821	12,780	18,162	30,942
Mean elevation (masl)	154	646	844	558	273	778	575	218	525	398
Mean annual rainfall (mm)	1,860	2,185	2,395	2,129	1,965	2,155	2,055	1,569	1,575	1,573
Mean annual river flow (m^3/s)	---	---	---	1,040	---	---	651	---	---	695
SOCIO-ECONOMIC										
Population '000 (2015)	37	369	30	436	121	946	1,068	163	2,348	2,511
Population density	6.7	16.4	35.5	15.1	16.1	84.1	56.7	12.8	129.3	81.2
Ethnic minority population '000 (%)	4 (10)	265 (72)	16 (53)	285 (65)	91 (75)	435 (46)	526 (49)	82 (50)	892 (38)	974 (39)
Population living in poverty '000 (%)	10,057	88,463	4,217	102,737	32,800	132,447	165,247	44,112	328,718	372,830
KEY SECTORS										
No. hydropower dams (installed capacity MW)	0 (0)	7 (1,252)	0 (0)	7 (1,252)	1 (1)	7 (3,331)	8 (3,332)	0 (0)	5 (1,184)	5 (1,184)
Agricultural area (km^2)				1,331			1,237			3,027
Capture fisheries (tons/yr)	1,100-1,530	690	100		370-845	1,268		682-1,136	1,576	

Table 1.1: 3S at a glance, key statistics by basin (Constable 2015)

Covering about 10% of the river basin, the 3S provide about 20% of the mean annual flow of the Mekong (Arias et al., 2014), a proportion that rises to 35% during the dry season, and almost 15% of its suspended sediment (Koehnken, 2012). These sediments provide nutrients vital to fisheries in the Tonle Sap and rice production in the Mekong Delta. The 3S is also the Mekong's most important river basin for migratory fish populations and plays a critical role in maintaining the hugely productive downstream fisheries (Ziv et al., 2012).



Figures 1.2-1.3: Elevation and population in the 3S

A large proportion of existing hydropower production in Vietnam (17%) and Laos (30%) is A large proportion of existing hydropower production in Vietnam (17%) and Laos (30%) is in the 3S and both Laos and Cambodia have plans for significant further power development (Figure 1.5). The 400 MW Lower Sesan 2 (LS2) was completed in late 2017. Located just below the confluence of the Sesan and Srepok, the LS2 blocks fish migration up the entire length of these two rivers and is estimated to reduce total fish biomass in the Lower Mekong by almost 10% (Ziv et al., 2012).

The 3S has a total population of just over four million, most of whom (82%) live in the Central Highlands (Figure 1.3). A significant proportion, particularly in Cambodia and Laos, are member of over 60 ethnic minorities. Migration of ethnic Vietnamese (Kinh) into the Central Highlands has resulted in a significant decline in the proportion that are ethnic minorities (D'haeze, et al., 2005) but in absolute terms the population of ethnic minorities is far larger in the Central Highlands than in either Cambodia or Laos.

Poverty is concentrated in ethnic minority groups. Often located on marginal lands, using traditional low productivity agriculture practices, and with limited access to roads, electricity, water supply and sanitation infrastructure, these are largely small-scale, subsistence farming communities that remain highly dependent on fisheries and forest products. Although conditions tend to be better than in many parts of Cambodia and Laos, the largest numbers of poor people live in the Central Highlands. Throughout the 3S, ethnic minorities remain exposed to economic and environmental vulnerabilities that undermine their livelihoods, health and general well-being. Life expectancy is low, and malnutrition remains a severe problem with rates well above national averages in all three countries.

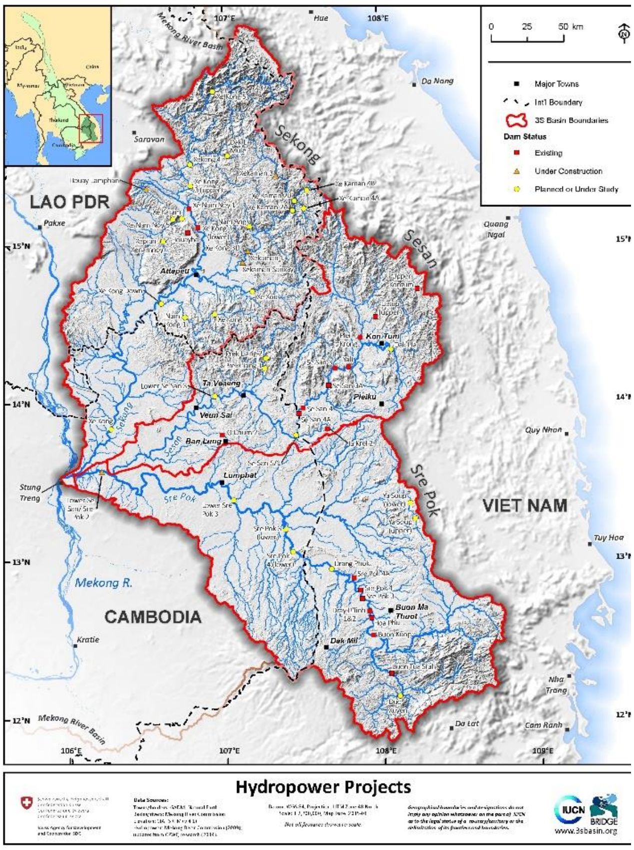
Expansion of agriculture and commercial plantations has led to rapid forest loss, particularly since the late 2000s (Box 1.2) in response to increased Vietnamese investment in rubber plantations in Cambodia and Laos and, in Cambodia, the allocation of 67 Economic Land Concessions (ELCs) covering 620,300 hectares.

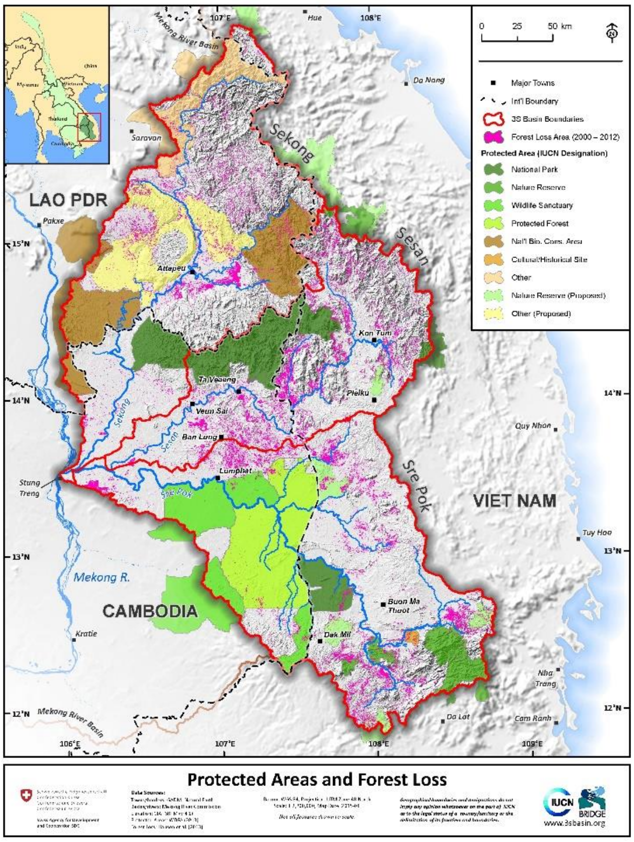
About one-third of the 3S has some form of legal protection. But minimal government investment in protected area management coupled with large-scale forest clearing for plantations and other forms of economic concession and improved road access has resulted in some of the world's highest deforestation rates. As forest landscapes have become fragmented, populations of commercially valuable wildlife have been extirpated by poaching to feed the illegal wildlife trade.

Box 1.2: Forest loss and protected areas in the 3S

Between 2000 and 2017, the 3S lost 947,000 hectares of forest (14% of forest extent in 2000, one of the highest rates in the world). Of this, 83% was in forests with >50% canopy cover and 66% in forests with >80% canopy cover, indicating that mostly high-quality forest was lost. There has also been significant forest loss within protected areas, which cover 35% of the 3S (Figure 1.5).

Between 2000 and 2017, protected areas lost 172,000 hectares of forest cover, equivalent to 7% of total protected area coverage and 18% of total 3S forest loss. Protected areas in the Srepok in Cambodia and Vietnam and the Sekong in Laos suffered the highest forest losses in absolute and relative terms. However, the rate of forest loss inside protected areas is about one-third of the rate of forest loss outside protected areas, indicating that they do provide a degree of protection.





Figures 1.4-1.5: Hydropower dams, and protected areas and deforestation in the 3S

Artisanal and large-scale mining is important in the Laos and Vietnam portions of the 3S. In Cambodia, mining is still very limited but there are plans for large gold mines, including inside protected areas. Environmental concerns relate to the impacts of mining on water quality, disturbance of aquatic habitats, and the influx of hundreds of foreign workers. Sand and gravel extraction from river beds in the 3S is a growing concern in all three countries because of river bank collapse and increased turbidity.

The Central Highlands is home to the world's third largest bauxite deposits (Figure 1.6). This is a potential game changer because the conversion of bauxite to alumina (the precursor to aluminum) requires large amounts of water and energy. There is only one bauxite mine in the 3S, in Vietnam. But if bauxite mining expands significantly it will require a major increase in hydropower that could have huge impacts on river flow and water quality. Similar environmental impacts could accompany the planned expansion of gold mining in Cambodia.

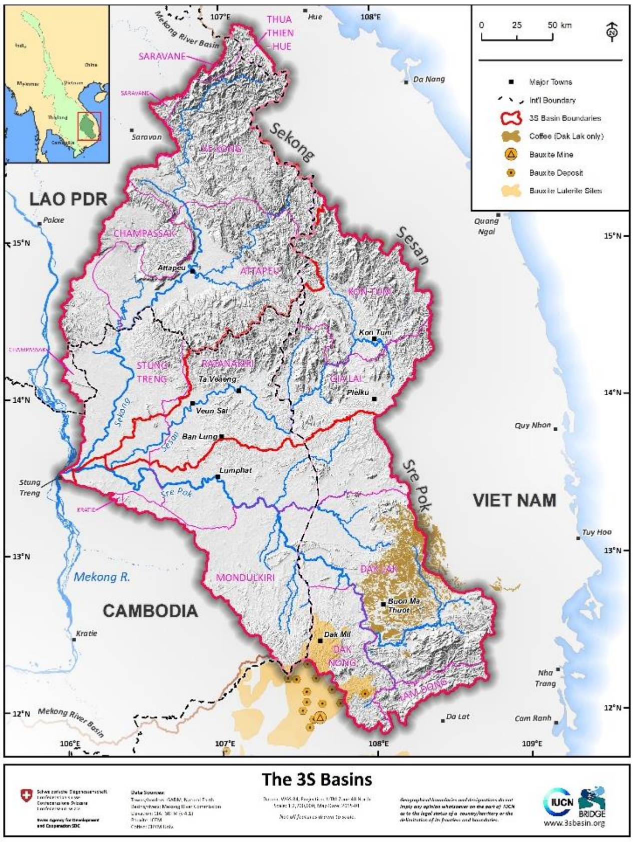


Figure 1.6: Coffee (Dak Lak) and bauxite deposits

Throughout the 3S, economic development in the form of concessions for hydropower, mines, and agribusiness (e.g., coffee, cassava, rubber, sugar cane) has reduced the quantity and quality of forests, rivers, and other natural resources. The impacts of different schemes often intersect, increasing their severity. For example, the resilience of communities affected by hydropower is often further undermined by the impacts of agribusiness and/or mining concessions on other resources. These cumulative impacts are hardly ever recognized and local people are rarely adequately compensated (Baird and Barney, 2017).

The Vietnamese government provides extensive rural welfare services. But these services are not tailored to ethnic minorities or address the underlying causes of exclusion and have not proved effective at reducing malnutrition and other non-material dimensions of poverty. In the 3S, it is the poorest, ethnic minorities, and women who disproportionately pay the price for national economic development.

Box 1.3: Impacts of Yali Falls Dam

More than 8,500 people, mostly from ethnic minority groups, were relocated from the dam's 68.4 km^2 inundation zone. The dam has also affected the livelihoods of people living downstream in both Vietnam and Cambodia. In both countries, communities report that alteration of river flows has made farming and fishing along the river banks extremely dangerous. From 1999 to 2001 flash floods killed at least 39 people and valuable livestock and destroyed vegetable gardens and rice fields. It is estimated that up to 55,000 villagers from 16 ethnic minority groups in Cambodia's Ratanakiri and Stung Treng Provinces and many thousands more in the Central Highlands continue to suffer due to lost rice production, drowned livestock, lost fishing income, and damage to rice reserves, boats, fishing gear and houses because of rapid river level fluctuations resulting from dam operation. These people have received no compensation for the adverse livelihood impacts caused by the dam (IEBR and IRN, 2004).

There is no institutionalized transboundary cooperation on the 3S. The mandate of the Mekong River Commission (MRC) only extends to the Mekong mainstream, not its tributaries such as the 3S. This has already resulted in major unplanned and unwanted transboundary impacts (Box 1.3). Conservation International's Freshwater Health Index study of the 3S gives the following scores: Ecosystem Vitality: 66%; Ecosystem Health: 80%; and Governance & Stakeholders: 43% (FHI, 2018). The low governance score was weighed down by particularly low scores for enforcement and compliance and information access.

While there are many causes for concern, there are also grounds for optimism.

The 3S has substantial solar and wind potential and dramatic price reductions in renewable energy generation give CLV the chance to achieve energy security at much lower social, environmental and financial cost (Figure 1.7).

Hydropower will remain an essential part of any regional power scenario. But by integrating solar and wind, expanding regional power trade, and improving energy efficiency, fewer dams will be needed to meet a given level of energy demand. That would reduce river fragmentation and sediment trapping and therefore threats to fisheries, food security, and the Mekong Delta.

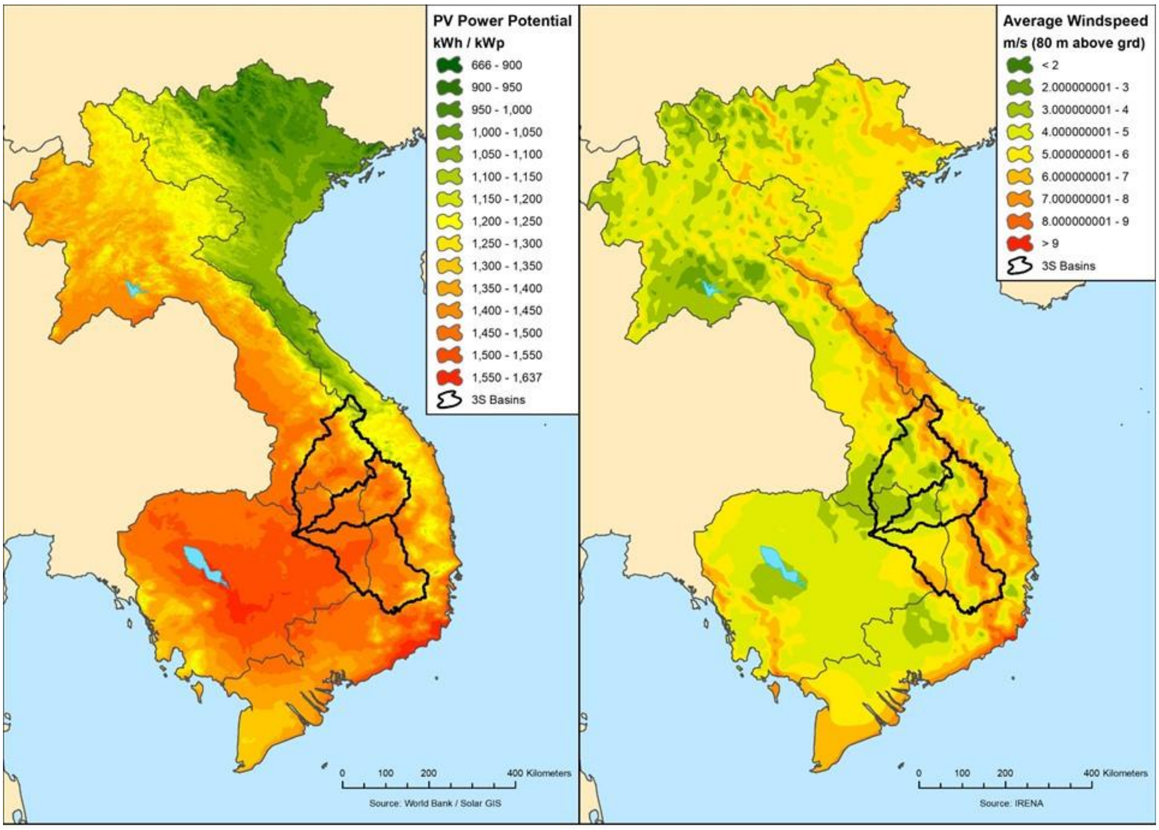


Figure 1.7: Solar and wind power potential in CLV and 3S

Another positive signal are plans to establish river basin organizations in Vietnam (for the Sesan and Srepok) and in Laos (for the Sekong, which is also undergoing an IFC-financed hydropower cumulative impact assessment). Since 2012, the World Bank's Mekong Integrated Water Resources Management Project (M-IWRM) has fostered transboundary cooperation between Cambodia and Vietnam on the Srepok and Sesan. While embryonic, these initiatives reflect recognition of the need for coordinated river basin development, including hydropower.

Official recognition of the benefits of improved planning is the Sustainable Hydropower Master Plan for Xe Kong (Sekong) Basin in Laos, which the Natural Heritage Institute (NHI) prepared on behalf of the Lao government (NHI, 2017). The purpose is to support implementation of the Policy on Sustainable Hydropower Development that was decreed by the Prime Minister in 2015. It provides standards or criteria for determining the sustainability of proposed hydropower projects.

The master plan's major recommendation is to defer any decision on mainstream dams and pursue instead the options in the order in which they are presented, with the solar augmentation of existing reservoirs as the top priority. (Solar augmentation, which benefits from existing transmission lines, has been deployed in China and South Korea. And in November 2018 the Electricity Generating Authority of Thailand (EGAT) announced plans for Thailand's first large-scale deployment of floating solar.[2]) If there comes a time when additional power from the Sekong is needed, the uppermost dams should be given a higher priority. The lowermost dams, notably the Sekong Downstream A, should not be developed under any circumstance because of the very large impacts relative to the power generated.[3] There is also investment in wind power in the 3S: Impact Energy Asia, a Thai firm, is building a 600 MW wind farm, ASEAN's largest, in Attapeu Province.[4]

A nexus study of the 3S is particularly timely because it can help answer important policy questions. For example:

- Now that the Sesan and Srepok are cut off by the LS2 dam, how can the two river systems be developed in ways that optimize remaining water, food, energy, and environmental benefits and allow for greater connectivity if LS2 were modified to allow for fish passage?
- Now that the Sekong is the last major tributary of the Mekong with no mainstream dams, how can energy planning ensure that its critical value in regional fisheries and food security be secured?
- As climate change impacts and adaptation costs increase, what combination of hard and soft engineering offers the best value for money?

The drought that struck the Central Highlands in 2016, the worst in 30 years, illustrates the need for a nexus approach. Hundreds of reservoirs ran out of water and over 165,000 hectares of coffee plantation were affected, of which 40,000 hectares were lost. Tens of thousands of households lost access to piped water. The total economic damage was almost $100 million. Was this the result of unbridled natural resource depletion that increased vulnerability to climate shocks? Or could it have simply been a consequence of lower than normal rainfall? One could argue that it demonstrates the need for more water storage, not less.

The following sub-section introduces the Lower Mekong Initiative, which advocates a nexus approach to defining win-win pathways toward equitable economic development in the 3S.

1.2 LMI and Nexus Futures Project

The Lower Mekong Initiative (LMI) is a multi-donor, country-driven platform founded on the assumption that meeting the development challenges in the Lower Mekong Basin requires regional

[2] https://www.pv-tech.org/news/thailand-utility-eyes-1gw-of-floating-solar-on-hydro-dams-pilots-energy-sto?utm_source=Mekong+Eye&utm_campaign=c778922c35-EMAIL_CAMPAIGN_2018_01_10_COPY_01&utm_medium=email&utm_term=0_5d4083d243-c778922c35-380875673

[3] https://www.iucn.org/news/viet-nam/201805/xe-kong-1-dam-why-it-matters-vietnam

[4] http://www.impactelectrons.com/wp-content/uploads/2017/09/Monsoon_Wind_Power_Factsheet_EN.pdf

cooperation.[5] One of LMI's components is an Environment and Water Pillar. It aims to advance sustainable economic development through regional dialogue and capacity-building. It promotes cross-cutting strategies to achieve water, energy, food and environmental security.

At the 8th LMI Ministerial Meeting in August 2015, the U.S. Secretary of State and the Foreign Ministers of Cambodia, Laos, Myanmar, Thailand, and Vietnam released a joint statement entitled "Building a Sustainable Future for the Mekong".[6] This statement commits signatories to seek avenues for collaboration in the capacity-building needed to drive sustainability in the Mekong region. The LMI Nexus Futures Program (NFP) is a subset of the LMI. It was created by merging LMI's water, energy, food, and environment pillars. Its goals are:

- the advancement of sustainable economic development;
- strengthened regional integration; and
- resilience to the impacts of climate change in the Lower Mekong countries.

These goals are to be achieved by strengthening regional discussions that advance integrated planning based on the inter-connections between water, energy, food and environment. The Siem Reap Declaration from the 3rd MRC Summit in April 2018 recognizes the need for a nexus approach.[7]

To map alternative approaches, the NFP will develop a science-based nexus assessment of the 3S to identify ways to maximize sustainable development outcomes**.** The term "nexus assessment" refers to an assessment of the current and future trends of water, energy, food, and environmental conditions arranged to support integrated planning and development decision-making at the regional level as well as recommendations to overcome data, technology, capacity, institutional and/or financial barriers.

The 3S nexus assessment has three objectives:

1. A nexus assessment produced in collaboration with key regional stakeholders to facilitate improved understanding within existing local, national, and/or regional dialogues, planning, and/or investments on the benefits from conjunctively managing water, food, energy, and the environment.
2. Integration of the assessment findings into local, national and/or regional discussions on infrastructure planning, development, and/or investments, notably the Cambodia-Laos-Vietnam (CLV) Initiative, ADB's Greater Mekong Sub-region (GMS), and MRC's Basin Development Plan (BDP) 2016-2020, which includes an as yet unfunded joint project on the Sesan and Srepok under the National Indicative Plan (NIP) 2016-20,[8] and the Sustainable Hydropower Development Strategy (SHDS), which is in preparation and will form an input to BDP 2021-2025.[9]
3. Dissemination of the best practices and lessons learned through existing mechanisms to improve development across the region through strengthening the capacity of relevant stakeholders, basin planning organizations, and local institutions to manage trade-offs and opportunities beyond the life of the project.

1.3 Integration of assessment findings

This document is concerned with the first objective. It assesses nexus-style management measures needed to mitigate water, food, energy and environmental security risks under business-as-usual and contribute to improved stakeholder understanding of planning and/or investments. The main text continues in *Section 2* with a brief assessment of future expectations stated in national policies and plans.

[5] https://www.lowermekong.org/
[6] https://2009-2017.state.gov/r/pa/prs/ps/2015/08/245710.htm
[7] http://www.mrcmekong.org/assets/Uploads/Siem-Reap-Declaration-5-April-2018.pdf
[8] http://www.mrcmekong.org/assets/Publications/MRC-promotional-report-on-Identified-Joint-Projects-for-2016-2020.pdf
[9] http://www.mrcmekong.org/assets/Uploads/Summary-note-Draft-SHDS-Aug-2018.pdf, http://www.mrcmekong.org/assets/Uploads/3.-Review-and-Update-of-SHDS.-120918.pdf

Section 3 identifies challenges and opportunities that could be addressed through synergy, trade-off or compromise. The section then presents possible nexus solutions.

Section 4 provides guidance to policy making in the 3S (and other river basins).

Section 5 addresses challenges in implementing a nexus approach in CLV.

The main text is supported by three annexes.

Annex 1 identifies the collaborations and partnerships that have characterized the work undertaken to date.

Annex 2 provides a detailed overview of the sub-basin and as such supports the summary background presented in Section 1.1.

Annex 3 summarizes water, food, energy and environmental plans and policies in CLV.

2. FUTURE EXPECTATIONS

The project's TOR require "*an assessment of the current and future trends of water, energy, food and environmental conditions*." CLV have objectives and plans for each sector, but not all are compatible, with some posing threats to others. By looking at competing sectors through a nexus lens it is possible to identify conflicts that could be resolved using various combinations of synergies, trade-offs or compromise.

This section explores relevant policy and planning frameworks in CLV and the 3S to identify how the expectations of one sector that might be incompatible with those of another.

Not all potential conflicts represent nexus opportunities. This section identifies those that do and explains why. Possible nexus approaches to these conflicts are suggested in Section 3.

2.1 Policy and planning framework

Annex 3 presents details of the policy and planning frameworks as they pertain to water (W), energy (EN), food (F) and environment (EV). Table 2.1 is a generic summary of the framework, providing the same information but in a more consolidated fashion.

SECTOR	CAMBODIA	LAOS	VIETNAM
W	Integrated management in a basin context	IWRM	Increase in "recovered" water bodies increased by 30%
	Prioritize river basin and aquifer conservation	Ensure multi-purpose, cross-sectoral management	
		Groundwater development	
		Prevent, control and reduce pollution	
		Build river dikes as a flood management measure	
F	Improve access to improved water services in the rural areas	Upgrade irrigation to permanent systems plus major irrigation expansion	Increase water service to both urban and rural users
	25% increase in irrigated area, of which paddy will comprise a significant component (see fisheries)	Massive increase in irrigated rice production	Increased area of rice production, which can be assumed to require irrigation
		Increase irrigated area	Existing rice area protected from development
		Increase fisheries	
	Protect ecosystem to support capture fisheries		1.2 million hectares of aquaculture
	Increase rice field fisheries (implies wetland rice)		
	Growth of culture fishery sector		
	Increase the number of fishes, especially endangered species		
EN	Expand service coverage	Expand service coverage	Prioritize hydropower development
	Expand regional energy trade	Complete 15 hydropower dams	
		Small hydropower development as default wherever possible	
EV	Protection and conservation of forest resources to alleviate poverty and ensure equitable economic growth	Effective management and utilization of natural resources	Improve climate change resilience
	Reforestation including flooded forest and mangrove areas	Reforestation	Reforestation
	Ensure climate resilience of critical ecosystems	Expand environmentally friendly tourism	
		Wetlands management according to Ramsar criteria	

Table 2.1: Generic policy and planning framework for water, food, energy, and environment

Table 2.1 includes repetitions and redundancies. These are consolidated into 18 objectives in Table 2.2, which shows which objective applies to which sector in which country. Water is the sector with the most objectives (7) followed by environment (5) and food and energy (3 each).

SECTOR		CONSOLIDATED OBJECTIVES						
W		IWRM or "multi-purpose, cross-sectoral management	Aquifer conservation	Aquifer develop-ment	Reduce pollution	Flood control	Water body rehabili-tation	Increase water supply service delivery
	C	Y	Y	N	N	N	N	Y
	L	Y	N	Y	Y	Y	N	N
	V	N	N	N	N	N	Y	Y
F		Substantial expansion of irrigation of which a large portion is for paddy	Increase capture fisheries	Increase culture fisheries				
	C	Y	Y	Y				
	L	Y	Y	N				
	V	Y	N	Y				
EN		Expand electrical service coverage	Prioritize hydropower	Regional energy trade				
	C	Y	N	Y				
	L	Y	Y	N				
	V		Y	N				
EV		Forest conservation for poverty alleviation and economic growth	Reforestation	Improve ecosystem climate change resilience	Expand environmentally friendly tourism	Effective management and use of natural resources		
	C	Y	Y	Y	N	N		
	L	N	Y	N	Y	Y		
	V	N	Y	Y	N	N		

Table 2.2: Consolidated policy and planning framework for water, food, energy and environment

2.2 Red flags

The consolidated policy and planning framework presented above can identify ways by which water, food, energy and environmental security are threatened by specific policies and plans. These threats are our red flags (Table 2.3), which arise from initiatives that provide benefits for one sector but impose costs on another.

THREATS	NEXUS SECTORS		EXPLANATION
	BENEFICIARY	THREATENED	
1. Over-pumping groundwater for irrigation	F	W, EV, EN	This can result in serious constraints on surface water baseflows

2. Location specific flood management infrastructure	F	W, EV	As above, plus the risk of water logging and soil degradation and compromised soil biota
3. Increased irrigation diversions	F	W, EV	Pollution from increased use of agricultural chemicals while unregulated pesticide use represents threats to the natural biome. Increased irrigation may be an implicit assumption embedded in "commercialization" especially if investments in value addition are an objective.
4. Over-exploitation of fish and other aquatic organisms	None	W, EV	Pollution
5. Intensified smallholder agriculture and agrochemicals	EN	W, F, EV	Although often thought of as a non-consumptive use of water, there are evaporation losses and usually there are also deep percolation losses that do not necessarily return to the surface drainage system. Also, hydropower operating rules may limit the allocation of water to uses with lower opportunity costs. Dam cascades for which the operating rules require the maintenance of full supply levels increase risk of catastrophic flooding. Hydropower reservoirs can be significant sources of greenhouse gases while dams and reservoirs represent obstacles to spawning and migratory routes.
6. Mining and processing impacts on water quality	None	W, EN, EV	Pollution and increased demand for energy
7. Increased industrialization in upper Sesan and Srepok	None	W, EV	Disrupted hydrographs and sediment problems with respect to water. These are also environmental problems that affect habitat and ecosystem services.
8. Maximizing hydropower, increased dams and reservoir area	F	EV, F	Included here because sustainable fisheries expansion and intensification can be incorporated into nexus investment opportunities
9. Over-pumping groundwater for irrigation	W	E, EV, F	There is a risk that flood containment using dikes to protect one location simply shifts and magnifies the problem downstream. In addition, river dikes severely curtail floodplain functions including fish reproductive cycles while reducing genetic diversity.

Table 2.3: Red flags

3. NEXUS ASSESSMENT IN THE 3S

Before understanding how a nexus approach can help solve water-related problems, stakeholders first need to understand the difference between a watershed and a “problem-shed”.

For example, unsustainable land and water use may result from limited non-agricultural livelihood opportunities. Fix that, and the problems of unsustainable land and water use could disappear. The lack of off-farm livelihoods is a problem-shed issue whereas its result is a watershed issue. However, the lack of off-farm livelihoods may arise from inadequate or unreliable energy or raw material supplies, and this could be a watershed issue because of energy (hydropower) or agricultural inputs (agribusiness). Hence the value of a nexus approach that reveals non-traditional, alternative pathways through the interconnected maze of problems situated in both the watershed and the problemshed.

For example, a large-scale agribusiness investment could stabilize watersheds, thereby restoring and sustaining stream flows for downstream users while establishing value chains that offer improved livelihoods and economic growth.

Achieving the benefits of integrated planning is constrained by institutional and policy silos and vested interests. The nexus approach breaks down these sector walls by providing policy makers with options for:

- *Synergies,* whereby one intervention achieves multiple objectives.
- *Trade-offs,* whereby a sector objective is rendered sub-optimal in favor of another that is optimized.
- *Compromise,* whereby a result that is less than perfect for one or more stakeholder is accepted by all for the sake of the common good.

Trade-offs and compromise always have “winners” and “losers” and may therefore fall under the remit of national rather than sectoral policy. This is a key issue for a study such as this, which is intended to increase understanding.

Mapping threats (Table 2.3) against the consolidated objectives (Table 2.2) identifies potential nexus solutions. This mapping leads to seven potential investment options (Table 3.2) that either singly or in combination can avoid or reduce threats (Table 3.1).

THREATS										
1. Over-pumping groundwater for irrigation										
2. Location specific flood management infrastructure										
3. Increased irrigation diversions										
4. Over-exploitation of fish and other aquatic organisms										
5. Intensified smallholder agriculture and agrochemicals										
6. Mineral mining and raw material processing impacts on water quality										
7. Increased industrialization in upper Sesan and Srepok										
8. Maximizing hydropower, increased dams and reservoir area										
9. Over-pumping groundwater for irrigation										
SECTOR	**CONSOLIDATED OBJECTIVES**	**THREATS WITH POTENTIAL FOR NEXUS SOLUTION**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
W	IWRM or "multi-purpose, cross-sectoral management”	1	1	1	1					1
	Aquifer conservation	1								1
	Aquifer development	1								1
	Reduce pollution			1	1	1	1			
	Flood control					1				1
	Water body rehabilitation	1	1	1	1		1			
	Increase water supply service delivery		1	1	1		1			
F	Substantial expansion of irrigation of which a large portion is for paddy	1			1	1				
	Increase capture fisheries		1	1	1	1	1		1	1

	Increase culture fisheries				1					
EN	Prioritize hydropower development	1	1							
EV	Forest conservation for poverty alleviation and economic growth					1		1		
	Reforestation					1		1		
	Improve ecosystem climate change resilience							1		1
	Expand environmentally friendly tourism							1	1	
	Effective management and use of natural resources		1					1	1	1

Table 3.1: Threats with possible nexus solutions

Nexus investment options fall into two categories: natural infrastructure and built infrastructure (Table 3.2). These are defined as follows:

- *Natural infrastructure* comprises investments in the conservation, adaptation or modifications of natural landscape features, e.g., natural or man-made wetlands, reforestation, restored floodplains, and catchment stabilization.
- *Built infrastructure* is the multi-purpose, civil works infrastructure needed to attenuate or otherwise manage flooding and/or increase water supplies for energy and food security and for the environment. In the 3S, built infrastructure includes dams, reservoirs, water harvesting facilities, and drains.

It should be noted that:

- Although each threat can be addressed by a nexus solution for at least one of the objectives (Table 3.2), it is possible that some threat/objective solutions threaten other solutions.
- In some cases, non-nexus measures could help. These can be thought of as complementary measures that add value to a nexus solution.

SECTOR	GENERIC OBJECTIVE	THREATS	NEXUS SOLUTIONS							NON-NEXUS SOLUTIONS							
			1. Multi-purpose dams/new operating rules							1. New crops/farming systems							
			2. Groundwater recharge infrastructure							2. Capacity building							
			3. Natural infrastructure 1: Seepage troughs							3. Effective enforcement							
			4. Natural infrastructure 2: Wetlands							4. Renewable energy technology							
			5. Natural infrastructure 3: Use of paddy fields														
			6. Natural infrastructure 4: Use of floodplains														
			7. Natural infrastructure 5: Other														
			1	2	3	4	5	6	7	1	2	3	4	5	6	7	8
W	IWRM or "multi-purpose, cross-sectoral management	Over-pumping groundwater for irrigation	Y	Y	Y					Y				Y			
		Increased irrigation diversions	Y	Y	Y												
		Intensified smallholder agriculture and agrochemicals	Y		Y	Y											
		Mining and processing impacts on water quality				Y						Y	Y	Y	Y		
		Location specific flood management infrastructure	Y				Y	Y									
W	Aquifer conservation	Over-pumping groundwater for irrigation	Y		Y					Y				Y			
		Location specific flood management infrastructure				Y		Y	Y								
		Over-pumping groundwater for irrigation	Y		Y	Y		Y	Y								
		Location specific flood management infrastructure						Y	Y								
W	Pollution reduction	Intensified smallholder agriculture and agrochemicals				Y						Y	Y	Y			
		Mining and processing impacts on water quality				Y								Y	Y		
		Maximizing hydropower, increased dams and reservoir area	Y														
		Increased industrialization in upper Sesan and Srepok	Y			Y								Y	Y		
W	Flood control	Mining and processing impacts on water quality	Y														
		Location specific flood management infrastructure	Y			Y	Y		Y								
W	Water body rehabilitation	Over-pumping groundwater for irrigation	Y	Y	Y			Y	Y								
		Increased irrigation diversions	Y		Y												
		Intensified smallholder agriculture and agrochemicals				Y						Y	Y				
		Mining and processing impacts on water quality												Y	Y		
		Increased industrialization in upper Sesan and Srepok				Y								Y	Y		
W	Increased water supply service delivery	Increased irrigation diversions															
		Intensified smallholder agriculture and agrochemicals	Y									Y	Y				
		Mining and processing impacts on water quality				Y								Y	Y		
		Increased industrialization in upper Sesan and Srepok	Y											Y	Y		
F	Substantial expansion of irrigation of which a large	Over-pumping groundwater for irrigation	Y	Y	Y		Y		Y								
		Mining and processing impacts on water quality	Y			Y								Y	Y		

	portion is for paddy	Mining and processing impacts on water quality	Y														
F	Increased capture fisheries	Increased irrigation diversions	Y			Y											
		Intensified smallholder agriculture and agrochemicals				Y						Y	Y				
		Mining and processing impacts on water quality	Y			Y								Y	Y		
		Maximizing hydropower, increased dams and reservoir area	Y														
		Increased industrialization in upper Sesan and Srepok				Y								Y	Y		
		Over-exploitation of fish and other aquatic organisms				Y		Y	Y								
		Location specific flood management infrastructure	Y			Y		Y	Y								
		Mining and processing impacts on water quality	Y		Y	Y											
EN	Prioritize hydropower development	Over-pumping groundwater for irrigation	Y		Y												Y
		Increased irrigation diversions	Y		Y				Y	Y							Y
EV	Forest conservation for poverty alleviation and economic growth	Maximizing hydropower, increased dams and reservoir area												Y			
		Deforestation												Y			
EV	Reforestation	Maximizing hydropower, increased dams and reservoir area															
		Deforestation							Y								
EV	Improved ecosystem climate change resilience	Location specific flood management infrastructure				Y	Y	Y									
EV	Expanded environmentally friendly tourism	Deforestation							Y								
		Over-exploitation of fish and other aquatic organisms	Y			Y		Y									
EV	Effective management and use of natural resources	Increased irrigation diversions	Y	Y	Y	Y											
		Deforestation							Y								
		Over-exploitation of fish and other aquatic organisms	Y			Y		Y									
		Location specific flood management infrastructure	Y			Y	Y	Y									

Table 3.2: Nexus investment opportunities

Before proceeding to consider various nexus solutions, it is useful to rank the contents of Table 3.2 in two ways:

- By the number of threats that a solution can address.
- The number of nexus solutions for each threat.

Table 3.3 shows the utility of natural infrastructure, especially wetlands. Natural infrastructure typically benefits local communities whereas built infrastructure is likely to benefit large and often remote investments such as irrigation projects or special economic zones while negatively impacting those who live nearby. Table 3.3 also shows that dams should be designed and operated to achieve multiple objectives.

NEXUS SOLUTIONS								
1. Multi-purpose dams/new operating rules								
2. Large-scale groundwater recharge infrastructure								
3. Natural infrastructure 1: Seepage troughs								
4. Natural infrastructure 2: Wetlands								
5. Natural infrastructure 3: Use of paddy fields								
6. Natural infrastructure 4: Use of floodplains								
7. Natural infrastructure 5: Other								
THREAT	**NEXUS SOLUTIONS**							**AVAILABLE SOLUTIONS**
	1	**4**	**7**	**3**	**6**	**5**	**2**	
1. Over-pumping groundwater for irrigation	1	1	1	1	1	1	1	**7**
2. Location specific flood management infrastructure	1	1	1		1	1		**5**
3. Increased irrigation diversions	1	1	1	1			1	**5**
4. Over-exploitation of fishery and other aquatic organisms	1	1	1		1			**4**
5. Intensified smallholder agriculture and agrochemicals	1	1		1				**3**
6. Mining and processing impacts on water quality	1	1		1				**3**
7. Increased industrialization in upper Sesan and Srepok	1	1						**2**
8. Maximizing hydropower, increased dams and reservoir area	1							**1**
9. Deforestation			1					**1**
Potential number of threats that could be addressed	**8**	**7**	**5**	**4**	**3**	**2**	**2**	

Table 3.3: Nexus solutions ranked by number threats (vertical) and solutions per threat (horizontal)

The following sub-sections:

- describe each of Table 3.3's nexus solutions;
- explain how they could mitigate the threats involved; and
- present non-nexus solutions that complement nexus ones.

3.1 Nexus solutions

3.1.1 Multi-purpose dams/new operating rules: 8 threats

Designing and operating dams to achieve multiple objectives addresses the largest number of threats and is thus a priority action in addressing the nexus. Dams can be operated for multiple ends including water supply, hydropower, culture fisheries, capture fisheries, partial re-establishment of natural hydrographs, groundwater recharge, maintenance of navigation depths, and flood management. In the 3S, most dams have been designed and are operated for a single purpose: hydropower. New operating rules for existing dams, and the design of new dams should be predicated on multi-purpose use.

Three examples illustrate how single-purpose dams can cause multi-sector problems. Two are from Vietnam and one from Zambia. All three are hydropower dams, which is important because all dams planned for the 3S are intended for hydropower and power generation operating rules almost always dominate other uses.

- *Example 1*, operating rules for hydropower dams in central Vietnam have led to:
  - greatly reduced environmental stream flows and changes in flow patterns;
  - inadequate flows stranding irrigation diversion infrastructure;
  - saline intrusion, which is compromising coastal irrigation schemes; and
  - excess salinity in coastal fish farms.

  While multi-use operation can maximize a dam's cross-sectoral value, it implies costs in terms of forgone power generation. A study by Meynell et al. (2014) of a cascade of seven hydropower dams on the upper Sesan in Vietnam shows that maintaining a near natural flow regime would reduce potential electricity production by 13%. The government issued rules for seven large dams on the Srepok in 2014 and for seven large dams on the Sesan in 2018 to ensure minimum environmental flows.[10] However, dam operators have resisted implementation of these rules.

- *Example 2*, cascades of hydropower dams in southern Vietnam increase the risk of severe coastal flooding. This is because of the risk that one dam is forced to open its flood gates thereby releasing excess water into the inundated area upstream of the next dam, which may itself be full, causing cities such as HCMC to suffer costly and potentially avoidable floods.

These problems arise because the operators of hydropower dams prefer to keep them as close to full supply level as possible and do not coordinate operations between upstream and downstream dams. This was a major factor behind the 2011 flooding in Thailand. However, new technology means that this is no longer necessary as the third example illustrates.

- *Example 3*: the Kafue Flats lie between Zambia's Itezi-Itezhi and Kafue Gorge dams and until the dams were built comprised a functioning, seasonal wetland covering 800 km^2 of immense socio-economic and environmental significance. Yet prioritization of hydropower operating rules at Itezhi-Itezhi, the upstream dam, has effectively terminated the annual floods and hence the recession agriculture, livestock herds, wildlife and tourist enterprises that depend on them. Fifteen years ago, WWF showed that if a hydro-meteorological network was used to quantify flows upstream of the dam, indicating to its operators what they could expect in terms of inflow, they would not need to maintain the dam as full as possible. The model confirmed that with such information, the dam operators could afford to release enough water to restore annual flooding in the wetlands without compromising power generation.

A study by WWF suggests that this approach has yet to be implemented while yet more power generation is planned (Cowx et al., 2018).

Box 1.4: Grand Ethiopian Renaissance Dam as a nexus investment

The 6,300 MW Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile on the Ethiopia/Sudan border, which started construction in 2011 and is currently 60% built, is considered an example of basin-level, nexus investment with potential benefits for the three eastern Nile countries: Ethiopia, Egypt and Sudan.

For Ethiopia, which is financing the dam, GERD will generate power for itself and for export and provide bulk water for irrigation. For Sudan, the dam will prevent floods and canal sedimentation, while increasing navigation depths in the Blue Nile and avoiding the need to raise Sudan's own dams for power generation, which would be very costly because of the country's flat terrain.

For Egypt, the evaporation loss from the high-altitude GERD would be much less than from Lake Nasser on the Egypt/Sudan border (Riddell and Thuo, 2014). These have been estimated to be as high as 15 km^3/year, equal to 17% of the Nile's discharge when it enters the Mediterranean. Egypt is rapidly approaching severe water insecurity and a storage alternative such as GERD is a possible pathway toward a more water secure future.

3.1.2 Wetlands: 7 threats

Wetlands, both constructed and natural, can address seven of the identified threats while having additional environmental benefits such as:

[10] In Vietnam, Prime Minister Decisions 1201/QĐ-TTg in July 2014 and 215/QĐ-TTg in February 2018 on protocols for inter-reservoir operations in the Srepok and Sesan river basins.

- reduced saline intrusion into coastal aquifers;
- easier management of certain lowland soil types such as acid-sodic soils;
- sustainable habitats;
- local climate amelioration; and
- range of alternative livelihood opportunities.

We have seen how restoration of wetland functions in Zambia's Kafue Flats could be achieved simply by changing the operating rules of the upstream dam to the benefit of the food and environmental nexus. Nearby, to the north of the flats, are 10,000 hectares of irrigated sugar cane. Most of this is managed by international agribusinesses. However, in some places they are supplied by small cooperatives who give up their water use permits to the central estates in return for free, pumped irrigation services.

A condition of this deal, however, is that each cooperative install and maintain small built wetlands between their plots and the watercourses to reduce agricultural run-off pollution.

The Kafue Flats and sugar cooperatives show how wetlands have the potential for both purifying and increasing the supply of water, another nexus component. But wetlands also provide flood management benefits. This is because they act as natural sponges, soaking up and retaining water while it infiltrates into the ground. The attenuating effects of wetlands means that water that does not infiltrate into the ground is slowly released into streams, thereby reducing flood risk. Wetlands vegetation also reduces the speed of water as it flows over the landscape. Wetlands therefore provide immense water storage benefits while mitigating floods and reducing erosion.

3.1.3 Other natural infrastructure: 5 threats

Table 3.3 shows five types of natural infrastructure of which four are specified and obvious. A fifth concerns two kinds of landscape-level intervention that may be less obvious. One type is best suited to public financing, the other for private sector investment. Both are man-made and both have multiple benefits.

The first kind comprises land terracing that:

- increases the intake opportunity time of run-off and hence replenishes groundwater and/or decreases flood risk;
- prevents soil erosion;
- could maintain root zone moisture content increasing crop yields; and
- in combination with "trash-lining" can reduce the need for chemical fertilizers.

The second kind comprises large scale production of crops with soil binding characteristics and diverse value chains. Not only would carefully selected crops prevent soil erosion and hence downstream sedimentation they could also contribute to economic growth and socio-economic transformation in the form of expanded and diversified livelihoods. In some cases, there could be energy sector or climate change mitigation benefits. Industrial hemp or bamboo, for example, both have watershed and economic benefits. Bamboo has a wide range of uses, including for construction laminates, paper, fabrics, charcoal, beer, furniture, and high-quality composites. However, despite its economic potential, bamboo supply chains and process facilities are poorly developed outside of China.

A potential third kind of natural infrastructure is forest conservation. This is less obviously multi-purpose, despite the potential water resource and biodiversity benefits.

3.1.4 Seepage troughs: 4 threats

Seepage troughs are a simple and cost-effective means to increase the supply of both surface and groundwater. As was shown in Figure 3.3, they represent potential solutions to three of the threats identified in this document. And although they are a small-scale option, if replicated they have great potential to increase local supplies of water by:

- reducing the risks of water insecurity caused by other, larger scale investments; and
- reducing the need for large, bulk water infrastructure.

3.1.5 Use of floodplains/restored floodplains: 3 threats
Functionally, floodplains are similar to wetlands, except that they are not characterized by bodies of standing water and usually do not have the same soils. Floodplains are nature's way of dealing with floods and are among nature's most highly productive ecosystems, providing vital spawning and nursery habitat for a variety of aquatic species. Several benefits occur when floods can flow freely across them. The genetic diversity of aquatic species is maintained, which is important for capture fisheries; fertility levels are maintained in soils; groundwater is recharged; polluted water is purified; and the potentially devastating power of more concentrated floods is reduced. None of these benefits would occur if the floods were contained by flood dikes (Box 3.1).

Flood dikes, urbanization, and dam construction are major threats to floodplains. There is an increasing body of evidence that conserving or restoring floodplain functions offers a "no regret" pathway to a wide range of benefits (EEA, 2017), even to the extent that in some highly developed river basins the removal of large dams and restored floodplain functions have resulted in higher economic productivity of water. Studies carried out by IWMI in the late 1990s and by International Food Policy Research Institute (IFPRI) in the early 2000s show that when economic efficiency of water use at the basin level increases, so too does access to water by the poor and environmental flows.

While existing dams do not need to be removed (although that is happening in some countries), if new dams can be avoided through other solutions, then floodplain functions are less likely to be compromised.

3.1.6 Use of paddy fields: 2 threats
Paddy fields can be very effective at reducing flooding. According to Sujono (2010), more than 40% of rainfall could be stored in paddy fields without compromising yields. This approach is already common in Thailand, where it is known as "monkey cheeks" and is being considered in northern Malaysia. As a rule of thumb, wetland rice can tolerate three days of inundation with little effect on yield. Anything beyond that would be covered by compensation paid by the government to the affected farmers on the assumption that this would be cheaper than large flood control dams that may only be needed on average every four years.

3.1.7 Groundwater recharge infrastructure: 2 threats
Seepage troughs are a form of groundwater recharge infrastructure based on the interruption of natural run-off. This section is more about large-scale built infrastructure intended to divert river flows into local aquifers either directly or via a network of canals spread out across the landscape. This is potentially of high value in the Central Highlands.

Such infrastructure should be selected with care. This is because an aquifer's transmissivity and quality can be seriously and permanently compromised if the water used has the wrong kind of sediment or is polluted in some way.

3.2 Non-nexus solutions

3.2.1 New crops/farming systems
Where water for irrigation is scarce relative to demand, as in the Central Highlands, demand itself could be reduced by shifting away from water intensive farming systems towards less water intensive alternatives. Ideally such a shift should be toward crops that improve farmers' livelihoods and increase opportunities for added value. That way, either the size and hence cost of bulk water infrastructure could be reduced or multi-purpose use could be increased.

However, risk averse farmers may need government support, perhaps in the form of time-bound, smart and stepped production subsidies until their risk perceptions have been obviated.

3.2.2 Capacity building
A nexus approach is institutionally challenging. Capacity building is needed to increase understanding of the advantages of a nexus approach to river basin planning and the utility of the resulting measures and interventions. Capacity building is needed both for the beneficiaries of a nexus solution and across the institutions involved.

3.2.3 Effective enforcement

Inadequate and/or weakly enforced regulations undermine efforts to improve water resources management. Continued illegal forest clearing or water pollution threaten the availability and productivity of water to downstream users. Polluting businesses should be legally obliged to clean up their effluent before it reaches the watercourse, through a water treatment system and/or built wetlands.

3.2.4 Renewable energy technology

The large-scale introduction of solar and wind energy could accelerate rural electrification and in turn reduce the need for new hydropower dams.

4. TOWARD IMPROVED UNDERSTANDING

Most stakeholders will be familiar with the IWRM approach and may wonder what the nexus has to offer. There are several differences that position the nexus as a more powerful tool. The most obvious is that as conventionally applied IWRM is only concerned with the allocation of water between competing uses. This usually means that important planning decisions are made by powerful but potentially competing water sector silos such as hydropower and irrigation. A nexus approach, on the other hand, looks beyond the watershed into the problem-shed. This stimulates the search for new pathways toward more productive futures for stakeholders with little or no voice in decision making (e.g., small-scale fisheries). New pathways could include policies encouraging off-farm livelihoods that reduce competition for irrigation water and/or the need for increased storage. Similarly, investments in industrial crops could increase off-farm livelihoods along value chains while reducing soil erosion and restoring hydrographs in degraded catchments.

Because of the combination of shared costs and multiple benefit streams represented by a nexus approach, investments are likely to have higher economic rates of return per sector and benefits that are more widely distributed across sectors and landscapes while making a greater contribution to broader economic growth.

This section provides a set of initial messages that would allow the optimal delivery of energy, food, water and environment in the 3S via trade-offs, compromise and synergies, and reflecting a landscape perspective. That said, it is recognized that:

- a nexus approach cannot solve all the 3S management challenges; and
- there are non-nexus solutions that might work equally well in some cases, especially when they address serious social and environmental problems.

Nonetheless, by adopting a nexus approach:

- many problems can be readily addressed through investments across sectors; and
- governments can meet their development objectives in a more economically efficient fashion because of the multiple benefits that can accrue to multi-purpose investments.

Based on this, the following nine messages are offered, six related to opportunities and three to risks.

4.1 Opportunity messages

1. **Strategic planning** is required for a nexus approach to realize its full potential. Expensive infrastructure should only be built if the need is justified. System-scale energy planning allows least-cost options to be determined objectively. A 2016 study by University of California-Berkeley's Energy & Resources Group (ERG) showed that Laos could save $2.6 billion by 2030 (net present value) by integrating solar, wind, and biomass into its energy mix and reducing reliance on large hydropower for a total additional capacity of 25,000 MW, compared to the government's planned build out (Avila et al., 2017). The savings would be greater if the study had factored in hydropower's environmental and social costs.

   Much-improved knowledge of fluvial geomorphology and modeling capacity allows the selection of dams that minimize downstream impacts for a given power output. Sediment modelling in the 3S shows that if dams were optimally located, designed, and operated, 75% of total energy potential could be harnessed with only a 20% reduction in downstream sediment delivery (Schmitt, 2016). Such an approach could also help ensure that the Sekong, the Mekong's last large free-flowing tributary, remains accessible to long-range fish migrations that form basis of the extraordinary fish productivity of the Lower Mekong.

   These benefits would be enhanced if a dam were designed or operated for multi-purpose use. *The question is therefore not dams versus no dams, but which dams, where, and how should they be operated.*

   In Vietnam, the prospects for coordinated planning will improve with the entry into force of the Planning Law in January 2019. This law will reduce by 90% the 19,500 statutory plans that the government has been required to produce every 5-year planning cycle. It is intended to reduce unnecessary environmental damage caused by single-sector, overlapping, and often conflicting plans and to increase accountability. It took five years to negotiate because of resistance from ministries that benefit from the status quo. The Ministry of Planning and Investment (MPI) is drafting the implementation decree and would like to incorporate nexus thinking into the guidelines.

2. The benefits from river basin-scale strategic planning can accrue at the *international* level. There is an opportunity to both meet regional power demand at lower cost and reduce political tensions by expanding regional power trade and linking long-term power purchases to agreements whereby high-risk dams are removed from consideration. If as part of its power development plan revision Thailand decides not to fund new dams in Laos (or Myanmar), Vietnam (where electricity demand will double by 2030) could assist Laos by substantially increasing its current, very low, level of hydropower imports (400 MW) on condition that planned dams in Laos that pose the greatest threats to the Mekong Delta are not built.

   Steps toward more power trade are underway. The World Bank has facilitated bilateral negotiations to increase Lao hydro exports to Vietnam with targets of 5,000 MW by 2020, 10,000 MW by 2025, and 15,000 MW by 2030, and a $100 million World Bank loan is connecting 15 dams in southern Laos to Vietnam. Negotiations have also started on exporting 1,000 MW from five Chinese built dams on the Nam Ou in northern Laos to north-west Vietnam. What is missing so far is Vietnamese leadership that links significantly increased power purchases to the selection of dams that minimize downstream impacts.

   Vietnam could make a similar offer to Cambodia. Vietnam has completed its hydropower build-out on the Srepok and Sesan, but dams with a total generating capacity of over 4,000 MW are planned on the Cambodia side. In exchange for investing in these dams, Cambodia would agree not to proceed with Mekong mainstream dams, notably Sambor (2,600 MW) and Stung Treng (900 MW).

   Vietnam could exploit its advanced manufacturing capacity to invest in solar energy in Cambodia where land is much cheaper and energy-hungry HCMC and surrounding industrial zones are within 100-200 km. A 49 MW solar plant under construction in Gia Lai Province, Vietnam is paying $25,000/hectare in compensation. By contrast, a 10,000-hectare economic land concession in Cambodia with no prior land claims and that can be leased for $5/hectare/year could conservatively generate 500 MW (more than LS2).[11] The need to import large quantities of power would increase greatly if bauxite mining and processing expanded in Vietnam. The company operating the LS2 dam is carrying out a feasibility study of a 20 MW floating solar project on the 26,000-hectare reservoir. See Figure 4.1.

[11] 1 hectare can generate 1 MW; at this latitude, average MW corresponds to about 15% of peak, so 10,000 hectares x 1 MW x 15% = 1,500 MW average output; if we assume that only one-third of the ELC is covered, that results in 500 MW.

[11] VPA is a legally binding trade agreement between the EU and Vietnamese government under which Vietnam develops Timber Legality Assurance Systems to verify that its timber exports are legal, and EU agrees to accept only licensed imports from Vietnam.

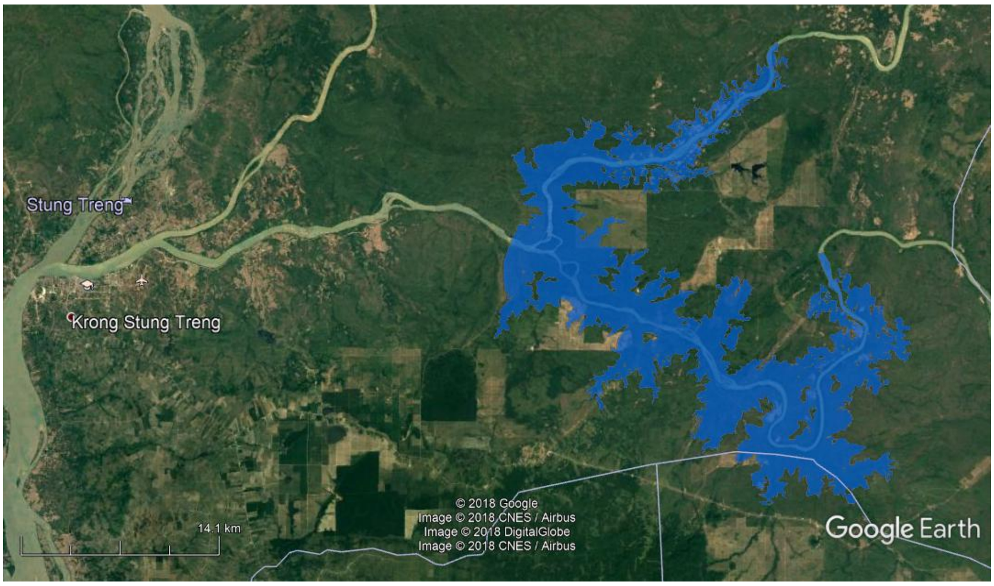


Figure 4.1: LS2 reservoir (blue)

(Source: Google Earth)

Such win-win transboundary outcomes could be enhanced if timber, marine fisheries, and wildlife were included in a regional agreement since these are sectors where Laos and Cambodia need Vietnamese cooperation in order to enforce their own laws. The signing of the Voluntary Partnership Agreement (VPA) on Forest Law Enforcement Governance and Trade (FLEGT) between Vietnam and the EU in October 2018 should signal greater Vietnamese participation in combatting illegal transboundary timber flows (EIA, 2017). By expanding the transboundary natural resource management challenge, therefore, new opportunities for reciprocity and mutual benefit emerge.[12]

3. Nexus solutions can **save significant sums of mone**y. For example, investment in a hydro-meteorological network upstream of a cascade of hydropower dams could obviate the need for expensive flood defense works downstream. This is particularly relevant for the Sesan and Srepok where the marginal environmental impacts of upstream dams are lower now that the LS2 is built. M-IWRM is financing the installation of 13 monitoring stations on the Srepok and Sesan.

   The dramatic cost reduction in non-hydro renewables opens the door to the conjunctive use of intermittent solar/wind and hydropower, which would allow countries to meet their energy generation goals at less cost and quicker. The MRC's draft SHDS reached the same conclusion. In June 2018, U.S. company Convalt Energy announced plans to install 100 MW of floating solar on reservoirs of two Vietnamese built hydropower dams on the Xekaman, a tributary of the Sekong.[13] If biofuels could be produced at landscape scales, subject to satisfactory social and environmental safeguards, there could be additional watershed benefits in terms of water quantity and quality.

   Meanwhile, recent dam collapses in Vietnam, Laos, and Myanmar have highlighted the costs of large hydro, particularly considering the possibility of increasingly extreme rainfall events. Following the July 2018 collapse of a dam in Champasak Province, which killed 40 with another 100 missing, the Lao government suspended all new hydropower applications.[14]

4. Many nexus solutions involve **natural infrastructure**. Natural infrastructure is not just about environmental conservation; it is also about landscape modifications at a range of scales that deliver wider benefits than a piece of built infrastructure to solve the same problem. The most

[12] https://m.phnompenhpost.com/opinion/mekong-cooperation-making-problem-bigger
[13] http://www.convalt.com/loa-solar-hte.html
[14] https://en.wikipedia.org/wiki/2018_Laos_dam_collapse

important nature-based solution is maintaining floodplain function. This is particularly relevant in the Sesan and Srepok where plans to build river dikes would displace flood risk downstream, as has happened in the Mekong Delta where high dikes upstream have caused urban flooding downstream.

5. Natural infrastructure can distribute its **benefits more widely** and locally than large-scale built infrastructure intended to solve the same problems. For example, strengthening capture fisheries management will provide livelihoods for a larger number of poor people than reservoir fisheries or aquaculture, which require more expensive gear and other inputs.

6. **Nexus and non-nexus solutions** complement each other. A non-nexus solution can decrease the costs and increase the benefits of a corresponding nexus solution. For example, reduced use of irrigation across 500,000 hectares of coffee in the Central Highlands will not only reduce dry season water stress and increase coffee quality, it will also conserve groundwater. The total volume of water that could be saved comes to about 1 billion m^3, equal to three times the combined average dry season flow of the Srepok (61 m^3/s) and Sesan (43 m^3/s) on the Vietnam-Cambodia border. In order to secure coffee supplies, Nestlé is training tens of thousands of coffee farmers in the Central Highlands on more efficient water use in an attempt to move coffee to a more sustainable footing (Vietnam is the world's second largest coffee exporter and global coffee consumption is growing 5% per year).

   Table 4.1 shows how non-nexus solutions could complement five of the seven nexus solutions.

Table 4.1: How nexus and non-nexus solutions complement each other

NON-NEXUS SOLUTIONS	**NEXUS SOLUTIONS**				
	Multi-purpose dams/ new operating rules	Seepage troughs	Use of paddy fields	Use of floodplains	Other natural infrastructure
Change crops/ farming systems	Farming systems that are less water intensive reduce the size of new dams or increase multi-use opportunities for existing dams	Farming systems that are less water intensive increase the value of seepage troughs			Landscape scale planting of soil binding crops can prevent erosion and reinstate catchment functions
Capacity building	Increase the possibilities for and utility of multi-purpose dam use		Increase use of paddy fields for flood management		
Effective enforcement	Reduce excessive abstraction of water			Prevent unauthorized encroachment	
Non-hydropower renewable energy technology	Reduce need for hydropower				Biofuels planted at landscape scale can prevent soil erosion and restore watershed functions

4.2 Risk messages

1. Measuring inter-sectoral trade-offs assumes **adequate understanding of key biophysical processes.** Accurate information on projected power output from a dam or paddy production, for example, is typically available and uncontested. But other information may be unreliable and controversial. For example, published studies estimate that capture fisheries in the 3S

total about 10,000 tons/year (Table 1.1). But an estimate that links fish production to land cover type comes to at least 89,000 tons/year, almost 10 times more.[15] Governments have argued that reservoir fisheries can compensate for lost river fisheries. But there is abundant evidence that actual reservoir production stabilizes at about one-third of initial production (which benefits from high nutrient levels in the freshly inundated zone). If these alternative estimates are correct, then assessments of the net loss of capture fisheries from dams in the 3S could be underestimated by a factor of 30. Because of uncertainties regarding capture fisheries, "hard" data on energy and rice production are often seen as more convincing. As a result, when deliberating the cost-benefit of a dam, the burden of proof tends to lie with the fisheries specialists rather than the dam proponents.

2. Because the nexus tends to focus on capital asset creation, there is a risk that **non-structural options** will be ignored or deemed unacceptable to builders of political monuments. Regionally, there is a well-recognized focus on technical and infrastructure solutions (even if this includes natural infrastructure) whereas some of the critical challenges arise from governance and institutions (which are particularly complex in transboundary basins).
3. The nexus approach may have nothing to say about **distributional issues** and may ignore the fact that the poor and ethnic minorities pay a disproportionate price for economic growth. This is an acute risk in the 3S where well-being indicators, particularly among ethnic minorities, are well below the national averages. nexus solutions are not explicitly designed to address distributional issues and there is a risk that a nexus approach may be no less "top down" than traditional approaches.

An initial set of nexus and non-nexus solutions for the 3S are show in Figure 4.2.

[15]Total fish catch from the Tonle Sap is estimated at 500,000 tons/year and from the entire Lower Mekong at 2.6 million tons/year.

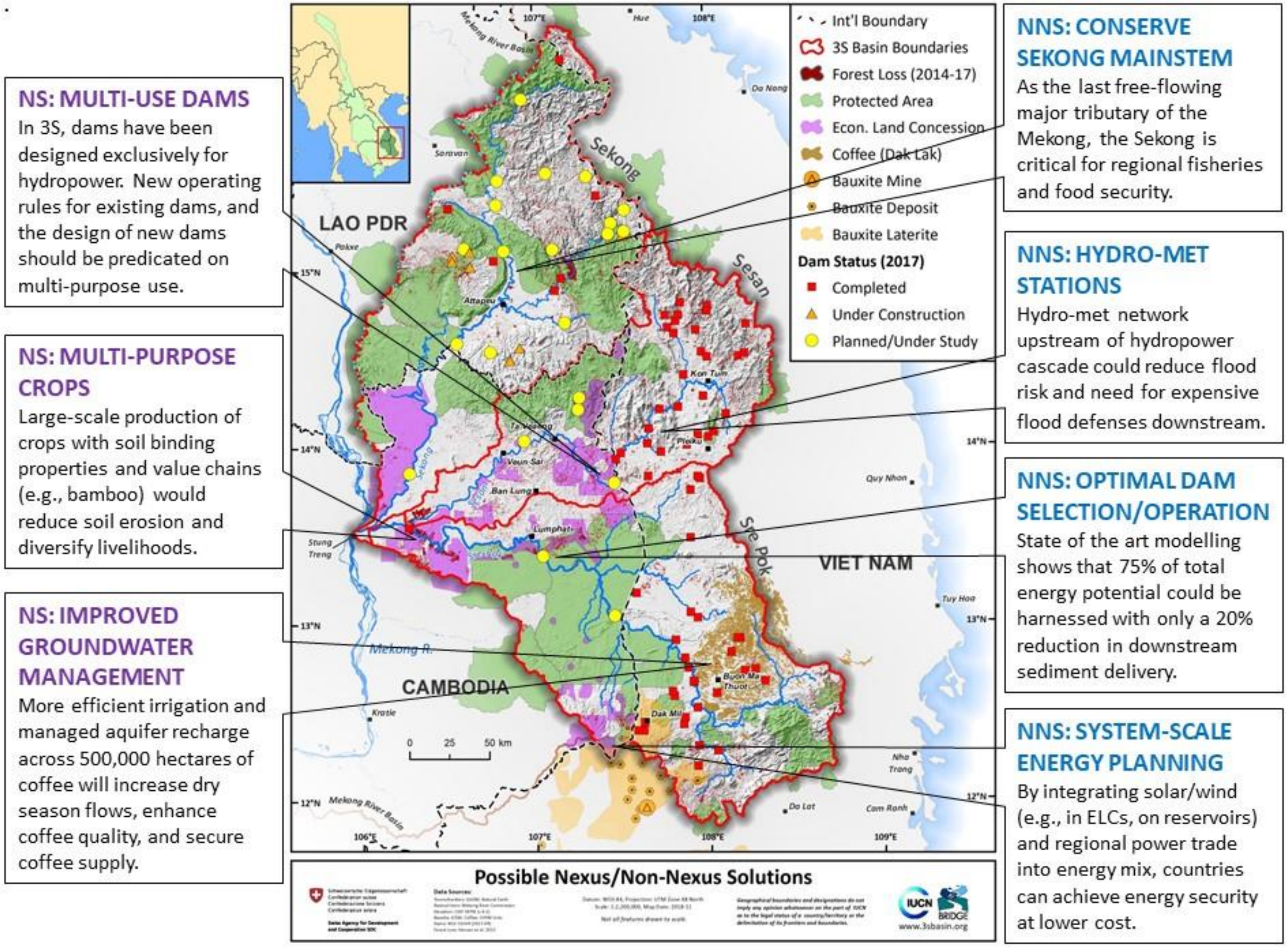


Figure 4.2: Nexus (NS) and non-nexus solutions (NNS) for the 3S

5. ADVANCING THE NEXUS AGENDA

5.1 Challenges

Feedback from the Technical Advisory Group (TAG) identified several challenges in nexus implementation. These concern low levels of technical capacity within governments to imagine, let alone negotiate nexus solutions; legal frameworks that are inconsistent or run counter to nexus principles of cooperative river basin planning; inertia within the policy and planning systems; and opposition from ministries, particularly those responsible for energy and irrigation, that fear losing power.

The nexus approach has been picked up faster in Africa than in Asia. One reason is that there appears to be more scope for institutional innovation in Africa. For example, because irrigation is typically the largest water using sector and where ministerial self-interest dominates, in several countries responsibility over irrigation is being transferred from the relevant line ministry to non-line ministries or even the president's office.

Another reason why the nexus has made more headway in Africa is the presence of regional organizations such as the Southern Africa Development Community (SADC) in Southern Africa and the Organisation pour la mise en valeur du fleuve Sénégal (OMVS) in West Africa, which actively promote a nexus approach to planning and investment that optimizes regional projects for national and local benefits. No such organization exists in the Mekong region; neither the MRC nor ASEAN currently has the mandate or the technical capacity to lead nexus negotiations.

5.2 Road map

In order to promote the findings and recommendations of the nexus assessment, the TAG (Annex 1) recommended three ways to integrate a nexus approach into development planning. Cambodia recommended assessing water use in Opok, a 150-hectare Khmer Rouge-era irrigation project in a sub-basin of the Sesan in Stung Treng Province where this is conflict between water for paddy, fisheries, and household use. Laos recommended a nexus assessment for the Sekong. Vietnam recommended reviewing the draft implementation decree for the new Planning Law to determine nexus compliance.

Given the novelty of the nexus, there is a pressing need to provide training for government staff on the technical approach, opportunities, and risks.

Given the political sensitivities, it is questionable if the traditional approach of a series of national workshops with government agencies to discuss nexus opportunities would work. An alternative, or complementary approach would be to introduce nexus thinking by working with think tanks that are increasingly part of the policy research and advocacy landscape in CLV. Several of these are politically well connected (and may even have links to political parties) and can serve as conduits to get new and potentially controversial ideas aired informally within government before proceeding to more formal discussions.

5.3 Four possible futures

Policy makers can benefit from a "horizon view" that examines a range of scenarios and provide a powerful way to raise awareness of the likely outcomes of different courses of action. Key to this type of scenario analysis is the selection of two key sector determinants, as these form the two axes of the scenarios. One axis concerns the extent to which investment decision making is acknowledged as a transboundary responsibility. The other axis concerns the extent to which investment planning is undertaken on a nexus or non-siloed basis. Figure 5.1 shows four scenarios based on these two axes.

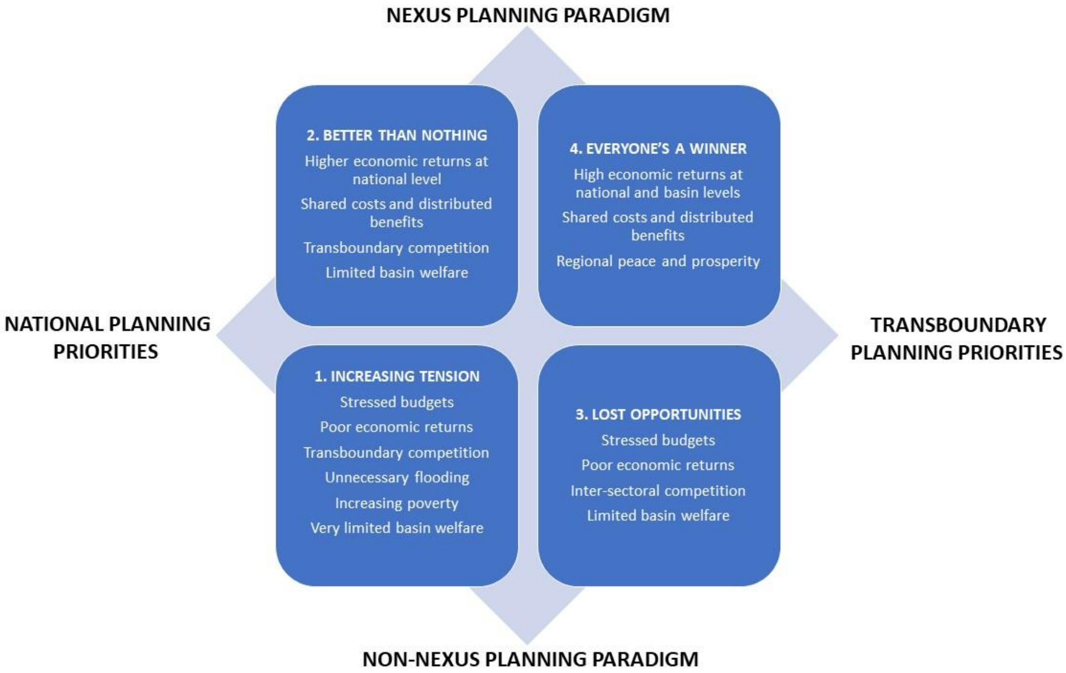


Figure 5.1: Four possible futures in the 3S

5.3.1 Scenario 1: Increasing tension

Development planning takes place in silos and is limited to national issues and priorities. Government budgets become stretched, leading to investments that are likely to be based on political interests rather than social, economic or environmental benefits. Some investments become a drain on the economy ("white elephants") rather than contribute to economic growth. Transboundary disputes grow, and tensions rise. Flood management investments in upstream increase flood risk downstream. Ecosystem loss continues and basin productivity declines, leading to increased social unrest and poverty.

5.3.2 Scenario 2: Lost opportunities

This scenario is probably the closest to reality in the 3S. It shares several characteristics with Scenario 1. These include sub-optimal economic returns accruing to siloed investments and stretched government budgets. Even so, transboundary planning, budgeting and natural resource allocation reduce transboundary competition and flood risk. This leads to modest increases in basin welfare. Nonetheless, the lack of nexus style planning increases the risk of unforeseen negative impacts.

5.3.3 Scenario 3: Better than nothing

Despite a lack of transboundary cooperation, capital investments at national level contribute to higher economic returns, while a combination of multi-purpose, built and natural infrastructure mean that the benefits are more widely shared. This in turn leads to reduced competition over natural resources and increases in basin welfare. Nevertheless, the lack of transboundary cooperation constrains development with a risk that one country's investments could negatively affect another.

5.3.4 Scenario 4: Everyone's a winner

This is the most favorable of the four scenarios. Higher economic returns would accrue to investments in the water, food, energy, environment sectors shared across both sectoral and national boundaries while the wider distribution of benefits would reduce competition over natural resources. This maximizes improvements in basin welfare while the risk of unforeseen circumstances would decline. The net result is increased regional prosperity and security.

REFERENCES

Asian Development Bank (ADB) (2012). *Greater Mekong Subregion. Atlas of the Environment*. 2nd edition. Manilla, Philippines: Asian Development Bank.

Asian Development Bank (ADB) (2013). *Overview of the GMS regional investment framework* (2013-2022). Vientiane, Laos: Asian Development Bank.

Asian Development Bank (ADB) (2010). *Key topic 8: large scale infrastructure development in the 3Ss: 8c – Irrigation development. Sesan, Sre Pok and Sekong (3Ss) River Basins Development Study in Kingdom of Cambodia*, Lao People's Democratic Republic and Socialist Republic of Viet Nam: Asian Development Bank.

Asian Development Bank (ADB) (2012). *Greater Mekong Subregion Atlas of the Environment*. Manila, Philippines: Asian Development Bank.

Amarasinghe, U.A., Hoanh, C.T, D'haeze and Hung, T.Q. (2015). Towards sustainable coffee production in Vietnam: more coffee with less water. *Agricultural Systems*, 136, 96-105.

Annandale, G. (2013). *Technical memorandum on options for sediment passage through Lower Sesan 2 Dam*. Natural Heritage Institute. 35pp.

Annim, S.K. and Imai, K.S. (2014). *Nutritional status of children, food consumption and ethnicity in Laos*. Kobe University, Japan

Ansar, A., Flyvbjerg, B., Budzier, A. and Lunn, D. (2013). 'Should we build more large dams? The actual costs of hydropower megaproject development'. *Energy Policy* 69:43-56.

Arias, M.E., Cochrane, T.A., Lawrence, K.S., Killeen, T.J. and Farrell, T.A. (2011). Paying the forest for electricity: a modelling framework to market forest conservation as payment for ecosystem services benefiting hydropower generation. *Environmental Conservation* 38(4) 473-484.

Attwood S.W., Fatih, F.A., Upatham, E.S. (2008). DNA-Sequence Variation Among Schistosoma mekongi Populations and Related Taxa; Phylogeography and the Current Distribution of Asian Schistosomiasis. *PLOS Neglected Tropical Disease* 2(3): e200. doi:10.1371/journal.pntd.0000200

Nkiruka Avila, Noah Kittner, Rebekah Shirley, Michael B. Dwyer, David Roberts, Jalel Sager, Daniel M. Kammen, (2017). *Beyond the Battery: Power Expansion Alternatives for Economic Resilience and Diversity in Laos*, draft book chapter, March 2017.

Baird, I.G. and Shoemkaer, B. (eds.) (2008). *People. livelihoods and development in the Xekong River Basin, Laos*. Bangkok, Thailand: White Lotus.

Baird, I.G. (2009). *Best Practices in Compensation and Resettlement for Large Dams: The Case of the Planned Lower Sesan 2 Hydropower Project in Northeastern Cambodia*. Phnom Penh: Rivers Coalition in Cambodia.

Baran E., Nasielski J. and Guerin E. Annex 3. *Reservoir sediment flushing and fish resources*. A report prepared for the project "A Climate Resilient Mekong: Maintaining the Flows that Nourish Life" Report of the Natural Heritage Institute and the US Agency for International Development.

Baran, E., Myschowda, C. (2009). 'Dams and fisheries in the Mekong Basin 2009'. *Aquatic Ecosystem Health and Management* 12(3) 227-234.

Baran, E., Jantunen, T., Chong, C.K. (2007*). Values of inland fisheries in the Mekong River Basin*. WorldFish Center, Phnom Penh, Cambodia.

Baran, E., Saray, S., Teaoh, S.J. and Tran, T.C. (2011). *Fish and Fisheries in the Sesan River Basin. MK3 catchment baseline-fisheries section*. WorldFish Phnom Penh, Cambodia.

Baran, E., Saray, S., Teaoh, S.J. and Tran, T.C (2014). 'Fish and Fisheries in the Sekong, Sesan and Srepok Basins (3S Rivers, Mekong watershed) with special reference to the Sesan River'. In: *Optimizing the management of cascades or system of reservoirs at catchment level.*. Hanoi, Vietnam: ICEM.

Bouapao, L. Insouvanh, C., Pholsena, M., Armstrong, J. and Staab, M. (2016). *Strategic review of food and nutrition security in Lao People's Democratic Republic.* World Food Programme.

Carvalho, F., Villeneuve, J.P., Cattini, C., Tolsa, I., Thuan, D.D and Nhan, D.D. (2008). 'Agrochemical and polychlorobyphenyl (PCB) residues in the Mekong River delta, Vietnam'. *Marine Pollution Bulletin* 56, 1476-1485.

Cheesman, J., Son, T.V.H and Bennett, J. (2007). *Valuing irrigation water for coffee production in Dak Lak, Viet Nam: a marginal productivity analysis*. Australian Centre for International Agricultural Research (ACIAR) Project: ADP/2002/015.

Conservation International (2018). *Freshwater Health Index*. Global Environment Facility, World Bank.https://www.thegef.org/sites/default/files/publications/CI%20FHI%203S%20Basin%20Technical%20Report%20Executive%20Summary%20December%202016.pdf

Constable, D. (2015). *Atlas of the 3S basins: the Sekong, Sesan and Srepok basins*. IUCN, Bangkok

Cowx, Lungu and Kalonga (2018). *Optimising Hydropower Development and Ecosystem Services in the Kafue River*. Zambia, Marine and Freshwater Research, CSIRO Publishing

Cui, L., Yan, G., Sattanbongkot, J., Cao, Y., Chen, B., Chen, X., Fan, Q., Fang, Q., Jongwutiwes, S., Parker, D., Sirichaisinthrop, J., Kyaw, M.P., Su, X-Z, Yang, H., Yang, S., Wang, B., Xu, J., Zheng, B., Zhong, D. and Guofa, Z. 201Annex 3*. Malaria in the Greater Mekong Sub region: Heterogeneity and Complexity*. Acta Trop. 121(3) 227-239.

D'haeze, D. Deckers, J., Raes, D., Phong, T.A. and Loi, H.V. (2005). 'Environmental and socio-economic impacts of institutional reforms on the agricultural sector of Vietnam. Land suitability assessment for Robusta coffee in the Dak Gan region'. *Agriculture, Ecosystems and Environment* 105, 59-76.

European Economic Area (EEA) (201*7). Restoring Floodplains and Wetlands Offer Value-for Money Solution to River Flooding European Union*.

EIA (2017). *Serial Offender Vietnam's continued imports of illegal Cambodian timber*. https://eia-international.org/wp-content/uploads/eia-serial-offender-web.pdf

Erhart, A., Ngo, D.T., Phan, V.K., Ta, T.T., Van Overmeir, C., Speybroeck, N., Obsomer, V., Le, X.H. Le, K.T., Coosemans, M., D'Alessandro, U., (2005). 'Epidemiology of forest malaria in central Vietnam: a large-scale cross-sectional survey'. *Malaria Journal* 4(58).

General Statistics Office of Vietnam (2017). Ministry of Planning and Investment (MPI) http://www.gso.gov.vn/default_en.aspx?tabid=774

Great Mining (2017). *Mining in Vietnam*. http://www.greatmining.com/vietnam_mining.php

Haslett, S., Jones, G., and Sefton. A. (2013), *Small-area Estimation of Poverty and Malnutrition in Cambodia*. National Institute of Statistics, Ministry of Planning, Royal Government of Cambodia and the United Nations World Food Programme, Cambodia.

Hirsch, P. and Scurrah, N. (2015). *The political economy of Land Governance in the Mekong Region.* University of Sydney, Australia. 52 pp.

Hortle, K.G. (2009). *Fisheries of the Mekong River Basin.*

Hortle, K.G. and Bamrungrach, P. (2015). *Fisheries Habitat and Yield in the Lower Mekong Basin*. MRC Technical Paper No. 47. Mekong River Commission, Phnom Penh, Cambodia. 80 pp.
http://english.vietnamnet.vn/fms/environment/179445/sand-mining-destroying-rivers-in-central-highlands--causing-landslides.html
https://www.researchgate.net/publication/284712392_VIETNAM%27S_HYDROPOWER_POLICY_REFORM

Institute for Health Metrics and Evaluation (IHME) (2013). *The Global Burden of Disease: Generating Evidence, Guiding Policy*. Seattle, USA. Institute for Health Metrics and Evaluation.

International Renewable Energy Agency (IRENA) and ASEAN Centre for Energy (ACE) (2016). *Renewable energy outlook for ASEAN: a REmap analysis*. Abu Dhabi, Jakarta: IRENA and ACE.

International Renewable Energy Agency (IRENA) (2012). *Renewable energy technologies: cost analysis series. Volume 1: Power Sector, Hydropower*. Abu Dhabi, International Renewable Energy Agency (IRENA).

International Rivers Network (IRN) (2014). *Starving the Mekong: expected social and environmental impacts from construction and operation of the Lower Sesan II dam*. Berkeley, USA. International Rivers Network.

International Union for Conservation of Nature (IUCN) (2017). *Resettlement impacts of hydropower development.* http://www.3sbasin.org/publication/2015-07-13-15-21-13/key-topics/large-scale-infrastructure/hydrropowe/275-resettlement-impacts-of-hydropower-development.html

Jackson, D.C and Marmulla, G. (2001). *The influence of dams on river fisheries. In Marmulla, G (ed.) Dams, fish and fisheries: opportunities, challenges and conflict resolution*. FAO Fisheries Technical Paper 419. FAO, Rome 166 pp.

Kenney-Lazar 201Annex 3. 'Plantation rubber, land grabbing and social-property transformation in southern Laos'. *Journal of Peasant Studies*, 39(3-4), pp.1017-1037.

Khampapongpane, B., Lewis, H.C., Ketmayoon, P., Phonekeo, D., Somoulay, V., Khamsing, A., Phengxay, M., Sisouk, T., Vongphrachanha, P. Bryant, J.E. (2014). 'National dengue surveillance in the Lao People's Democratic Republic, 2006-2012: epidemiological and laboratory findings'. *Western Pacific Surveillance And Response Journal* 5(1) doi: 10.5365/wpsar.2014.5.1.001

Khamphavong, K. and Homesombath, I. (undated). *Minerals potential and minerals law of Laos*. http://www.dmr.go.th/download/asean/Minerals%20Potential_Minerals%20Law%20of%20Lao%20Pdr.pdf

Khouangvichit et al. (2014). *Knowledge and Institutional Systems in the Management and Coordination of Hydropower Social Safeguards: Hydropower Development in Attapeu Province*. Laos, Vientiane

Laos News Agency (2017). *Laos expects to have 100 hydropower plants by 2020*. http://kpl.gov.la/En/Detail.aspx?id=25944

Le, D.P. (2016). *Vietnam Presentation at the Technical Meeting on Country Nuclear Power Profiles*. International Atomic Energy Association, Vienna, Austria May 10-13, 2016.

https://www.iaea.org/NuclearPower/Downloadable/Meetings/2016/2016-05-10-05-13-NPES/Country_pres/Vietnam_Presentation-CNPP_TM_2016.pdf

Lu, X., Kummu, M. and Oeurng, C. (2014*). Reappraisal of sediment dynamics in the Lower Mekong River, Cambodia*. Earth Surface Processes and Landforms. 11pp.

Madhur, S. and Menon, J. (2014). 'Growth development and Inclusion in the Greater Mekong Subregion: an assessment' In: *CDRI, Inclusive Development in the Greater Mekong*

Maunsell and Lahmeyer International (2004). *Power System Development Plan for Laos. Volume C: Project Catalogue*. Maunsell Ltd. And Lahmeyer GmbH, Auckland, New Zealand.

McCartney, M.P., Kura, Y., Meynell, P-J., Senratna Sellamuttu, S. and Matthews, N. (2016). *Hydropower reservoirs as novel ecosystems: adopting an ecosystems-based approach for management. Proceedings of Asia 2016: Water Resources and Hydropower Development in Asia*. Vientiane, Laos.

McKenney B. and Tola, P. (2002). *Natural Resources and Rural Livelihoods in Cambodia: A Baseline Assessment – Working Paper 23*, CDRI.

Mekong project MK3 'Optimizing the management of a cascade of reservoirs at the catchment level'. ICEM – International Centre for Environmental Management, Hanoi Vietnam, 2014

Mekong River Commission (MRC). (2009). 'Hydropower project database.' In: *Basin Development Plan Programme*. MRC, Vientiane, Laos.

Meusch, E., Yhoung-Aree, J., Friend, R. and Funge-Smith, S.J. (2003). *The role and nutritional value of aquatic resources in the livelihoods of rural people – a participatory assessment in Attapeu Province, Laos*. FAO Regional Office Asia and the Pacific, Bangkok, Thailand, Publication No. 2003/11, pp. 34.

Meynell, P., Carew-Reid, J., Räsänen, T., Tilleard, S. and Ketelsen, T. (2014). *Exploring environmental flows: case study of the Lower Se San River*. Project report: Challenge Program on Water & Food

Ministry of Agriculture and Forestry, Laos (2014). *Lao Census of Agriculture 2010/11. Analysis of Selected Themes*. Vientiane, Laos.

Ministry of Energy and Mines, Laos (2015). *Demand Forecast Main Report 2016-2030*.

Ministry of Energy and Mines, Laos (2015). *Electricity statistics yearbook 2014*.

Ministry of Mines and Energy, Cambodia (2016). *Electricity Data Collection*. Presentation in Paris, France March 2 2016. https://www.iea.org/media/training/alumni/escmarch2016/cambodia.pdf

Mongabay (2017). *Cambodian dam proceeds despite opposition over fish, ousted villagers*. https://news.mongabay.com/2015/08/cambodian-dam-proceeds-despite-opposition-over-effects-on-fish-ousted-villagers/

Ministry of Planning and Investment (MPI) (2008). *Relationship between rapid economic growth and sustainable, quality development in Vietnam. Final research report*. Hanoi: Ministry of Planning and Investment.

Mekong River Commission (MRC) (2011). *Assessment of Basin-wide Development Scenarios. Vientiane, Laos*. Mekong River Commission.

MRC (2017). *Fisheries*. http://www.mrcmekong.org/topics/fisheries/

Mueller D. and Zeller, M. (2002). 'Land-use dynamics in the central highlands of Vietnam: a spatial model combining village survey data with satellite imagery interpretation'. *Agricultural Economics* 27(3):333-354 https://doi.org/10.1016/S0169-5150(02)00073-7

NHI, (2017), 5 volumes:
https://www.dropbox.com/s/cf31brvnppf5c7q/Volume%201_Executive%20Summary_English%20%26%20Lao.pdf?dl=0; https://www.dropbox.com/s/0ttnr8a98ob9lhj/Volume%202_sections%201-10%20.pdf?dl=0;
https://www.dropbox.com/s/m2tc79q6z26ckyp/Technical%20Annexes%20for%20Volume%202%20Sections%201-10.pdf?dl=0;
https://www.dropbox.com/s/a4b3qpodmisyexr/Volume%203_Section%2011.%20Floating%20Solar%20Assessment%20for%20Xekaman%201_FINAL_01.31.18.pdf?dl=0;
https://www.dropbox.com/s/0ica1mqzqplun7f/Volume%204_Implementation%20Plan_FINAL_01.30.18.pdf?dl=0

Open Development Cambodia (2017). *Mining*.
https://opendevelopmentcambodia.net/topics/mining/

Piman, T., Cochrane, T.A., Arias, M.E., Green, A. and Dat, N.D. (2013). 'Assessment of flow changes from hydropower development and operations in Sekong, Sesan and Srepok Rivers of the Mekong Basin'. *Journal of Water Resource Planning and Management* 2013.139:723-732. DOI: 10.1061/(ASCE)WR.1943-5452.0000286

Radio Free Asia. (2013). *Lao dams, mining ruing Sekong Water Quality in Cambodia* http://www.rfa.org/english/news/laos/sekong-0625201319074Annex 3.html

Riddell and Thuo, (2014). 'Political Economic Versus Comparative Advantage in the Nile Basin: short term advantage or long term gain?' In: *River Basin Management in the 21st Century*. CRC Press, eds Daniells, Milner and Squires.

Riddell (2016). *Nexus Trade-offs and Strategies for Addressing the Water, Agriculture and Energy Security nexus in Africa.* Infrastructure Consortium for Africa/IWA.
Royal Government of Cambodia, 2010.

Schmitt, R. (2016). *CASCADE: a framework for modeling fluvial sediment connectivity and its application for designing low impact hydropower portfolios*. PhD thesis. Politecnico di Milano.

Schönweger O., Heinimann A., Epprecht M., Lu J., Thalongsengchanh P. (2012). *Concessions and Leases in the Laos: Taking Stock of Land Investments*. Centre for Development and Environment (CDE), University of Bern, Bern and Vientiane: Geographica Bernensia

Senaratna Sellamuttu, S., Joffre, O., Nguyen Duy P., Pant, J., Bouahom, B. and A Keophoxay (2014). *Hydropower development and livelihoods: a quest for a balanced approach through research and partnerships*. Proceedings of the Fifth International Conference on Water Resources and Hydropower Development in Asia, Colombo, Sri Lanka. March 2014.

Smith and Bergkamp (2013): *Nexus Dialogue on Water Infrastructure Solutions - Building Partnerships for Innovation in Water, Energy and Food Security*. IUCN/IWA

Someth, P., Chanthy, S., Pen, C., Sean, P. and Hang, L. (2013). *Basin profile of the Lower Sekong, Sesan and Srepok (3S) rivers in Cambodia. Project Report: Challenge Program on Water and Food Mekong project MK3: Optimizing the management of a cascade of reservoirs at the catchment level*. International Centre for Environmental Management, Hanoi, Vietnam.

Southeast Asia Globe (2015). *Lower Sesan 2 dam putting livelihoods and environment at risk*. http://sea-globe.com/lower-sesan-2-dam-communities-threatened-southeast-asia-globe/
Subregion: An Assessment (Phnom Penh: CDRI)

Sujono, (2010). 'Flood Reduction Function of Paddy Rice Fields under Different Water Saving Irrigation Techniques', *Journal of Water Resource and Protection*. Vol. 2 No. 6 (555-559) DOI:10.4236/jwarp.2010.26063

SWECO-Groner (in association with Norwegian Institute for Water Research, ENVIRO-DEV and ENS consult and Electricity of Vietnam) (2006). *Environmental Impact Assessment on the Cambodian part of the Se San River due to hydropower development in Vietnam*.

Takamatsu, M., Kawasaki, A., Rogers, P.P. and Malakie, J.L. (2014). 'Development of a land-use forecast tool for future water resources assessment: case study for the Mekong River 3S sub-basins'. *Sustainability Science* 9, (157-172) DOI: https://doi.org/10.1007/s11625-013-0225-5

The Cambodia Daily, (2017). *Police stop activists from reaching Sesan II dam village*. https://www.cambodiadaily.com/news/police-stop-activists-from-reaching-sesan-ii-dam-village-132810/?utm_source=Mekong+Eye&utm_campaign=d700b8387f-Mekong+Eye_2017_137&utm_medium=email&utm_term=0_5d4083d243-d700b8387f-380870829

Tran, V.T., Sunada, K., Ichiwaka, Y and Oishi, S. 201Annex 3. 'Scenario-based impact assessment of land use/cover and climate changes on water resources and demand: a case study in the Srepok River Basin, Vietnam-Cambodia'. *Water Resource Management* 26, 1387-1407.

Tuan. L.A. (undated). *Vietnam's hydropower policy reform*.

USAID (2016*). Vietnam climate change vulnerability profile*. USAID Mekong ARCC Climate change impact and adaptation study
http://www.mekongarcc.net/sites/default/files/vietnam_vulnerability_profile_english_may2014-press.pdf

USGS (2013a). *Minerals Yearbook 2013 Cambodia (advance release)*
https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-cb.pdf

USGS (2013b). *Minerals Yearbook 2013 Laos (advance release)*
https://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-la.pdf

USGS (2014). *Minerals Yearbook 2014 Vietnam (advance release)*
https://minerals.usgs.gov/minerals/pubs/country/2014/myb3-2014-vn.pdf

Vientiane Times (2016). *PM announces continued suspension of mining concessions*
http://www.vientianetimes.org.la/FreeContent/FreeConten_PM245.htm

Viet Tan (2009). *Vietnam scientist clash with government over bauxite project*.
http://www.viettan.org/Vietnam-scientists-clash-with.html

VietnamNet Bridge (2017). *Sand mining destroying rivers in Central Highlands, causing landslides.*
Weatherby, C. and Eyler, B. (2017). *Letters from the Mekong: Mekong Power shift emerging trends in the GMS power sector*. The Stimson Centre, Washington DC, USA.

Wikipedia, (2017). *Mineral Industry of Cambod*ia
https://en.wikipedia.org/wiki/Mineral_industry_of_Cambodia

World Bank (2010). *Laos development report 2010. Background paper: Social impact mitigation from hydropower and mining in Laos: examining potential for benefits sharing approaches.*

http://siteresources.worldbank.org/LAOPRDEXTN/Resources/293683-1301084874098/LDR2010_Social_Impact_Mitigation.pdf

World Energy Council (2017). *World Energy Resources: hydropower 2016*.

World Wildlife Fund for Nature (WWF) (2016). *Power Sector Vision. Towards 100% renewable electricity by 2050*. Greater Mekong Region. Cambodia Report. WWF Cambodia.

Ziv, G., Baran, E., Nam, S., Rodriguez-Iturbe, I. & Levin. S.A. 201Annex 3. *Trading off fish biodiversity, food security and hydropower in the Mekong River Basin*. PNAS 109 (15) 5609-5614. www.pnas.org/cgi/doi/10.1073/pnas.1201423109.

ANNEX 1: COLLABORATION AND PARTNERSHIPS

The study was carried out by a coalition of IUCN, ICEM, and IWMI that received strong support from a regional Technical Advisory Group (TAG), which was formed in February 2017.

The TAG is composed of 5-7 individuals from each country:

- 3-4 representatives from central governments (covering energy, agriculture, fisheries, environment, etc.) including at least 1 member from the National Mekong Committee (NMC).
- 1-3 representatives from the 3S provinces.
- At least 1 representative from a local civil society organization (CSO) or NGO.

As of April 2017, TAG members are:

Name	Position	Organization
CAMBODIA		
Ms. Im Phallay	Environmental Program Manager	NGO FORUM
Meach Mean	Technical officer	DOE, Ratanakiri Province
Youk Senglong	Deputy Executive Director	Fisheries Action Coalition Team (FACT)
Pich Sereywath	Deputy Director, Department of Community Fisheries Development	Fisheries Administration, MAFF
Chheang Hong	Director, Department of Information and Knowledge Management	NMC
Dr. Chan Sodavath	Deputy DG, General Department of Energy (Hydropower)	Ministry of Mines and Energy
LAOS		
Dr. Duangmany Luangmany	Technical Staff	NMC, MONRE
Phokhin Muangchanh	Head of Project Development Division, Department of Energy Business	Ministry of Energy and Mines
Phousavanh Fongkhamdeng	Deputy Director	Administration & Planning Division, Department of Water Resources, MONRE
Khampha Keomanichanh	Program Director	Community Development and Environment Association (CDEA)
Sengsoulivanh Inthachak	Head of Water Resources Section	PONRE, Champasak Province
Representative		PONRE, Sekong Province
Representative		PONRE, Attapeu province
Dr. Anoulak Kittikhoun	Chief Strategy and Partnership Officer	Chief Strategy and Partnerships, MRC
VIETNAM		
Tran Duc Cuong	Deputy Secretary General	NMC, MONRE
Dr. Dao Trong Tu	Deputy Director	CEWAREC
Ms. Truong Tung Hoa	Officer	Department of Water Resources, MONRE
Ms. Le Thị Huyen	Officer	Department of Water Resources and Rural Clean Water, MARD
Tran Trung Dung	Vice Rector	Tay Nguyen University

TAG members have three main responsibilities:

1. Support, advise, and guide the design and implementation of the 3S nexus assessment, including identifying data sources and commenting on methods applied and the draft report. In particular, the TAG will provide guidance to the technical team to ensure that the assessment builds on existing knowledge to provide practical decision-oriented analysis to policy makers and planners in the 3S.

2. Provide regular updates on opportunities to link the nexus assessment results with policy and planning decisions and processes, and facilitate the realization of those opportunities whenever possible

3. Act as ambassadors to present and disseminate the project findings and outcomes within their own organizations and more widely.

TAG members agreed to participate in:

- Three meetings during the preparation of the assessment.
- Regular coordination calls to discuss updates provided by the project team.

The TAG has met four times: in Hanoi in March 2017, in Vientiane in May 2017, and in Phnom Penh in July 2017 and November 2018, when the draft version of this report was discussed.

In April 2017, the writing team met NHI in Vientiane to discuss its study of alternatives to mainstream dams on the Sekong.

The nexus assessment benefited from cooperation with the Stimson Center, a DC-based security think tank. In mid-2017, the Stimson Center's Southeast Asia Program,[16] University of California at Berkeley's Energy & Resources Group (ERG),[17] and IUCN formed Mekong Basin Connect (MBC), an initiative to advocate nexus solutions across the Lower Mekong.[18]

MBC has focused on how the dramatic reduction in the prices of solar and wind, increased regional power trade, and lower than forecast energy consumption in Thailand was likely to reduce the future need for large-scale hydropower in Laos. How these trends combine is shown in Figure 1. MBC organized consultations with ministries in Hanoi in February, June, and December 2017 and in Phnom Penh in July and December 2017.

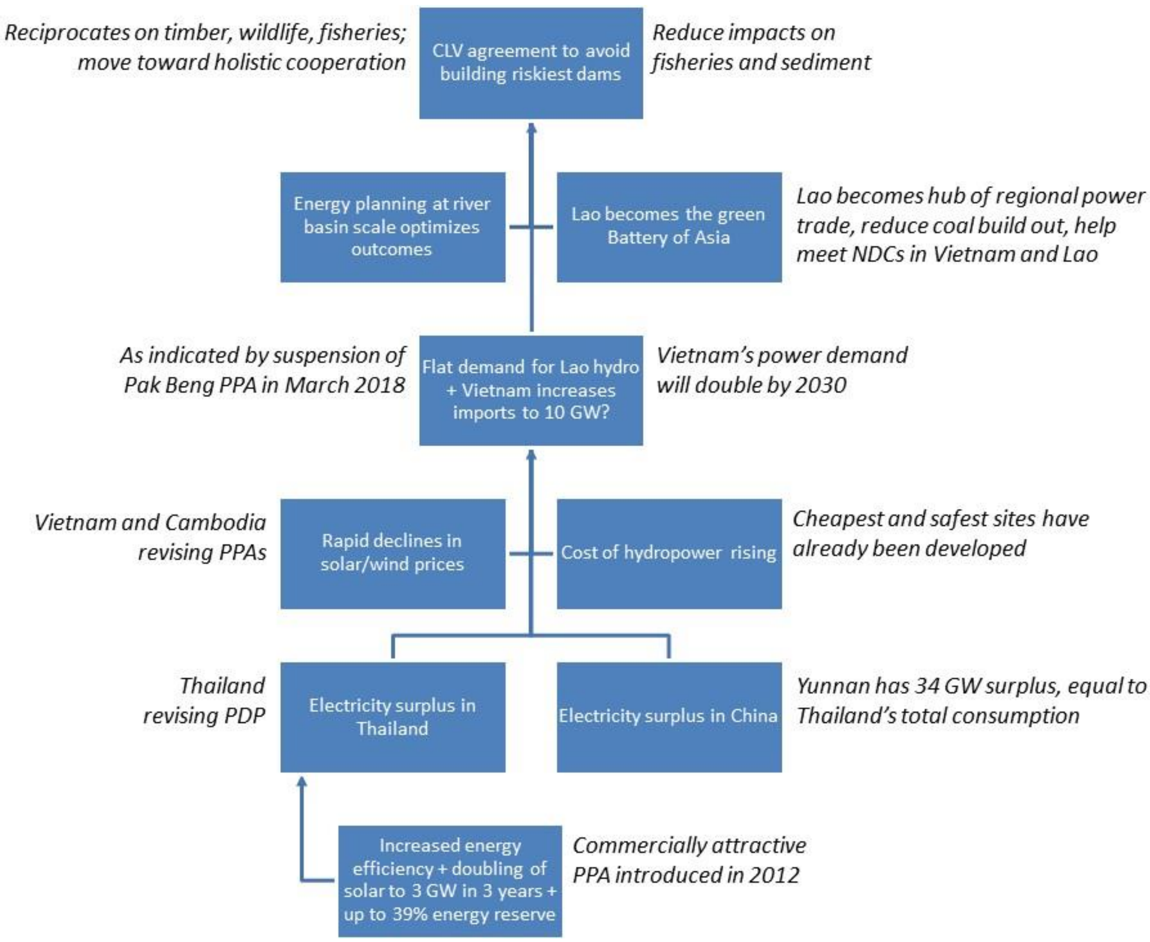


Figure 1: MBC theory of change

16 https://www.stimson.org/programs/southeast-asia/
17 https://erg.berkeley.edu/
18 https://www.stimson.org/programs/mekong-basin-connect

MBC has published a series of op-eds in regional newspapers to attract attention to the new opportunities to achieve energy security at much lower social and environmental cost.

IUCN presented these conclusions at the 10th and 11th LMI meetings in Vientiane in November 2017 and in Nay Pyi Taw in May 2018, at CGIAR's Greater Mekong Forum on Water and Food (WLE) in Yangon in October 2017, and at the MRC's International Conference in Siem Reap in April 2018.

At the WLE Forum, the fisheries data that were used to assess impacts of the 3S were criticized by Dr. Ian Cowx, a Mekong fisheries specialist. He provided what he considered much more accurate data based on an analysis of land cover in the 3S (Section 4.4). He also questioned what he considered to be over-estimates of long-term reservoir fisheries productivity.

Between March and September 2017, ICEM and IWMI produced reports on different 3S sectors: agriculture, hydropower, forestry, mining, human health, etc. In September 2017, following an assessment of the extent to which the initial findings and recommendations met the TOR requirements, Philip Riddell, a nexus consultant, was hired to draft this report.

ANNEX 2: 3S SECTOR SUMMARIES

1. AGRICULTURE

Current situation

In CLV, Agriculture is shifting from traditional smallholder subsistence farming to modern commercial farming. Countries are progressing at different rates, but all three governments promote agricultural intensification, with increased agrochemical use, irrigation and mechanization. In Vietnam, liberalization of land and trade laws in the 1990s have led to farmers choosing what to grow, increasing focus on commercial crops and unsustainable farming practices (D'haeze et al., 2005). Attempts to "regularize" upland farming and eradicate shifting cultivation has been a long-term policy objective in Laos.

In the 3S, traditional systems of rainfed paddy farming, riverbank farming and, in the uplands, shifting cultivation, are juxtaposed with commercial plantations of rubber, cassava, sugarcane and robusta coffee (Takamatsu et al., 2014; USAID, 2016). Rice remains the dominant crop but in recent years, deforestation, expansion of agricultural and urban areas, and expansion of commercial plantations have been the major land use changes in the basins (Takamatsu et al., 2014). Between 1993 and 1997 cultivated area increased by 741 km^2 with corresponding declines in forest (303 km^2) and grass/shrubs (470 km^2) (Takamatsu et al., 2014).

The 2003 land use map (the most recent year for which complete and consistent data are available) indicates that agriculture covers on average 7.5% of the 3S with by far the greatest coverage in the Srepok (Table 1.1). The largest cultivated area is in Vietnam, where rapid immigration and population growth have driven effectively uncontrolled agricultural expansion and forest loss (Tran et al., 2012; Takamatsu et al., 2014). Over the past decade, the areas of irrigated rice, maize, cassava, and sugarcane have expanded rapidly in the Central Highlands. For example, in Gia Lai Province the area planted with cassava and maize grew by 13% and 10% per annum, respectively, between 2003 and 2013 (USAID, 2016). The area of coffee in Dak Lak Province has reached 2,600 km^2, which is half of Vietnam's total coffee area (Amarasinghe, 2015). These trends are the result of growing market demand and higher prices for commercial crops. Nestle, for example, sources 30% of all its coffee globally from Vietnam.

In the Cambodian portion of the 3S, commercial agricultural area expanded almost 4-fold from 10 km^2 in 1995 to 36 km^2 in 2007, predominantly in the middle Sesan and Srepok and to a lesser extent in the Sekong (Someth et al., 2013). Total cassava production increased from 40,000 tons in 2008 to close to 170,000 tons in 2010 (Royal Government of Cambodia, 2010).

In southern Laos, between 1998 and 2011, there was a substantial increase in the proportion of households engaged in commercial agriculture, from 20% to 40% in Champasak; from 5% to 17% in Sekong, and from 3% to 10% in Attapeu Provinces (Ministry of Agriculture and Forestry 2014). In Champasak Province, the area of dry season rice cultivation fell from 73.3 km^2 to 27 km^2 between 2004 and 2005, which has been explained as a move from rice to market crops such as soybeans, corn, long beans, and watermelons (Baird and Shoemaker, 2008).

	Sekong		**Sesan**		**Srepok**		**Total**	
	Area (km^2)	% of basin	Area (km^2)	% of basin	Area (km^2)	% of basin	Area (km^2)	% of basin
Rice (paddy)	407.8	1.48	204.7	1.15	424.4	1.43	1,036.9	1.38
Shifting cultivation	173.7	0.63	516.2	23.90	149.9	0.51	839.8	1.12
Commercial plantation	726.4	23.64	230.1	1.29	1,749.8	5.90	2,706.3	3.61
Field crops	22.7	0.08	263.2	1.48	685.8	23.31	971.7	1.30
Orchard	0.0	0.00	23.0	0.13	17.3	0.06	40.3	0.05
Total	1330.6	4.84	1237.2	6.94	3027.2	10.21	5,595.0	7.46

Table 1.1: Agricultural land use in the 3S in 2003

Irrigation

Irrigation is considered essential to boost agricultural production, not just enabling dry season irrigation but also, importantly, supplementing wet season rainfall. Currently, the total area of dry season irrigation in the 3S is 610 km^2 (i.e., 11% of the total cultivated area) (Table 1.2). Vietnam has by far the largest area under irrigation (70% in the Srepok), with an unknown but significant proportion being supplied from groundwater. In Cambodia, out of 82 schemes with a potential for 28 km^2 of dry season irrigation, only eight are operational and there is only 5 km^2 of dry season irrigation. All the schemes use water from small reservoirs filled during the wet season.

In Laos, formal irrigation is supplied by pumps lifting water from the Sekong and its tributaries. In addition to dry season irrigation there are 360 traditional weirs that divert wet season river flows, but dry season water storage is negligible (ADB, 2010). As part of their national agricultural development strategies, all three countries plan to increase irrigated area in the 3S, to a total of 2,104 km^2 by 2025 (Table 1.2).

In recent years, increasingly large and unpredictable reductions in dry season river flow have been reported in the Vietnamese portions of the Sesan and Srepok, leading to competition between agricultural and urban sectors. This is widely attributed to hydropower dam operation, in conjunction with increased water abstractions, in large part for irrigation (ADB, 2010). In addition, while average groundwater levels are stable, dry season groundwater levels are falling, largely due to irrigation of coffee and other cash crops (Cheesman et al., 2007).

Total future irrigation requirements in the Vietnamese portion of the Sesan are estimated to be 13% of the average annual dry season flow (674 million m^3) and just 4% of the total groundwater reserve (2,071 million m^3). Similarly, future irrigation requirements in the Vietnamese portion of the Srepok are estimated to be 21% of the average annual dry season flow (957 million m^3) and 10% of the total groundwater reserve (2,071 million m^3). Thus, at the sub-basin level, there is a significant water surplus in both the Sesan and the Srepok. If critical low flow problems and groundwater declines are already being reported, this implies that farmers are over applying irrigation water and better coordination and management is needed to resolve water supply issues. Research has shown that better irrigation scheduling, in conjunction with improved management of other inputs (e.g., fertilizers) can lead to considerable reductions (>60%) in irrigation application without comprising, and in fact potentially increasing, crop yields (Amarasinghe et al., 2015).

	L	C	V	Total
	2010			
No. of schemes	41	8	492	541
Dry season irrigated area (km^2)	27	5	578	610
Wet season irrigate area (km^2)	36	40	1430	1,506
Estimated dry season water requirement (million m^3)	13.7	2.6	289	305
	2025			
Dry season irrigated area (km^2)	40	24	2,040	2,104
Estimated dry season water requirement (million m^3)	20	12	1,020	1,052

Table 1.2: Irrigated area in 2010 and potential irrigated area in 2025 in the 3S (ADB, 2010)

Agrochemical use

There has been an increase in the use of agrochemicals in the 3S since the early 1990s. In the Central Highlands, fertilizer use increased in the 1990s because of government programs (Mueller and Zeller, 2002). Similarly, there was a large increase in fertilizer use in Cambodia in the early 1990s when the market was opened to the private sector (McKenney and Tola, 2002). In southern Laos, the proportion of farmers using chemical fertilizers increased from 40% in 1998-99 to 56% in 2010-11 (Ministry of Agriculture and Forestry, 2014). There are no data specifically for the 3S but national level statistics, indicate that Vietnam has a much higher use of agrochemicals (293 kg/ha) than either Laos (9 kg/ha) or Cambodia (12 kg/ha) (Ministry of Agriculture and Forestry, 2014). There is no reason to believe that this broad difference in use is not replicated in the 3S.

Commercial plantations

In both Cambodia and Laos, large concessions have been granted to national elites often with overseas financing (e.g., China, Vietnam, Thailand, Singapore and the Middle East). In southern Laos, 757 concessions cover 3,141 km^2 (out of total area 64,509 km^2). Of these, 2,001 km^2 are classified as "forestry" and 750 km^2 as "agriculture" (most of the remainder are "mining"). The largest number of concessions in the Lao portion of the 3S are for coffee in Champasak Province but the total area under coffee cultivation is relatively modest (191 km^2) (Schonweger et al., 2012).

By far the largest recipients of land concessions in southern Laos are Vietnamese investors in rubber plantations,[19] notably the private company Hoang Anh Gia Lai (HAGL) and the state-owned Vietnam Rubber Group (VRG). HAGL works partly through subsidiaries and is estimated to have 266 km^2 under rubber in southern Laos, while VRG owns more than 380 km^2 of rubber across Laos, much of it in the south (Hirsch and Scurrah, 2015). Most of these concessions have come from land earmarked as fallow but which in fact have been forested or have been part of fallow cycles important to farmers for grazing livestock (Kenney-Lazar 2012). In some cases, concessions in Laos have overlapped with protected areas. For example, some 4.39 km^2 of rubber plantation concessions in Champasak Province overlap with the Donghuasao National Protected Area (Schönweger et al., 2012).

In Vietnam, most large land and forest enterprises in Vietnam's uplands are run by state enterprises (Hirsch and Scurrah, 2015). It should be noted that not all land "grabbing" is done by large players at the expense of smallholders. In parts of the 3S in Vietnam and Cambodia, ethnic majority farmers have displaced minority shifting cultivators from their lands through a range of market-based and more forceful means (Hirsch and Scurrah, 2015).

Future direction

Agriculture has been a major driver of land use and social change in the 3S. Although not well documented, past efforts to increase agricultural production through both expansion and intensification have certainly resulted in long term costs to ecosystem services (e.g., deforestation, habitat loss, soil erosion, nutrient run off and water pollution), and most likely to human health (e.g., from pesticides and fertilizers). These impacts disproportionately affect poor rural communities.

Currently, all three governments are promoting agricultural intensification and, notwithstanding options for increasing organic cultivation, it is likely that irrigation and agrochemical use will continue to increase. This could have major consequences for water supplies, soil health, human health and productivity and other ecosystem services.

2. FISHERIES

Importance of 3S in regional fisheries and food security

Throughout the lower Mekong, fisheries make a vital contribution to the livelihoods and well-being of many millions of people. The bulk of the catch is harvested by part-time subsistence fishers who are poor and generally use fishing as part of a diversified livelihood strategy (Baran and Myschwoda, 2009). According to FAO statistics (almost certainly underestimated) the freshwater inland fisheries of CLV varies annually but produce on average 588,000 tons/year, of which 67% is in Cambodia (primarily from the Tonle Sap) and just 6% is in Laos (Figure 2.1). In Laos, the fisheries value is equivalent to 7% of the country's GDP and in Cambodia, although also including marine fisheries, accounts for nearly 12% of GDP (i.e., a greater proportion than rice production).

[19] There is an indirect link with hydropower. For the Xekaman 1 hydropower project on the Sekong there is an expectation that rubber plantations will absorb labour resettled from the reservoir area (Khouangvichit et al., 2014).

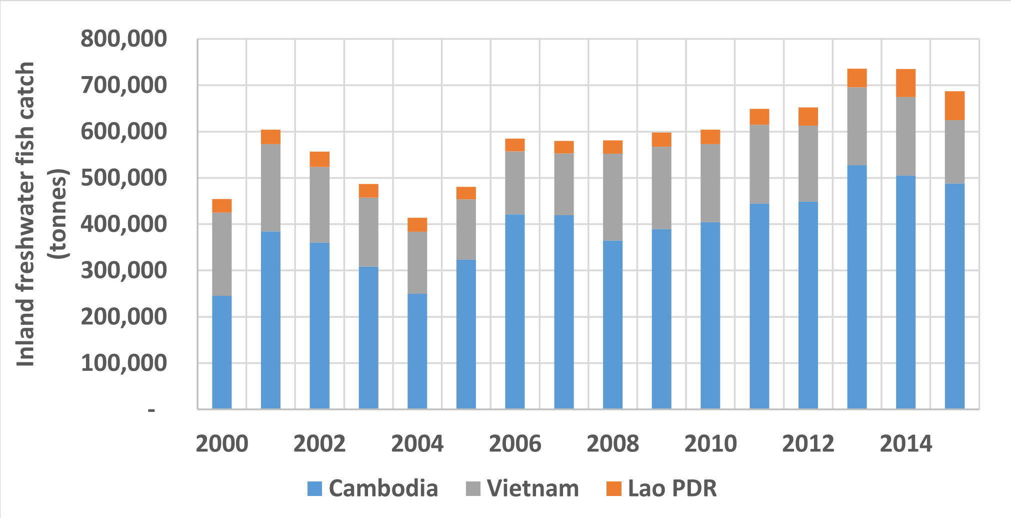


Figure 2.1: Estimated inland freshwater fish catch in CLV (2000-2015) (http://www.fao.org/fishery/statistics/global-capture-production/en)

Although fishing is the primary livelihood activity of only a relatively small number of people in the 3S, for large numbers of smallholder/subsistence farmers, fishing is a vital secondary activity. For many tens of thousands of people in the 3S, capture fisheries (i.e., fish and other aquatic organisms) remain a vital contribution to their food security (including nutrition) and household income (Box 2.1). Because of higher living standards and the greater agricultural commercialization, the 3S population in Vietnam is not as dependent on capture fisheries as it is in Cambodia and Laos (Baran et al., 2014).

Despite its importance, data on the capture fisheries yields in each basin are sparse, contradictory, and in many cases, underestimated.

Table 2.1 presents estimates of annual capture fisheries yield for the Sekong and the Cambodian portions of the Sesan and Srepok derived specifically for the current study, using data obtained from a variety of sources. These estimates suggest that the Sekong produces at least 2% of the average annual catch of Laos and the 3S combined produce between 0.5% and 1% of the much larger total average annual catch of Cambodia.

Compared to some previous estimates these are conservative figures. Other studies have estimated the total annual fish catch for the Cambodian portion of the Sesan to be anywhere between 370 and 6,700 tons and for the Cambodian portion of the Sekong to be anywhere up to 9,500 tons (Baran et al., 2014). Official Vietnamese government statistics indicate that between 1995 and 2014, capture fisheries increased steadily in Kon Tum and Gia Lai and were fairly constant in Dak Lak Provinces, with a total of 3,886 tons (General Statistics Office of Vietnam, 2017). Weighting by the proportion of each province in the basins gives a total of 2,944 tons from the 3S (i.e., 1.8% of the national inland freshwater catch) in 2014.

Box 2.1: Contribution of fish to livelihoods and well-being

Many people in the 3S live in a rural subsistence economy and supplement rice with fish and other aquatic animals (Baran et al., 2007). In the Sekong, local livelihoods depend on capture fisheries more so than in other river basins in Laos, with even villages far from the mainstem of the Sekong reporting harvesting fish for food (Baird and Shoemaker, 2008). Rural families commonly harvest fish and other aquatic animals such as crabs, shrimps, snails, frogs, insects and plants from nearby fields, canals, ponds, rivers, streams and lakes. Although daily harvests are modest and largely go unrecorded in government statistics, the cumulative total is large, and the fishery is critically important for peoples' wellbeing, providing them with their primary source of protein and micro-nutrients essential for health (Meusch et al., 2003).

		Sekong	Sesan	Srepok
C	Dependent population	11,025-15,330	30,000-50,000	40,350-67,250
	Per capita fish catch (kg)	99.9	12.2	16.9
	Total fish catch (tons)	1,100-1,530	370-845	682-1,136
L	Dependent population	30,124	-	-
	Per capita fish catch (kg)	23	-	-
	Total fish catch (tons)	692	-	-
V	Total fish catch (tons)	100	2,844	

Table 2.1: Estimated average annual fish catch in the CLV portions of the 3S

Although the direct contribution of the 3S to capture fisheries is a relatively small proportion of the total produced in CLV, this greatly understates the importance of these rivers to the total fisheries of the Lower Mekong. Many of the fish in the 3S are migratory (65, 54 and 82 species in the Sekong, Sesan and Srepok respectively (Ziv et al, 2012)), travelling long distances to reach spawning and nursery grounds (SWECO-Groner, 2006). These fish are not only important for fisheries within the 3S but also for the entire Lower Mekong.[20] Disruption of regional fish migration by dams on the 3S will likely reduce the fisheries productivity of the Tonle Sap and the Lower Mekong floodplains. By blocking migration up the Sesan and Srepok, the LS2 dam alone may cause a decrease in fish biomass by 9.3% (i.e., 58,829 tons/yr) across the whole of the Lower Mekong. Similarly, three planned dams on the Sekong (Sekong 3D, Sekong 3 Up and Sekong 4) could cause declines of 3.3%, 0.9% and 0.8% respectively (i.e., a total of 25,300 tons/yr) (Ziv et al., 2012).

Trends in capture fisheries

Although there are no statistically significant trends in terms of total production, per capita capture fisheries are declining across the Lower Mekong, largely as a result of population growth and increased fishing pressure. There is also evidence that the size of fish caught is declining, another indicator of fisheries under pressure (MRC, 2017).

Throughout the 3S, even in the remotest areas, there is growing use of modern fishing gear (i.e., nylon gillnets and factory-made metal hooks)[21], which makes it easier for more people to catch more fish. In recent years, the mesh size of gillnets has decreased and there is increasing use of mosquito nets. Some fishers use diving masks and spear guns to collect 20-30 kg of fish in one night, which many villagers believe is harmful to fish stocks. Electric shock fishing is an increasing problem and is very destructive to fish stocks (Baird and Shoemaker, 2008).

Role of aquaculture

Across the Lower Mekong, aquaculture is expanding rapidly and has the potential to offset total losses in capture fisheries (MRC, 2011). All three governments are promoting aquaculture, particularly small-scale culture-based pond fisheries as a contribution to rural development and, in the case of Laos, to food security in the south of the country. FAO statistics indicate that at national level, aquaculture production already exceeds capture fisheries in Vietnam and Laos, with total production in 2015 nearly four times greater than capture fisheries (Figure 2.2). By far the largest component of this aquaculture takes place in the Mekong Delta in Vietnam.

[20] Monitoring of fish catch in the Sesan indicates that at least 41 migratory fish species are commonly caught by fishermen and these migratory fish represent 60% of the fishermen's total catch (Baran et al., 2014). Generally, there is greater fish diversity and greater migration of fish in the Sekong and Srepok than there is in the Sesan and it would be expected that migratory fish would comprise an even greater proportion of the total catch in these two rivers.

[21] Traditional fishing gear comprised traps, scooping devises and forks and rakes (Hortle, 2009).

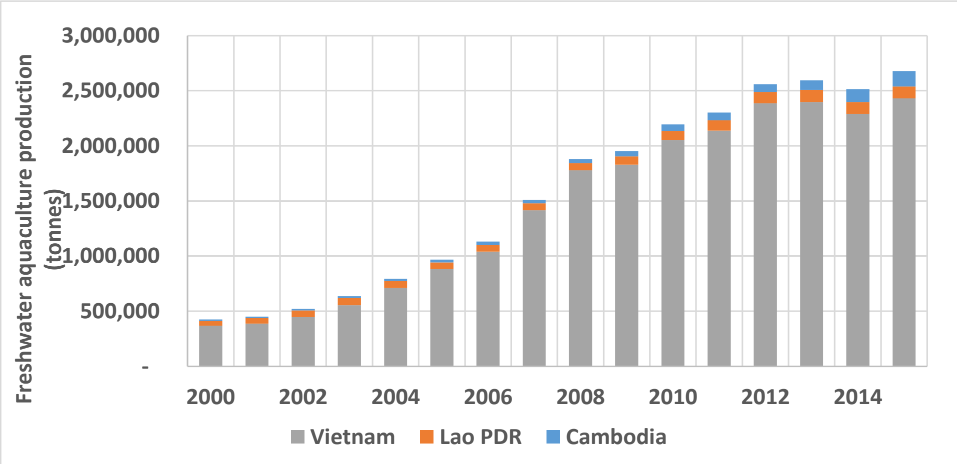


Figure 2.2: Estimated inland freshwater aquaculture yield in CLV (2000-2015) (http://www.fao.org/fishery/statistics/global-aquaculture-production/en)

Aquaculture production is increasing in the 3S but is still in the early stages of development (Baird and Shoemaker, 2008). There are few recent data on extent or yields. In southern Laos, it is estimated that less than 10% of households participate in aquaculture, compared to more than 80% that participate in capture fisheries. However, between 1998-99 and 2010-11, the area for aquaculture in southern Laos increased from 900 to 2,700 hectares (Ministry of Agriculture and Forestry, 2014). Government statistics indicate that in the three provinces in the Vietnamese portion of the 3S, aquaculture production has risen steadily since 1995, with a total of 19,324 tons produced in 2014 (0.8% of national freshwater aquaculture production) of which 75% was from Dak Lak Province (General Statistics Office of Vietnam, 2017).

Increased fish production is often promoted as an important secondary benefit of reservoirs created for hydropower or irrigation. Dam proponents often propose reservoir fisheries to compensate for the disruption to livelihoods caused by a dam. However, compensation for loss in yield from river fisheries is often difficult to achieve through reservoir fisheries. Hydropower reservoirs are typically characterized by deep, standing or slow flowing water that is not ideal habitat for the fish that evolved in the relatively shallow free-flowing conditions of the 3S. Typically, there are significant changes in fish species diversity, composition, and biomass in tropical river systems, with general declines a few years after impoundment (Jackson and Marmulla, 2001).

There are no data on reservoir fisheries in the 3S. Although outside the 3S, small reservoirs (0.5 to 6.5 km^2) in the highlands of Vietnam have reported yields in the range 126 to 588 kg/ha/yr (Hortle, 2009). With a yield of 133 kg/ha/yr in 2007, the much larger Nam Ngum 1 hydropower reservoir in Laos, completed in 1971, is an example of sustained healthy self-sustaining stocks of native fish, decades after the impoundment, despite the disappearance of long-distance migratory fish. Fisheries experts generally recommend enhancement of native fish species in reservoirs in preference to stocking because they are likely to be more sustainable. However, careful management of both reservoirs and upstream catchments is needed to maximize and sustain production, as well as to ensure that the benefits of reservoir fisheries accrue to those that lost the riverine fisheries and not, as is often the case, outsiders (Box 5.2).

Average reservoir yields of 200 kg/ha/yr (with yields inversely proportional to reservoir area) have been estimated for Lower Mekong reservoirs (Hortle and Bamrungrach, 2015). In the 3S, the surface area of many existing and possible future reservoirs is unknown. However, data from various sources indicate that for 23 of the maximum 42 hydropower schemes that will exist in the 3S, reservoir surface areas vary from 1.8 km^2 to 723 km^2, with a total of 3,033 km^2. Applying the relationship presented in Hortle and Bamrungrach (2015)[22] to these reservoirs provides an area-weighted average possible yield of 131 kg/ha/yr (i.e., somewhat less than that estimated for the

[22]The relationship developed is: $y = 466.4A^{-0.23}$ where: y = yield (kg/ha/yr) and A = reservoir surface area at full supply level (km^2) (Hortle and Bamrungrach, 2015).

entire Lower Mekong). If we assume that total reservoir area in the 3S will eventually be between 3,500 and 5,000 km^2 this implies a maximum possible reservoir fisheries production of between 45,000 and 65,000 tons/yr. Hence, it seems unlikely that, even if well managed, reservoir fisheries in the 3S can fully compensate for the likely dam-induced losses of capture fisheries both in 3S and downstream.

3. HUMAN HEALTH

Current status

Many factors influence the health and well-being of people, including availability of food, diet, water quality, sanitation, socio-economic status and cultural practices, literacy, and lifestyle. These factors have changed significantly during the economic transitions that have shaped CLV in recent decades, resulting in considerable improvements to health and increased life-expectancy in all three countries. However, these broad regional improvements are not experienced equally; health inequities remain a significant problem. Remote border and forested areas, such as the 3S, are socio-economically worse off and present unique challenges to public health initiatives. Consequently, they tend not to have improved as much as other areas. In the 3S there are two nexus-related public health concerns: malnutrition and water pollution.

Malnutrition

Like all other poverty indicators, the vulnerable and children are most affected by malnutrition. Since nutrition is essential for a child's intellectual and physical development many nutrition indicators focus on children under 5.

Malnutrition is a major problem in all three countries and is particularly prevalent in rural communities and among the poor. Ethnic minorities located in remote upland areas are disproportionately affected and there are high levels of malnutrition throughout the 3S, including in Vietnam (Table 3.1). Most households have acceptable levels of food consumption, but nourishment is undermined by lack of diversity and poor quality in terms of both nutritional content and food safety (Bouapao et al., 2016). Micronutrient deficiencies, especially iron, vitamin A and iodine are a major concern. Cultural practices that impose restrictions on what infants consume and lack of education of mothers have also been found to be significant variables in explaining malnutrition in ethnic minorities (Annim and Imai, 2014).

		Underweight	**Stunting**	**Wasting**
C	Mondulkiri, Ratanakiri, Stung Treng	23.8%	48.6%	-
L	Attapeu, Sekong, Saravane	30.0%	44.3%	11.0%
V	Kon Tum, Dak Lak, Gia Lia	26.1%	37.75	9.1%

Table 3.1: Nutritional status of children <5 in the 3S (Haslet et al., 2013; Bouapao et al., 2016)

Water pollution

Data are sparse, but it seems that water pollution in the 3S is not yet a serious problem. Nevertheless, concerns for human health remain. Results from all monitoring stations in the 3S in all three countries indicate that over time total suspended solids (TSS) and total nitrogen and phosphorous loads, are increasing in both dry and wet seasons. TSS levels are particularly high, exceeding quality standards for water used for domestic purposes in some places.

Increasing agrochemical use and mining present the greatest threat to water quality and thus to human health in the 3S. Agrochemicals can pose significant (acute and chronic) risks to human health (Wimalawansa and Wimalawansa, 2014). Agrochemical use is far greater in Vietnam than in Cambodia and Laos, but because Vietnam forms the headwaters, high application rates there potentially pose a risk downstream, particularly in Cambodia where there is widespread use of untreated river water for domestic and potable supplies. Given the likelihood of agricultural expansion and much greater rates of application in both Laos and Cambodia, and possibly even in Vietnam as soil fertility declines, the risk of agrochemical pollution is likely to increase.

Pollution from mining is also likely to increase. In Laos, local communities have complained of toxic pollution from gold mines in tributaries of the Sekong (Radio Free Asia, 2013). Discharge of red mud in bauxite mining, waste water containing toxic compounds and heavy metal salts, or toxic chemicals (e.g., mercury to purify gold or cyanide in bauxite production) all represent serious threats to human health. If, as is likely, mining in the 3S increases, this threat will intensify.

Continued forest loss puts additional pressure on water quality as it increases soil erosion, unnatural turbidity levels, and organic matter in river water. The lack of centralized wastewater treatment system in large cities in the Central Highlands coupled with steady population growth potentially creates local water pollution issues.

General well-being

In all three countries, the 3S fares badly in most social and health indicators. Harsh natural conditions, unpredictable weather and poor infrastructure are among the factors that limit access to markets and social services, undermining livelihoods and constraining opportunities to escape poverty. This is also true in the Central Highlands, but social conditions there tend to be better than in many parts of Cambodia and Laos (ADB, 2012).

Many ethnic minority groups live in the 3S. For these communities, traditional livelihoods are largely dependent on shifting cultivation supplemented with fisheries and forest products. Generally, these communities lack secure title to their land and other resources, are poorly educated, and have limited livelihood alternatives. They tend not to be represented in decision making. This is particularly true for women and youth and comes to the fore when communities are relocated for dams, mines or plantation concessions (Box 3.1).

Such communities now rely on a dwindling resource base. The loss of forests disproportionately affects them, particularly women and children. Most spend significant time and energy on traditional activities of collecting fuel, fodder, and water. If forests near their homes are already exhausted, they may have to walk long distances. Such women have less time to earn an income and take care of their children; and their school-age children spend fewer days in school (ADB, 2013).

4. HYDROPOWER

Arguably, hydropower is the single biggest driver of change in the 3S. In common with much of the rest of the world, the dominant development paradigm is that high levels of infrastructure investment (including electricity generation) are a precursor to economic growth and hence social development (ADB, 2013). Although the links between electricity generation and economic growth are complex, regression analyses present a simple and seemingly compelling national-level narrative for policy-makers: increasing electricity generation increases GDP and increasing GDP reduces poverty.

Against this background – and in the context of high oil prices, an emphasis on renewables, the availability of private financing, and improved transmission – hydropower has been perceived as increasingly attractive and its development has accelerated. A significant proportion of installed hydropower capacity in Laos (30%) and Vietnam (17%) is installed in the 3S (Table 4.1).

Box 3.1: Resettlement from large dam construction

Dams require the resettlement of people living and/or farming in the area that will be inundated by the reservoir. Displacement is recognized as one of the most detrimental social impacts caused by dams. In the 3S, about 60,000 people, mostly ethnic minorities, have been, or will be, displaced by large dams. About 5,000 villagers are being relocated from the reservoir site of the LS2 dam in Cambodia (Mongabay, 2017) and about 8,500 people were moved by the Yali Falls dam in Vietnam. Their livelihoods often do not survive relocation (Scudder, 2005). They may lose not only their land but also access to resources that they once depended on. This forces a greater reliance on cash incomes and breadwinners often have to seek wage labor. In general, relocated people experience disproportionately higher levels of landlessness, unemployment, indebtedness and hunger. Funds for resettlement and rehabilitation are almost always inadequate.

	Potential capacity (MW)	Installed capacity (MW)		% of total electricity from installed hydropower
		National total	3S	
C	10,000	945	1	57
L	23,000	4,168	1,252	99
V	19,000	15,703	2,533	42

Table 4.1: Economically-feasible hydropower generation in the 3S (various sources)

Electricity consumption in CLV has increased rapidly over the past 20 years and is forecast to continue increasing because of higher living standards, rural electrification, and industrial development. In Vietnam, more than 98% of rural households have access to electricity. This compares to less than 30% of rural households in Cambodia (KfW, 2014) and 88% in Laos (Ministry of Energy and Mines, 2015). Laos and Cambodia have ambitious rural electrification programs. Laos aims to supply electricity to at least 90% of households in the country by 2020 (Ministry of Planning and Investment, 2016) and Cambodia anticipates 100% electrification of villages by 2020 (Constable 2015).

Laos has commissioned more than 3,500 MW of hydropower over the past 20 years and added 600 MW in 2015 (World Energy Council, 2016). The rapid development of hydropower in has been driven not by domestic needs but by the government's plan to promote national development through the sale of electricity to neighboring countries. Laos is seeking to increase exports of electricity to Thailand, Vietnam, Cambodia and possibly Myanmar. According to government targets, installed hydropower will reach 5,500 MW by 2020 with a further 20,000 MW planned. There are 54 hydropower projects under construction, all of which should be complete by 2020 (Laos News Agency, 2017).

Cambodia has struggled to meet basic electricity needs in recent years and this is seen as a significant drag on development. Furthermore, the need to import about 25% of its electricity (primarily from Thailand and Vietnam) contributes to concerns over energy insecurity (Weatherby and Eyler, 2017). As a result, Cambodia wants to more than double electricity generation between 2014 and 2018 and is rapidly developing hydropower (IRN, 2014). Despite concerns over the impacts on fisheries, the government aims to reduce electricity imports to zero by 2024 and increase hydropower production to 3,000 MW (about 50% of anticipated total demand) by 2027 (Ministry of Mines and Energy, 2016).

About one-third of Vietnam's installed hydropower is in the Central Highlands. The government plans to increase total hydropower capacity to 21,000 MW by 2020 with about 2,000 MW in the Central Highlands (World Energy Council, 2016). However, there is growing public awareness of the negative environmental and social impacts of hydropower, which led to the cancellation of more than 400 mostly small hydropower projects in 2012 and 2013 (Tuan, undated).

History of hydropower in the 3S

Contributing a combined mean annual discharge of 2,890 m^3/sec (i.e., 20% of the annual flow of the Mekong) and with significant elevation change, the 3S is well suited for hydropower. Currently, there are 20 hydropower dams with a total installed capacity of 3,786 MW in the 3S (Figure 4.4). Total potential hydropower in the 3S is 6,560 MW with total reservoir storage of 53,000 million m^3 (i.e., 75% of the average annual outflow from the 3S).

Commissioned in 1996, the 720 MW Yali Falls dam was the first large hydropower plant in the 3S. Located in Gia Lai and Kon Tum Provinces on the Krong Poko, a tributary of the Sesan, 70 km upstream of Cambodia, it is the second largest dam in Vietnam. Vietnam, particularly in the Sesan, has the greatest overall installed capacity and only limited small-scale development is envisaged in the future.

There are 22 dams at various stages of planning and construction in the 3S (Table 4.2). Most future development is planned for the Laos portion of the Sekong and the Cambodian portions of the Sesan and Srepok.

	LAOS			**CAMBODIA**			**VIETNAM**		
	EXISTING								
	No.	Reservoir volume (million m^3)	Generating capacity (MW)	No.	Reservoir volume (million m^3)	Generating capacity (MW)	No.	Reservoir volume (million m^3)	Generating capacity (MW)
Sekong	7	7,215	1,252	0	0	0	0	0	0
Sesan	0	0	0	1	0	1	7	3,331	1,849
Srepok	0	0	0	0	0	0	5	1,184	684
Total	7	7,215	1,252	1	0	1	12	4,515	2,533
	PLANNED								
Sekong	15	18,729	1,672	0	0	0	0	0	0
Sesan	0	0	0	4	6,565	703	0	0	0
Srepok	0	0	0	2	14,599	3,470	1	1,088	49
Total	7	18,729	1,672	6	21,164	4,173	1	1,088	49

Table 4.2: Existing and planned hydropower schemes in the 3S

The LS2, Cambodia's first major hydropower project in the 3S was completed in late 2017, blocking fish migration into, and sediment transport from, both the Sesan and Srepok. There are seven hydropower projects undergoing feasibility assessments in the Lao portion of the Sekong. Given the closure of the Sesan and Srepok by the LS2, any one of these seven dams will compromise the last major free flowing tributary of the Mekong with potentially significant implications for fish migration and sediment (Thomas, pers. comm. 2017).

Evolving energy sector

The energy sector in Southeast Asia is evolving rapidly. ASEAN has set a target of securing 23% of its energy from renewables by 2025 (34^{th} ASEAN Ministers on Energy Meeting, Nay Pyi Taw, Myanmar, September 2016). Although hydropower is classified as renewable, there is a recognition that non-hydropower renewables (primarily solar, wind and bioenergy) can also make a significant contribution to this target (IRENA and ACE, 2016).

Globally, record low prices for utility scale photovoltaics and wind turbines in 2016 (i.e., as low as $0.03/kWh[23]), as well as more and more examples of how renewables can be integrated into existing grids while maintaining or even improving reliability of supply are increasing both the economic and technical viability of these energy sources. Most estimates indicate that the global price of solar and wind will continue to fall in coming years because of economies of scale and the rise of alternative funding frameworks (Weatherby and Eyler, 2017). Although the very low prices of non-hydropower renewables are yet to reach the Mekong, CLV could benefit from these global trends. Each country has different resource endowments and different levels and growth rates of

[23] By comparison, hydropower costs are very site specific but typically $0.02-$0.19/kWh (IRENA, 2012). For 10 planned hydropower schemes in the Laos portion of the Sekong, average energy costs were estimated to be between $0.025 and $0.053/kWh in 2004 (Maunsell and Lahmeyer International, 2004). However, the cost to the consumer depends very much on the price fixed in negotiations between the government and the developers in the power purchase agreement. In Laos in 2014, the average electricity tariff was $0.086/kWh (Ministry of Energy and Mines, 2015). In Cambodia, electricity prices are among ASEAN's highest: in 2012 households paid $0.25-$0.80/kWh (Weatherby and Eyler, 2017). There is a risk that as costs of non-hydropower renewables drop, governments will be locked into hydropower agreements that oblige them to pay significantly more for electricity than they need to.

electricity demand, but there are significant opportunities for non-hydropower renewables in all three.

Table 4.4 presents estimates of potential renewable power installation by 2025 in CLV as a contribution to the ASEAN 23% target. The current level is 10%. Although, electricity generation will remain dominated by hydropower and, particularly in Vietnam, by fossil fuels, non-hydropower renewables are likely to be increasingly competitive on price and, over time, may reduce the number of dams that need to be built (Weatherby and Eyler, 2017). Such a scenario is more likely with system-scale planning, as opposed to the current approach of ad hoc, project by project planning, and if a regional grid and framework for power trade could be established (Weatherby and Eyler, 2017).

	CAMBODIA	LAOS	VIETNAM
Total installed generating capacity	4,200	19,200	77,200
Renewable capacity			
Hydropower	2,600	14,700	23,700
Wind (on and off shore)	200	0	5,700
Biofuels	100	300	1,000
Solar PV	700	1,300	8,100

Table 4.4: Estimates of installed electricity generating capacity (MW) in 2025 required to achieve ASEAN target of 23% renewables (IRENA and ACE, 2016)

Future direction

Dams in the 3S have altered landscapes, increasing the abundance of standing water, radically altering the aquatic ecosystems on which many people, both in the basins and downstream, depend. Typically, these dams are managed in isolation and almost exclusively to maximize electricity production.

The need for sustainability and greater inclusiveness requires a different approach whereby dams and reservoirs are considered not in isolation but as critical elements of the landscapes in which they are located. They need to be managed not only for electricity but also to sustain and enhance critical ecosystem services. This requires a systematic approach, considering each reservoir in the context of the basin in which it is located and the associated interconnections with the upstream and downstream aquatic and terrestrial landscape. It means managing the dams in each basin, and indeed across basins, conjunctively. Importantly, it also means giving much greater consideration to the role of reservoirs in livelihood adaptation for local communities coping with dam driven change.

In this regard, management of dams in the 3S needs to be better integrated both within countries and across national borders. It is possible that more integrated management of the dams would ensure adequate electricity production whilst simultaneously providing opportunities to:

- Enhance reservoir fisheries, through an appropriate mix of physical, biological and natural resource governance interventions, including on inflowing tributaries.
- Enhance other reservoir related ecosystem services including, for example, restoration of shoreline vegetation which can enhance fish habitat, reduce erosion, maintain deltas, provide a carbon sink, purify water, improve aesthetics and, in some instances, provide agricultural opportunities (Box 4.2).
- Safeguard downstream environmental flows for human use and to support healthy river ecosystems, including downstream fisheries and flood dependent agriculture, as well as, in some instances, downstream irrigation (Box 4.3).

In addition, managing sediment is an aspect of dam management in the 3S that needs critical attention. Consideration needs to be given to both enhanced watershed management to reduce sediment deposition within the reservoirs and sediment flushing/sluicing. The former may be linked to payment for ecosystem service schemes (Box 4.4) and the latter needs careful consideration in the context of environmental flows and the direct and indirect impacts on downstream fisheries (Baran et al. 2012).

Box 4.1: Cultivation in the Yali hydropower reservoir

In some places the drawdown area of reservoirs can represent a significant agricultural opportunity, particularly where there is limited arable land for farming communities that have had to be relocated because of dam construction. In such cases, consideration needs to be given not only to matching agricultural activities and crop cycles to variation in reservoir water-levels but also to issues such as potential fertilizer and pesticide pollution and possible soil erosion and associated sedimentation arising from farming activities. In the Sesan, trials undertaken since 2008 have indicated the feasibility of local communities using 2,600 hectares of the fertile drawdown zone of the Yali reservoir for growing cassava (Senaratna Sellamuttu et al., 2014).

Box 4.2: Environmental flows

To date, environmental flows have not been widely applied in the region. The key to achieving implementable environmental flows is reaching a compromise that minimizes the potential impacts on downstream ecosystems while ensuring adequate production for reservoir operators. Ideally, this achieved in the planning and design phase of dams but in some instances can be achieved retroactively. Implementing a comprehensive environmental flow program in the 3S will require cross-sector and transboundary commitments. One recent study investigated the cascade of seven hydropower dams on the upper Sesan river in Vietnam, and the impacts of the changes in the flow regime in the habitats and ecosystems in the lower Sesan in Cambodia. Modelling of the hydrological character of the river enabled a comparison of full regulation with a near natural flow regime if all the dams were operated in run-of-river mode. This illustrated that there would be a reduction in the potential electricity production of 13% with a near natural flow regime (Meynell et al. 2014). This illustrates the likely scale of the trade-offs required to achieve adequate environmental flows but also that compromises are feasible.

Box 4.3: PES: protecting forests to safeguard hydropower generation

Payments for ecosystem services (PES) is a tool for ensuring that those who maintain an ecosystem’s ability to provide services, such as watershed protection, are compensated for doing so. Payees may be beneficiaries (i.e., users of the services), or polluters offsetting negative environmental impacts. PES arrangements have been implemented in some places to improve the operation and longevity of hydropower schemes. The idea is that paying to protect forest cover and implement soil and water conservation measures in watersheds upstream of dams, reduces erosion and hence reservoir sedimentation. Thus, investment in improved watershed management can extend the life and economic viability of a hydropower scheme. Vietnam is one of the first countries in Southeast Asia to implement a national PES policy. It is estimated that to date the scheme has generated about $140 million, largely funded by hydropower operators, to protect around 4 million ha of the country’s forest. A study of a proposed hydropower scheme in Cambodia (Pursat 1) estimated that the net present value of forest conservation (attributed to safeguarding hydropower revenue) was $4.7 million (or $42.15/ha of watershed area) (Arias et al., 2011). The viability of such schemes in the 3S should be investigated.

For new hydropower dams, careful consideration needs to be given to how they fit within the context of existing ones, how they will add to cumulative total impacts (both upstream and downstream) and how they are best managed in combination with the existing schemes, within each country and across national borders. Equally, given the rapidly evolving nature of the energy sector and the relative economic fragility of large infrastructure schemes (Ansar et al., 2014) careful consideration should be given to whether these schemes should proceed.

5. MINING

Current situation

Mineral mining and quarrying are important economic sectors in Vietnam and Laos, contributing a significant proportion of national GDP (Table 5.1). Vietnam is the third largest mineral producer in Southeast Asia (Great Mining, 2017). In contrast, although there is significant potential and many exploration licenses have been granted, the mining sector in Cambodia is largely undeveloped. Across Cambodia (including in the 3S) there are thousands of artisanal miners and small-scale quarrying activities but currently no large industrial-scale mining (Open Development Cambodia, 2017).

	Output of mining/	% of GDP

	quarrying sector ($ million)	
CAMBODIA	56	0.6
LAOS	596	7.4
VIETNAM	12,436	10.9

Table 5.1: Contribution of mining and quarrying sector to GDP in CLV in 2010 (ADB, 2012)

Several types of mining activity occur in the 3S (Table 5.2).

L	**Active** • Alluvial gold mining in Attapeu and Sekong Provinces • Anthracite coal in Saravan Province by Xekong Power Plant Limited • River sand and gravel **Potential** • Copper, lead and tin • Bauxite on Bolaven and Sanxay Plateaus
C	**Active** • Sand and gravel have been extracted from the Sesan in Stung Treng • Rattanakiri is famous for its gemstones (sapphires and amethysts) and there are several artisanal zircon mines in the province, primarily in the lower Sekong **Potential** • Coal deposits are on the Sekong and Sesan in Stung Treng • Precious metals, gold and silver resources in the Sesan and Srepok in Rattanakiri • Base metals like copper and lead minerals in the Sekong • Bauxite deposits are mainly found in Mondulkiri
V	**Active** • Bauxite at Nhan Cho mine • Artisanal gold • Sand and gravel in Sesan and Srepok **Potential** • Bauxite

Table 5.2: Existing and potential mining activities in the 3S (Someth et al., 2013; Schonweger et al., 2012; Khamphavong and Homesombath, undated)

The Central Highlands are home to large bauxite reserves. Currently two bauxite mines, in Nhan Cho in Dak Nong Province and in Tan Rai in Lam Dong Province, are targeted to produce a total of 1.3 million tons of alumina per year, primarily for export to China (USGS, 2014). Nan Cho lies within the 3S and Tan Rai lies just outside. Another four sites are planned in the Central Highlands, covering a total of 1,800 km^2. It is probable that they will partially extend into the 3S. Bauxite is typically strip mined with potentially major environmental impacts in absence of strong safeguards. Plans for bauxite mining have faced strong criticism from environmental groups concerned about the impacts on forests and farmers (Viet Tan, 2009; Box 5.1).

Box 5.1: Bauxite mining in the Central Highlands (https://ejatlas.org/conflict/tan-rai-bauxite-mining-in-central-highlands-vietnam)

Vietnam is estimated to hold the world's third-largest bauxite ore reserves, after Guinea and Australia (USGS, 2014). Up to 96% of this reserve is in the Central Highlands. In 2006, the government approved plans to begin mining bauxite reserves and in 2007 signed an unusual party-to-party agreement with China to mine bauxite in the Central Highlands. There are two operating mines (one of which is in the Srepok) and plans for four more.

The greatest concern with bauxite mining is the impact of the red mud (bauxite residue) and tailing slurry (waste water discharged during the sifting process). Containing high levels of metal oxide and sodium hydroxide, the sludge could damage water supplies and agriculture (primarily coffee), as well as to the health and safety of thousands of people. Moreover, deforestation, relocation and population displacement in a region that is home to ethnic minorities, and the large amount of water and energy required for producing alumina, are also matters of concern, particularly when water scarcity is growing in the Central Highlands.

In the Lao portion of the Sekong, active mining concessions pertain primarily to alluvial gold mining. It is estimated that 50 medium-scale units have been operating over the past five years (IUCN, 2017). These companies (many Vietnamese owned) use backhoes to scoop up soil from streams and riverbanks, then extract the gold on-site using chemicals or mercury. Communities in southern Laos have complained of toxic water pollution from gold mining in recent years (Radio Free Asia, 2013). In response, the government imposed a 4-year moratorium on new mining projects in 2012. Despite pressure from mining companies, the moratorium was extended in 2016 so that investigations in to some mining operators could be completed (Vientiane Times, 2016).

In Cambodia, 22 mining licenses have been issued in Rattanakiri Province to 11 companies to extract gold, bauxite, iron, gemstones and granite. The total area of concessions covers 4,000 km^2 (Someth et al., 2013). Stung Treng Province contains several mineral deposits but apart from the alluvial gold deposits in the Sekong none are yet exploited (Someth et al., 2013). The first industrial scale mining license for gold was issued in September 2016 to a mining company in Ratanakiri (Open Development Cambodia, 2017). There is significant extraction (much of it illegal) of sand and gravel from river beds in the 3S, especially on the Sesan and Srepok in Vietnam, on the Sekong near Attapeu in Laos, and on the Sesan in Stung Treng in Cambodia (IUCN, 2017). Sand and gravel are used primarily by the construction industry but there are no data on volumes being taken or the extent to which they are exported[24]. River sand and gravel mining can cause severe turbidity and increase downstream erosion. In the Krong Ana and Krong No, two tributaries of the Srepok in Vietnam, uncontrolled mining has caused significant loss of farmland (VietnamNet Bridge, 2017).

Mining impacts depend, to a large extent, on the location, topography and climatic condition as well as the exact nature of operations. As with hydropower, local communities often bear the brunt of negative impacts while the rewards tend to accrue at regional, national and international levels. Within affected communities, some groups are better positioned to benefit from local development due to education or skills or for other reasons. Conversely, others tend to be particularly vulnerable to detrimental impacts (e.g., women, the elderly, poor households or ethnic minorities). These factors can combine in ways that exacerbate vulnerabilities and inequality. For example, well-connected and educated young men often do well while less-educated ethnic minority women tend to be excluded from job opportunities. Poor households, particularly ethnic minorities, depend heavily on forests and rivers. As these resources become scarce, or their access is restricted, households inevitably became more vulnerable with serious implications for poverty, food security and nutrition (World Bank, 2010). Men tend to be the primary beneficiaries of employment opportunities created by mining while women tend to be disproportionately affected by the loss or degradation of forest and water resources.

[24] At the national level a significant proportion of river sand and gravel mined in Laos is exported to China.

Future direction

Given the significant mineral reserves, the considerable financial value and the growing global demand it seems likely that mining activities will increase in the 3S in the immediate future. The one exception maybe in Laos, but even there it seems unlikely that the moratorium on new mining ventures will continue indefinitely. Against this background, mining practices in the 3S need to be considerably improved with greater emphasis on sustainability, environmental stewardship and social responsibility.

ANNEX 3: POLICY AND PLANNING FRAMEWORK SUMMARY

The following table summarizes various policy and planning frameworks for Cambodia, Laos, and Vietnam. These policies include national-level development priorities, and thematically-focused policies for water, food/land, energy, and ecosystems.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
CAMBODIA						
	Strategy for Agriculture and Water 2010-2013	*Cambodia Agricultural Sector Strategic Development Plan 2014-2018*	*Cambodia Strategic Planning Framework for Fisheries 2010-2019*	*Policy document*	*National Policy, Strategy and Action Plan on Energy Efficiency in Cambodia*	*National Forest Program 2010-2029*
	MOWRAM	MAFF	MAFF	*Owner*	Owner institution?	MAFF
• Average annual economic growth of 7%. • Achieving >1% reduction in the poverty rate annually. • Agriculture development is a priority through diversification, value-added, productivity	• Promotes sustainable and pro-poor management of water resources that envisages the integrated management of water and land resources in a river basin context. • Area of cropland with access to irrigation services will increase by 100,000 ha. • Incidence of drought- or flood-affected farmland reduced by 20%. • Agricultural output will increase by 20%. • Beneficiary income will increase by 20%. • Focus on delineating and classifying river basins and creating multi-stakeholder water basin committees. • Build 20,000 ha of wet season and 5,000 ha of dry season irrigation schemes per year.	• Prepared in line with policy goals in Rectangular Strategy Phase III, National Strategic Development Plan, 2014-2018, and Policy Paper on "The promotion of paddy production and rice export" 2010. • Contribute poverty reduction, ensure enough and safe food availability for all people, through modernization of agricultural sector based on a new approach and with changed scope and pace for accelerating agricultural economic growth, and sustainable natural resource management and conservation. • Increase agricultural growth around 5%/yr. • Growth of all kinds of crops by 10%/yr. • Increase rice yield to 3.25 tons/ha by 2018. • Increase paddy surplus to 6 m	<u>Strategic interventions include</u>: • Protecting and maintaining the ecosystem to support wild capture fisheries at levels that are both sustainable and sufficient to support demand. • Increasing rice field fisheries. • Supporting the growth of small, medium and large-scale freshwater aquaculture. • Livelihood diversification away from capture fisheries, especially for poor, disadvantaged and vulnerable people to help them out of poverty. <u>Key targets</u>: • Wild fish capture production is stabilized and sustained at not more than 500,000 tons/yr. • Rice field fish production is increased by 15% annually, to reach 500,000 tons/yr by 2019. • Aquaculture production is increased by	*Objectives, including quantitative targets*	Objectives, including quantitative targets?	• Ensure environmental protection and conservation of forest resources. • Maximize sustainable forest contribution to poverty alleviation, enhanced livelihoods, and equitable economic growth. • Continue formalizing titles to the indigenous peoples and permit them access to NTFPs.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
	• Large-scale village irrigation development.	tons by 2018. • Four priority areas: (1) enhancing value added of milled rice production and export, especially fragrant and organic rice and other high value agricultural products; (2) promoting livestock production and aquaculture; (3) encouraging investments in agroindustry; and (4) enhancing agricultural productivity, modernization and commercialization.	15% annually, to reach 185,000 tons/yr by 2019.			
National Strategic Development Plan 2014-2018	*National Strategic Development Plan 2014-2018*	*National Strategic Development Plan 2014-2018*	*National Strategic Development Plan 2014-2018*		*National Strategic Development Plan 2014-2018*	*National Strategic Development Plan 2014-2018*
MOP	MOP	MOP	MOP		MOP	MOP
• Natural resources managed and ecosystems used sustainably, 60% forest cover. • Implement rice intensification policy. • Implement the Industrial Development Policy (IDP) to promote industrial growth with an emphasis on diversifying the production base and creating more non-farm jobs. • Implement the Cambodia Climate Change Strategic Plan 2014-2023, National Policy on Green Development and the National	• Rehabilitate and construct the existing irrigation schemes. • Maintain water discharge and minimum water. • Encourage the implementation of river basin development and management plan with the cooperation of concerned ministries, stakeholders and beneficiaries, especially women. • Promote the study and river basin development planning in short, medium and long term. • Pay attention and focus	• Implement the "Policy on the Promotion of Paddy Production and Rice Export" fully to improve agricultural productivity in which exporting milled rice assumes centrality. Address low productivity and low value-addition. • Maintain the targeted agricultural growth of 5% per annum through enhanced productivity, diversification and commercialization.	• Comprehensive strategy for regional cooperation to address issues facing fisheries in Cambodia, including climate change, upstream damming of rivers, and environmental degradation, developed and fully implemented. • Fish availability for local consumption to remain at least at 52.4 kg/person/yr. • Continue to implement the Prime Minister's Recommendations "where there is water there is fish".		• All villages to have access to electricity by 2020. • Exploration of energy sources such as hydropower. natural gas, and coal. • Development of all types of renewable energy. • Promote regional energy trade through bi- and multi-lateral cooperation.	• Adopt green growth and low carbon development strategies, which are key to sustainable economic development. • Strengthen the management of protected areas to eliminate illegal exploitation of natural resources, and curb illegal land and forest clearings. • Evaluate environmental impacts of any development projects proposed.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
Strategic Plan on Green Development 2013-2030 to support sustainable development. • Improve rural access to improved drinking water and sanitation to 60% of households. • Reduce maternal mortality ratio (100,000 live births) to 130 by 2018. • Reduce infant mortality rate (1,000 live births) to 38 by 2018. • Reduce under 5 mortality rate (1,000 live births) to 42 by 2018.	more on the prioritized river basin and aquifers conservation.					
		National Strategy on Food Security and Nutrition 2014-2018	*National Strategy on Food Security and Nutrition 2014-2018*		*Climate Change Strategic Plan 2014-2023*	*National Strategic Plan on Green Development 2013-2030*
		MOH	MOH		NCCC	MOE
		• Increase the local availability and accessibility of diversified food (through homestead food production) and raise awareness on nutritional values of local agricultural products. • Improve food access for the poor and vulnerable. • Improve child and maternal nutrition. • Intensify and diversify smallholder farming systems and improve linkages to markets. • Enhance sustainable and secure access to land for the poor and food-insecure.	Improve access to and sustainable use of common property fishery resources.		• Develop decentralized energy production systems integrating the application of renewable energy, especially solar energy. • Promote appropriate technology transfer for low-carbon development (e.g. improving energy efficiency, renewable energy).	Focus on ensuring harmony between economic and environmental development; environmental protection; green investments (and creating green jobs); green technologies; economic reforms taking into account green incentives (especially green taxes, green finance, green credit and green micro- and macro-finances); Blue Economy Development with Sustainability.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
		Cambodia Climate Change Strategic Plan 2014-2023	*Cambodia Agricultural Sector Strategic Development Plan 2014-2018*			*Cambodia Agricultural Sector Strategic Development Plan 2014-2018*
		NCCC	MAFF			MAFF
		• Agricultural diversification (e.g. crops, livestock). • Increase in productivity (e.g. crops, fisheries, livestock, forestry).	• Increase quantity of each endangered species to 15% in 2018. • Increase quantitative fisheries biology in the replanted flooded forest/mangrove areas to 15% in 2018.			
		Strategy for Agriculture and Water 2010-2013				*NBSAP 2015-2016*
		MOWRAM				MOE
		• Diversify agricultural production through extension and training. • Focuses on village-level institutional development and capacity building, through farmers' groups and farmer cooperatives; they will receive technical and input support, including credits for intensification and diversification of agriculture; land and soil management, post-harvest practices; processing and marketing. • Aims to improve the productivity of lowland and upland rice soils, strengthen smallholder land tenure security and productivity and the management of state land. • Improving the				Program 4: Sustainable Forestry & Wildlife Resource Management: • Seeks a "balance between development and conservation", in particular increase the contribution of natural resources to the development of agriculture sector by ensuring: (1) green cover, forest and wildlife conservation; and (2) the sustainability of the ecosystem. • Reforest at least 20,000 ha/yr; establish 32 community forests/yr. • Increase protected areas and wildlife conservation areas to 1.75 m ha by 2018.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
		management of social and economic land concessions (SLCs and ELCs) within a dual-track approach to land use and land tenure that uses a systematic land titling program for smallholder farmers. • SLCs for resource-poor smallholders focus on rice-growing areas in the Mekong and Tonle Sap river basins. Seen as a way of enabling landless farmers to gain access to land for residential and subsistence farming.				
		Policy Paper on the Promotion of Paddy Production and Rice Export 2010				*Cambodia Climate Change Strategic Plan 2014-2023*
		Owner?				NCCC
		• Envisages the export of 1 m tons of milled rice by 2015, which would require an overall rice surplus of 4 m tons. • Increase paddy rice productivity by using high-yield seed varieties and modern farming techniques.				• Ensure climate resilience of critical ecosystems (Tonle Sap Lake, Mekong River, coastal ecosystems, highlands, etc.), biodiversity, protected areas and cultural heritage sites. • Watershed and ecosystem management. • Integrate climate change into EIA processes.
LAOS						
8th 5 Year National Socio-Economic Development Plan 2016-2020	*8th 5 Year National Socio-Economic Development Plan 2016-2020*	*8th 5 Year National Socio-Economic Development Plan 2016-2020*	*8th 5 Year National Socio-Economic Development Plan 2016-2020*	*8th 5 Year National Socio-Economic Development Plan 2016-2020*	*8th 5 Year National Socio-Economic Development Plan 2016-2020*	*8th 5 Year National Socio-Economic Development Plan 2016-2020*
MPI	MPI	MPI	MPI	MPI	MPI	MPI
National level • Country is developed out of LDC status by 2020	• Manage water resources based on IWRM	• Inclusive approach focused on supporting smallholder	• Produce 229,500 tons of fish and aquatic animals/yr. • Increase fishery	• Improve mineral production so that raw ores are	• Focus on hydropower development, thermal electric	• Strive to complete the development of the national master plan on

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
through continuous, inclusive and sustainable growth. • Effective management and efficient utilization of natural resources. • Poverty rate 10% by 2020. • GNI per capita higher than $1,574 by 2018 and at or higher than $1,810 by 2021. • Real GDP growth not less than 7.5%/yr on average. Southern Region: • By 2020, GDP growth rate is targeted at no less than 12.13%.	principles in 10 priority river basins, including the Sekong.	farmers to diversify and improve production within integrated farming systems. • Promote clean and organic agriculture. • Expand modern and highly effective agricultural production, and apply advanced science and technology into primary production • Concentrate on improving and upgrading irrigation to permanent and robust systems with effective management • Focus on food security and commercial products from agriculture. • Availability of food for the people is sufficient with essential nutrients; each person will have daily energy intake of 2,600-2,700 kcal • Agriculture growth 3.2%, 19% of GDP. • Rice: achieve 2.5 m tons by 2020 on an area of 600,000 ha, of which 2.1 m tons is for domestic consumption and 400,000 tons for reserves. • Produce rice for export of 1-1.5 m tons and 500,000-600,000 tons for the processing industry/yr. • Extend irrigated water supply from the 315,374 ha	and aquatic animal breeding by 8-10%/yr. Southern Region: • Prioritize fish farming.	processed, and value added before export. • Mining areas. upgraded for regular excavation avoiding socio-environmental impact. Southern Region: • Develop the mineral processing industry.	power, solar energy and industrial plants energy to turn the power sector into a sustainable income-generating sector to support production and to solve the people's poverty. • Complete 15 hydroelectricity power dams. • Expand electricity coverage to rural remote and hard-to-access areas, leading to at least 90% of the total number of families in the country having access to electricity by 2020. • Develop projects to export energy to foreign countries. • In the next 5 years, strive for project development agreement (PDA) and concession agreement (CA) contracts to start the construction of 24 projects, expand the electricity sector by an average of 32%/yr. • Reduce the negative balance of electricity export and import by limiting electricity imports to no	land use and complete the comprehensive land allocation in 18 provinces, 92 districts and 3,455 villages across the country. • Develop tourist areas for clean, beautiful and environmentally friendly services. • Complete the reforestation to achieve forest cover over 70% of the total country area, by restoring natural forests on 1.5 million ha and planting trees on 35,000 ha of protected and conservation forests. • Formulate and implement the wetlands management plan to strictly and effectively adopt the Ramsar Convention on Wetlands. • Develop a comprehensive environmental management plan at provincial and district levels. Strive to achieve at least 50% of provinces having implemented an integrated spatial plan. • Monitor and control pollution in the 10 priority basins, including Sekong. Southern Region: • Intertwine forest exploitation and forest conservation by replanting trees in the exploited forest areas.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
		currently covered to 476,012 ha by 2020, yielding 4-5 tons rice/ha. • Produce 258,000 tons/yr of meat and eggs. • Increase livestock by 6%/yr. • Continue surveys and allocate at least 600,000 ha to forestry. <u>Southern Region</u>: • By 2020, agriculture sector growing ay 7.8% accounting for 29.5% of GDP. • Promote and expand production areas for coffee, cashew nuts, organic vegetables, tea, pepper and fruit tree plantations in Champasak, Saravane and Sekong. • Prioritize the plains of Champasak and Attapeu for rice production for domestic consumption to reduce imports. In the next five years, strive to increase the rice farming area to 1,308,772 ha, yielding total production of 6,080,590 tons of rice. • Promote commercial-industrial tree plantation in the provinces with potential and opportunities, such as promoting rubber tree plantation and industrial tree plantation in Attapeu to produce paper for export.			more than 20% of the country's usage by 2020. • Construct small hydropower plants in areas where it is possible, and solar power or diesel power in remote areas where hydropower is not possible. <u>Southern Region</u>: • Develop electricity generation industry. • Build a wind power factory in Dakjeung, Sekong.	

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
	Water Resources Law 1996	*Agriculture Development Strategy to the year 2025 and Vision to 2030*		*Mining moratorium 2012/2016*		*National Environment Strategy to the Year 2020*
	National Assembly	MAF		MEE		MONRE
	• Use of water in the production of electrical power and irrigation shall be specifically regulated. • Water and water resources use must be thrifty and there must be measures to diminish undesirable effects upon the environment and natural beauty. • Exploitation use, control, protection, and development of water and water resources between countries must be conducted in compliance with signed treaties and conventions, e.g.: use and preservation of water and water resources between Laos and neighboring countries must be carried out based upon fairness, reasonableness, equality, recognition of independence sovereignty and autonomy.	• Ensuring food security, producing comparative and competitive potential agricultural commodities, developing clean, safe and sustainable agriculture and shift gradually to the modernization of a resilient and productive agriculture economy, linking with rural development contributing to the national economic basis. • By 2020, GDP of agriculture and forestry sector would grow at the average rate of 3.4%, contributing to the National Economic Structure at 19%. • Ensuring nutrition that people would receive minimum energy of 2,600 Kcal/person/day; these include rice and starch covering approximately 62%; meat, eggs and fish 10%; vegetables, fruits and beans 6% and fat, sugar and milk 22%. • The sector shall produce total paddy rice of at least 4.7 m tons, including non-glutinous rice 30%.		• Government implemented a nationwide 4-year moratorium on new mining projects in 2012; moratorium was extended in 2016.		• Implement policies to ensure valuable environmental resources are conserved. • Protect the rich and valuable forest resources to ensure sustainability of agricultural and forestry development. • Manage water resources to ensure multi-purpose and sustainable use and equal access for the general population; and to provide resources for the development of other sectors. • Develop and promote the use of land to ensure rich biodiversity to facilitate production for domestic, market and export use. • Develop and promote environmental and social assessment in agricultural, industrial, mining, infrastructure and urban development projects. • Protect and restore natural, historical and cultural heritage, sound and ethical traditional practices of the ethnic communities to promote the development of tourism.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
		• Commercial production such as (paddy) rice for both domestic supply and export shall be at least 1 m tons, maize for animal feeds 1.3 m tons, coffee 120,000 tons, sugar canes as inputs for factories 2.15 m tons, cassava 1.5 m tons, beans 50,000 tons. • Produce meat, fish and eggs up to 487,500 tons, which includes meat and eggs 262,500 tons, fish and aquatic animals 225,000 tons/yr, at which the animal growth rate approximately 6% per year, fish and animal breeding at 8-10%/yr.				
	Lao National Water Resources Strategy and Action Plan 2016-2020					*National Pollution Control Strategy and Action Plan 2018-2025 with Vision to 2030*
	MONRE					MONRE
	• Expand IWRM into 10 priority river basins, including Sekong. • Water quality monitoring: 158 points nationally. • Conduct groundwater assessment and develop action plan by 2020.					Provide overall guidance to ensure pollution prevention and control for sustainable development in Laos. <u>Targets until 2025</u>: • Prevent, control and reduce unavoidable pollution generated from hazardous substances and timely reduce the impact to be under Environmental Quality Standards and/or National Pollution Control

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
						Standard. <u>Major targets to 2030</u>: • Halt environmental pollution, remedy degraded areas and improve the environment quality and ensure sustainable development of the country be achieved;
VIETNAM						
		Master plan for agricultural development to 2020 with visions to 2030	*Decision 1445/QD-TTg August 16, 2013, approving the master plan on fisheries development through 2020 with a vision to 2030*	*Directive 02/CT-TTg on enhancing the state management for exploration, mining, processing, use and export of minerals*	*National master plan for power development in the 2011-2020 period, with considerations to 2030 (Decision 1208/QĐ-TTg July 21, 2011)*	*National Strategy on Environment Protection to 2020 with vision to 2030 (Decision 1261/QĐ-TTg September 5, 2012)*
		MARD	MARD	MONRE	MPI	MONRE
		• By 2020, 9.59 m ha of agricultural production land, reduced by 580,000 ha compared to 2010. • Allocate 6.05 m ha for annual crops, including 3.812 ha for rice cultivation and 300,000 ha for animal feed crops; and 3.54 m ha for perennial trees. • Forest land in 2020 will be 16.2-16.5 m ha, up by 879,000 ha compared to 2010, including 8.132 m ha of production forests, 5.842 m ha of protection forests and 2.271 m ha of special-use forests. • By 2020, stabilize coffee plantation area at 500,000 ha nationwide. Central Highlands continues to be the main area	To be industrialized by 2020, modernized in 2030 and continues to develop comprehensively, sustainably and effectively. <u>By 2020</u>: • Total fisheries output is about 7 m tons. • Export value of fisheries reaches $11 b; average growth rate hits 7-8%/yr in 2011-2020. • Proportion of export value added products reaches 50%. • About 50% of fisheries workers will be trained. • Income per capita of employees will be 3-fold times higher than that at present. • Reducing post-harvest losses of fisheries products from over 20% at present to under 10%. <u>By 2030</u>:	• Exploration and mining of minerals must take into account short- and long-term needs of the country to achieve socio-economic efficiency and to ensure national security, environmental protection, and protection of landscape, historical monuments, culture. • Bauxite ore: to implement Tan Rai and Nhan Co mines to serve materials for 2 projects producing alumina in Lam Dong and Dak Nong. The implementation of other	• Prioritize the development of hydropower resources, especially the projects of multi-purposes such as flood control, water supply and electricity production: Raising output to 17,400 MW by 2020. • Development of thermal power plants using natural gas: by 2020, the natural gas-fired electricity output will reach about 10,400 MW, generating 66 b kWh, accounting for 20% of electricity production. • Make the most use of domestic coal resources for the development	• To reduce sources of environment pollution; • To improve the environment in polluted and deteriorated areas; to better living conditions of people. • Mitigate deterioration and exhaustion of natural resources; to restrain the degradation of biodiversity. • Improve the capability of actively responding to climate change and reduce the increase of greenhouse gas emissions. <u>Specific targets</u>: • New production and business establishments meeting environment protection requirements: 75% in 2015, 100% in 2020. • Environment polluting establishments: down 20%

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
		for coffee production with a total coffee plantation area of 447,000 ha (89.4% of nationwide area). The average productivity is to reach 2.7 ton/ha. By 2030, the targets are 479,000 ha and 433,000 ha for nationwide and Central Highlands respectively. • Stabilize rubber plantation area at 800,000 ha nationwide while increase production capacity to 1.3 m tons/yr by 2020. • To stabilize the cassava acreage at 450,000 ha by 2020 with an output of about 11 m tons for use as raw materials of animal feed and biofuels; to use land with a slope of less than 15° and a thick layer of over 35 cm.	• Total fisheries output reaches about 9 m tons. • Export value of fisheries reaches about \$20 b; average growth rate hits 6-7%/yr in a period of 2020-2030. • Proportion of export value added products reaches 60%. • About 80% of fisheries workers will be trained. • Maintain fishing output at 2.4 m tons by 2020, including 2.2 m tons from marine fishing and 0.2 m tons from inland fishing. • Output structure by species: 2 m tons of fishes (83.3% of the total output, including 15,000-17,000 tons of ocean tunas); 200,000 tons of squids (8.3%); 50,000 tons of shrimp (2.1%), and 150,000 tons of other marine species (6.3%). • Aquaculture: about 1.2 m ha will be put under aquaculture by 2020 of which: 25,660 ha in the Central Highlands; and 805,460 ha in the Mekong Delta. • According to farming methods: 190,000 ha under industrial-scale aquaculture of major species, including 80,000 ha for giant tiger prawns, 60,000 ha for white-legged shrimp,	projects to exploit bauxite and alumina are taken after the above two are evaluated on socio-economic efficiency. No new licenses for the exploration of bauxite ore in the northern provinces.	of thermal power plants: by 2020, the total coal-fired thermo-electricity capacity will approximate 36,000 MW, generating some 156 b kWh (46.8% of electricity production) and consuming 67.3 m tons of coal; By 2030, reach about 75,000 MW, generating some 394 b kWh (56.4% of electricity production) and consuming 171 m tons of coal. • Prioritize development of power sources from renewable energy (wind energy, solar energy, biomass energy), gradually increasing the proportion of electricity produced from renewable energy sources: from 3.5% of total electricity output in 2010 to 4.5% by 2020 and 6% by 2030.	compared to 2010 by 2015, 50% by 2020. • Industrial parks meeting environment protection requirements: 70% by 2015, 95% by 2020. • Communes meeting environment and hygiene standards: 20% by 2015, 50% by 2020. • Urban areas (grade IV or higher) having standard concentrated sewage treatment system: 30% by 2015, 70% by 2020. • Industrial parks and complexes, EPZs having standard concentrated sewage treatment system: 75% by 2015. 95% by 2020. • Urban solid wastes collected: 90% by 2015, 95% by 2020. • Rural solid wastes collected: 60% by 2015. 75% by 2020. • Water surface area of recovered ponds, lakes, canals, channels, and rivers in urban and residential areas: up 30% compared to 2010 by 2015, 70% by 2020. • Urban population supplied with clean water: 95% by 2015, 100% by 2020. • Rural population supplied with clean water: 85% by 2015. 95% by 2020.

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
			10,000 ha for pangasius, and 40,000 ha for mollusks. • Aquaculture output: To reach 4.5 m tons by 2020, including 42,400 tons from the Central Highlands; and 2,976,420 tons from the Mekong Delta.			• Public green area in urban and residential zones: up 15% compared to 2010 by 2015, 30% by 2020 (1-4 sq m/person by 2010). • Area of agricultural lands lost due to use purpose conversion, degradation, impoverishment, and desertification: down 20% compared to 2010 by 2015, 30% by 2020.
		Resolution 63/NQ-CP on national food security		*Decision 2427IQD-TTg of December 22, 2011, approving the mineral strategy through 2020, with a vision toward 2030*	*Approval of adjustment the national electricity development planning in the 2011-2020 period, with a vision to 2030 (Decision 428/QĐ-TTg March 18, 2016)*	*Development planning of Central Highlands to 2030*
		MARD		*Owner?*	MPI	MOC
		• By 2020, to protect the rice land fund of 3.8 m ha for an output of 41-43 m tons of paddy to meet the total domestic consumption and export demand of around 4 m tons of rice/yr. • Increase the maize acreage to 1.3 m ha for an output of 7.5 million tons, the fruit tree acreage to 1 .2 ha for an output of 12 m tons; the vegetables acreage to 1 .2 m ha for an output of 20 m tons. • Increase the subsidiary food crop output over 30%, the outputs of domestic animals in live weight to 8 m		• Clearly evaluate mineral resource potential for exploitation and national reserve. • Conduct exploration to meet exploitation and processing demands up to 2050 with regard to coal, uranium, titanium-zircon, rare earth, apatite, iron, lead-zinc, copper, tin, manganese, chromite, bauxite, crystal sand and some other minerals. • Mineral exploitation must be	• Gradually increase the weight of electricity generated from renewable sources • Prioritize hydropower: total production f to increase from 17,000 MW to 21,600 MW (29.5%) by 2020, 24,600 MW (20.5%) by 2025 and 27,800 MW (15.5%) by 2030. • Increase wind power from 140 MW to 800 MW (0.8%) by 2020, 2,000 MW (1%) by 2025, and 6,000 MW (2.1%) by 2030. • Increase	• Preserve current forest area, replant forest that have industrial material value to increase coverage to 61%. • Have centralized wastewater treatment plant for big cities. • Industrial parks and economic zones have their own wastewater disposal and treatment system. • Wastewater in towns and rural communities are treated through septic tanks. • 1 regional solid waste treatment complex in Buon Ma Thuot (150-200 ha) and 24

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
		tons, fresh milk to 1 m tons, poultry eggs to 14 b, fishing output to 2.4 m tons and aquaculture output to 4 m tons. • By 2020, to improve the nutrition conditions towards nutrition balance, raising the average daily calorie consumption to 2,600-2,700 kilocalorie/person and reducing the malnutrition rate among <5 children to below 5%.		linked with processing to create high-value products. • By 2020, abolish all scattered mineral processing establishments with polluting and inefficient obsolete technologies and form industrial parks for centralized mineral processing with advanced technologies on a scale corresponding to the potential of each mineral. • Export only high-value products processed from minerals of large deposits. Other minerals will be tapped and processed according to domestic demand for higher national mineral reserve to serve sustainable socio-economic development.	solar power to 850 MW (0.5%) by 2020, 4,000 MW (1.6%) by 2025, and 12,000 MW (3.3%) by 2030.	provincial solid waste treatment complexes (total area 1,120 ha). • Towns and rural communities have their solid waste buried in landfill. • Enhancing protection and development of forests, in particular national parks and nature reserves (Chu Mom Ray, Kon Cha Rang, Kon Ka Kinh, Yok Don, Chu Yang Sin, Ta Dung, Cat Tien, Bidoup-Nui Ba, etc.). • Prioritize building wastewater treatment system, solid waste collection and treatment system in urban areas, industrial facilities. • Hydropower projects on Sesan, Srepok, and Dong Nai minimize impacts on environment, ecosystems and biodiversity.
NCSS	*NCSS*	*NCSS*			*NCSS*	*NCSS*
MONRE	MONRE	MONRE			MONRE	MONRE
Guarantee food security, energy security, water security, poverty reduction, gender equality, social security, public health, and better livelihood as well as protect natural resources in the context of climate change	• Build a database of change and use of water resource in relation to climate change, and enhance qualitative and quantitative surveys, researches, evaluations, forecasts and observations in exploiting and using water resource.	• Maintain a proper and sustainable land fund for agricultural activities in all localities. • Survey and change the cultivation and husbandry structure in line with conditions of climate change and sea level rise.			• Review, plan and develop hydroelectric projects properly for various purposes, so that the total output capacity of hydroelectric plants can reach 20,000-22,000 MW by 2020. • Guarantee national energy security through	• Speed up the schedule of afforestation and re-afforestation projects, encourage enterprises to invest in planting economic forests. • Up to 2020, it is necessary to establish, manage, protect, develop and use 16.24 m ha of land planned for forestry

National Development	Water	Food/Land			Energy	Ecosystems
		Agriculture	Fisheries	Mining		
	• Enhance international cooperation in researching, evaluating, and managing quality and volume of water resource as well as sharing transboundary water profits. • Design the master planning scheme of water resource in big territorial areas and river basins, including the Sesan-Srepok. • Set up and finalize standards and regulations for effective and multi-purposed exploitation and use of water resource in conformity with climate change and sea level rise. • Improve, upgrade, repair and build irrigation works, hydropower plants, and systems of river dike and breakwaters which can effectively cope with floods, droughts, seal level rising, and salt contamination in the context of climate change.				synchronously developing different sources of energy; raise the % of new energies and recycled ones to 5% of the totality of primary commercial energies by 2020 and 11% by 2050.	activities in a sustainable way; raise the forest coverage to 45%; sustainably and effectively manage 8.132 m ha of production forests, 5.842 m ha of preventive forests and 2.271 m ha of special-use forests. • Preserve biodiversity, protect and develop ecosystems and species which can well resist climatic changes; to protect and preserve genes and species endangered by impacts of climate change. • To craft programs to reduce greenhouse gas emission through efforts of minimizing forest loss and deterioration, managing forest in a sustainable way, preserving and improving forests' absorption of carbon, and maintaining and diversifying local people's livelihood as well as helping them to adapt to climate change.

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