Strategic priorities for trans-boundary water cooperation in the Sekong, Sesan and Sre Pok (3S) Basins

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Contents

List of abbreviations

3S	Sekong, Sesan and Sre Pok (River Basins)
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BDS	Basin Development Strategy
BRIDGE	Building River Dialogue and Governance
CRA	Cooperative Regional Assessment
GMS	Greater Mekong Sub-region
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
LMB	Lower Mekong Basin
MONRE	Ministry of Natural Resources and Environment
MOWRAM	Ministry of Water Resources and Meteorology
WB	World Bank
NGO	Non-Government Organization
NIPs	National Indicative Plans
NMCs	National Mekong Committees
NPV	Net Present Value
RBO	River Basin Organization
TIGC	Technical Inter-Governmental Commission

1. Executive summary

Purpose. This paper evaluates the needs and opportunities for trans-boundary water cooperation in the 3S Basins based on existing documents and databases. Most of the trans-boundary projects and studies in the 3S Basins have focused on visioning and stakeholder engagement approaches to promote trans-boundary water cooperation. This paper deliberately takes a more technical approach and argues that the implementation of a regional 'technical' cooperative assessment is long overdue (see below).

Setting. The 3S Basins comprise the trans-boundary Sekong, Sesan and Sre Pok River Basins, which drain to the Mekong River in Stung Treng Province in Cambodia. Cambodia lies downstream of Lao PDR and Viet Nam in the Sekong River Basin, and downstream of the Viet Nam Central Highlands in the Sesan and Sre Pok River Basins. The total area of the three basins is 78,650 km^2 corresponding to about 10% of the area of the entire Mekong Basin. The total population in the 3S Basins is about 3.5 million, of which about 3 million people inhabit the Central Highlands and about 250,000 people inhabit each of the Lao and Cambodian parts. Many Lao and Cambodian people still live close to the river system and remain dependent on natural resources.

Basin development. Large-scale water resources development in the 3S Basins started in the 1990s in the rapidly developing Central Highlands with the development of cascading hydropower plants and irrigated agriculture. Currently, Viet Nam has largely completed its water related development plans in the Central Highlands. More recently, large scale water resources development commenced in the less developed Laotian and Cambodian portions of the 3S Basins. Both countries have ambitious hydropower development plans and relatively modest irrigation plans in their portions of the Basins.

Impact of development. Planned water resources development in Lao PDR and Cambodia will create large economic benefits but also large environmental impacts on capture fisheries, aquatic ecology and sediment transport, which may also affect the Mekong mainstream. Dry season water flows may not change much or even increase in the Sekong River Basin due to the interplay between hydropower and irrigation developments. Trans-boundary impacts may be limited as most of the adverse impacts from nationally planned development will be felt nationally. Flooding is an increasing problem in the 3S Basins mostly due to watershed deterioration.

Water resources management. All three countries have developed clear statements relating to national water-related policy and strategy. Improving institutional and regulatory frameworks increasingly support these policies and remove uncertainties as to which agency plays the role of 'water resources manager' (i.e. MOWRAM in Cambodia and MONRE in Viet Nam and Lao PDR). River Basin Organizations (RBOs) have been established to support the implementation of integrated approaches to address water allocation and other water management issues in the Viet Nam Central Highlands. The establishment of RBOs in the Cambodian and Lao portions of the 3S Basins is premature. But there is a need to strengthen the role of national water management agencies and

their provincial departments to steer an integrated multi-sectoral planning and management process to balance a range of desired outcomes and prevent, minimize and mitigate environmental and socio-economic impacts.

Trans-boundary cooperation. Trans-boundary cooperation saw an upsurge in 1996 when Cambodian people living along the lower Sesan River began to experience unusual flood events that were attributed to releases from the Yali hydropower project in Viet Nam. In response, the predecessor of the Sesan Protection Network initiated investigations in the affected areas. The Mekong River Commission (MRC) facilitated the establishment of the Cambodia-Viet Nam Joint Committee for the Management of the Sesan River, which agreed on the establishment of a system for advance warning of unusual water releases. The committee was dissolved in 2004. Currently, mitigation measures, such as re-regulation reservoirs, are common practice in the 3S Basins to reduce trans-boundary impacts from hydropower plants.

In 2005, the National Mekong Committees of Cambodia and Viet Nam signed a Memorandum of Understanding to set up mechanisms for coordination with national agencies that plan or implement water related activities in their common border areas in order to maximize mutual benefits and minimize possible negative impacts on each other. In 2011, the MRC Mekong Integrated Water Resource Management (IWRM) Project was launched and the initiative included interlinked regional, trans-boundary and national components. There are also plans to improve the hydro-meteorological and data management systems in the Cambodian and Viet Nam border areas of the 3S Basins.

Strategic Priorities

Strengthening water resources management at the national level. The development of sustainable benefits from the 3S Rivers requires first and foremost the strengthening of water resources planning and management at the national level. At this level, the national agencies responsible for water resources management (and their provincial departments) play their most challenging role by coordinating and steering an integrated multi-sector planning and management process. Long-established sector agencies can continue to do most of the on-the-ground planning but in a way that maintains the most acceptable balance between development and protection. RBOs might be needed at the national level in critical river basins where serious water management problems exist or are predicted, such as in the Central Highlands in Viet Nam.

Increasing trans-boundary cooperation. The strengthening of national water resources management will go a long way to realizing higher economic benefits and lower environmental impacts in the 3S Basins. Nevertheless, there are still a few pertinent areas where trans-boundary cooperation is needed. They include the following:

Water resources monitoring and the exchange of data. Trans-boundary cooperation on water resources monitoring and the sharing of data between the three countries is needed for development planning, flood forecasting, hydropower operations, and for water resources management in the basins. The cooperation could build on the initiated improvement of the hydro-meteorological systems in the 3S Basins under the Mekong IWRM Project.

- **Flood forecasting and early warning.** Although clearly a trans-boundary issue, flood forecasting and early warning in each of the three river basins are mainly dealt with at the national level. The cooperation could build on the established system for advance warning of unusual water releases from reservoirs and natural flood situations in the Sesan and Sre Pok River Basins, with support from the Mekong IWRM Project and MRC's regional Flood Management and Mitigation Centre.

- **Coordination among cascading hydropower plants.** In the absence of joint planning and design, there is a need for coordination on the design of the planned hydropower cascades, as well as for information sharing to assist in their smooth operation. The required communication system, probably in the form of a website, is particularly necessary during flood conditions or in the event of equipment or structural failure that could result in extraordinary flow releases.

- **Cooperative Regional Assessment (CRA)**. Joint assessment by the three countries regarding the impacts of existing and planned development, and the identification of opportunities for achieving greater benefits through cooperation is long overdue in the 3S Basins. The proposed assessment process can be used to build further trust and confidence among the countries and set the stage for discussing trade-offs and consider joint projects that provide incremental benefits that can be shared. Joint projects could significantly reduce environmental impacts in the Cambodian portion of the 3S Basins.

Implementation modalities. The above cooperative actions could be initiated by the National Mekong Committees (NMCs) of the 3S Basins countries. The responsible national agencies would implement the actions. Relevant MRC Programmes could provide technical support and coordinate trans-boundary working groups with representatives of the relevant provinces and national agencies involved.

2. Introduction

Water resources development and management in the Mekong Basin (Figure 1) is being shaped by rapid socio-economic change across the region as the riparian countries move towards middle and high-income status. The countries each have development plans which are focused on leveraging the comparative advantage each possesses in terms of their natural resources, human capital and access to the Mekong River's abundant water resources. However, according to the Basin Development Strategy (BDS) of the Mekong River Commission (MRC, 2015), the Member Countries' national plans for water resources development and management are sub-optimal at the basin level.

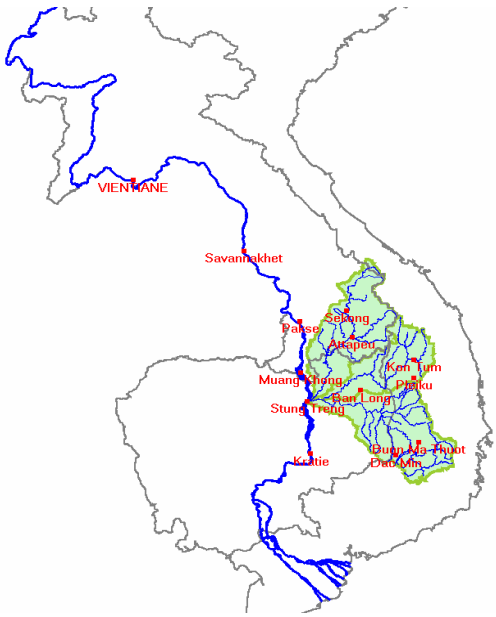
A major thrust of the BDS for 2016-2020 is to move to more optimal and sustainable development through increased levels of regional and trans-boundary cooperation and benefit sharing. This could lead to higher overall basin benefits, lower adverse trans-boundary impacts, and greater interdependent development and regional integration.

This report focuses on trans-boundary water cooperation in the Sesan, Sre Pok and Sekong tributary basins of the Mekong mainstream which cover parts of Cambodia, Lao PDR and Viet Nam (Figure 2). Together the three sub-basins are referred to as the 3S Basins. The Sesan, Sre Pok and Sekong basins are the only large trans-boundary tributaries in the Mekong Basin. Since 2000, the three basins have received substantial international assistance supporting both water resources development and management. This has resulted in increased information on the water related benefits, impacts, risks and challenges in the basins.

This report reviews this information in order to (1) evaluate the needs and opportunities for trans-boundary water cooperation and (2) identify and prioritize cooperative actions for discussion and promotion.

Figure 2. The Lower Mekong Basin.

Figure 1. The Sekong, Sesan and Sre Pok (3S) Basin, not to scale (modified from ADB 2010).



3. The Mekong Spirit of Cooperation

The Mekong Spirit was mentioned in the 1975 Joint Declaration of Principles of the Mekong Committee[1]:

> *NOTING with pride the unique spirit of cooperation and of mutual assistance which has constantly inspired the Committee's work, and which has made it possible for a great number of friendly governments and organizations to contribute substantially to these achievements ....*

In its preamble, the 1995 Mekong Agreement also makes a clear reference to the 'Mekong Spirit' as a cornerstone of the intended collaboration:

> *NOTING the unique spirit of cooperation and mutual assistance that inspired the work of the Committee for the Coordination of Investigations of the Lower Mekong Basin and the many accomplishments that have been achieved through its efforts ...*

The 'Mekong Spirit' implies an orientation towards consensus, and a clear aversion against any open conflicts. This is sometimes reflected in the language of the Council (MRC's governing body), where 'approved in principle' (or 'additional information is required' are routinely preferred to a statement of 'not approved.' Also, it may be claimed that the 'spirit' includes a reluctance to commit to clear rules and binding commitments, including a considerable vagueness in the delineation of trans-boundary issues.

The 'Mekong Spirit' is regarded as a strength of the MRC to be maintained at all times, but it can be also a weakness when valuable opportunities are lost. It has undoubtedly provided a precondition for successful achievements, such as Member Country agreement to a procedural framework for cooperation, the development of regionally recognized knowledge base and an ongoing participatory process for basin planning. A suggested weakness is the rather discreet emphasis of the value of the MRC and its institutions, with their implicit support to peaceful co-existence in a region that was quite volatile in the not too distant past.

The basin-wide planning process, facilitated by MRC's BDP Programme since 2000, has been a very important project in terms of regional and trans-boundary water cooperation in the Mekong. It has dismantled longstanding barriers to substantive cooperation among Lower Mekong Basin (LMB) countries. It has demonstrated that Member Countries' governments will share their data and plans. It has resulted in governments working together to: identify analytical tools such as scenarios and models; classify results; rank development scenarios; identify development opportunities; and prioritize strategic guidance, special studies and guidelines that they collectively believe will enable the

[1] Joint Declaration of Principles for Utilization of the Waters of the Lower Mekong Basin, adopted by the Committee for Coordination of Investigations of the Lower Mekong Basin at its 68th Session, Vientiane, Laos, 29 January - 3 February 1975.

achievement of high and shared standards in water resources development and the mitigation of impacts. This is a ground-breaking outcome that can be regarded as a necessary (but alone, insufficient) condition for effective cooperation and, particularly, for any joint (or trans-boundary) projects or actions.

The 1995 Mekong Agreement could have been more articulate on the purpose, scope and mechanisms for trans-boundary water cooperation, in particular with respect to trans-boundary tributary basins such the 3S Basins. The three countries in the 3S Basins have long-term experience establishing and maintaining a partnership for peace and development in the region and they successfully increased cooperation in various sectors of their economy, including transport, education, and interconnected power grids. However, the concept of trans-boundary water cooperation is still quite new for the three countries.

With the United Nations (UN) General Assembly resolution 65/154 in year 2013, declared as the International Year of Water Cooperation, the UN General Assembly initiated appropriate steps to promote actions at all levels, including through international cooperation, as appropriate, aimed at the achievement of the internationally agreed water-related goals contained in the Programme for the Further Implementation of Agenda 21 of the United Nations Millennium Declaration and the Johannesburg Plan of Implementation, as well as to increase awareness of their importance. This report supports these international initiatives through: (1) evaluating the level and nature of past, present and possible future trans-boundary water cooperation in the 3S Basins, and (2) identifying strategic priorities for trans-boundary water cooperation in the 3S Basins.

4. Physical and social setting

As mentioned earlier, the Sekong, Sesan and Sre Pok Basins are trans-boundary river basins of the Mekong River Basin. The rivers all rise at altitudes around 2,000 metres (m) in the Central Highlands of Viet Nam. In their middle reaches, the rivers flow at altitudes of 800 – 500 m (in all three countries), before they drop off through waterfalls and rapids to enter the lowlands of Cambodia at an altitude of 250 – 150 m. They merge over a distance of only 40 kilometres (km) upstream of their joint confluence with the Mekong River at Stung Treng province in Cambodia (Figure 3).

Cambodia lies downstream of Lao PDR and Viet Nam on the Sekong River and downstream of Viet Nam on the Sesan and Sre Pok Rivers. Table 1 provides an overview of the catchment sizes and the shares of the three countries in the 3S Basins. The total area of the three basins is 78,650 km^2 corresponding to about 10% of the area of the entire Mekong Basin.

Table 1. The 3S Basins and contribution by countries (COWI, 2006a)

Basin area (km^2)	Cambodia	Lao PDR	Viet Nam	Total
Sekong	5,565	22,565	690	**28,820**
Sesan	7,630	0	11,260	**18,890**
Sre Pok	12,780	0	18,160	**30,940**
Total	**25,975**	**22,565**	**30,110**	**78,650**
Ratio	**33%**	**29%**	**38%**	**100%**

Rainfall varies across the 3S Basins, ranging from about 1,500 millimetres (mm) in the downstream areas and middle reaches of the Sre Pok Basin to more than 2,500 mm in the upstream portions of the Sekong and Sesan Basins. Rainfall is distinctly seasonal with more than 80% of the annual rain falling during the seven months' rainy season from May to November.

The runoff pattern of the three rivers closely follows the rainfall but is slightly buffered by retardation of runoff by the tropical forests in the mountains and recharge and runoff from substantial groundwater aquifers. Recurrent flooding takes place during short periods, particularly the late part of the rainy season, and may be aggravated by intense rainfall and flash floods when tropical cyclones from the South China Sea enter the 3S Basins.

Table 2 provides an overview of average discharges and annual runoffs of the Sesan, Sre Pok and Sekong Rivers. At Stung Treng, where the rivers of the 3S Basins discharge as one joint stream into the Mekong mainstream, the Mekong River has an average annual discharge of 13,000 cubic metres per second (m^3/s). The respective discharge contribution of about 20% to the flow in the Mekong mainstream is very significant (particularly since the three basins make up only 10% Mekong Basin's surface area). Human or climate-driven alterations in the 3S Basins could therefore have a significant effect to the discharge of the Mekong mainstream.

Table 2. Average discharge and annual flow of the Sekong, Sesan, and Sre Pok Rivers (ADB, 2010).

3S Rivers	Average Discharge (m^3/s)	Annual Runoff (million m^3/year)	Contribution to total flow (%)
Sekong River	998	32,000	38
Sesan River	610	19,500	23
Sre Pok River	1014	32,500	39

Land resources and natural vegetation correlate closely with the area's topography. The mountains and foothills occupy about 25% of the basin and are suitable only for watershed protection or commercial forestry. The highly dissected plateaus occupy another 25% and have high potential for a wide range of agricultural production, particularly perennial crops that depend on good drainage. The lowland, which occupies the remaining 50% of the river basins, comprises hills with moderate agricultural potential and river valleys and flood-plains with potential for irrigated agriculture and hydropower development. The area is also rich in biodiversity.

The total population in the 3S Basins is about 3.5 million, of which about 3 million people inhabit Vietnamese territory while about 250,000 people inhabit each of the Lao and Cambodian parts. The 3S Basins in Cambodia and Lao PDR have some of the lowest population densities in the Lower Mekong Basin with 10 people or less per square kilometre (km^2). Many of Lao and Cambodian communities still live close to the river system and remain highly dependent on natural resources from, and ecosystem services of, the rivers. Poverty incidence is high and in Cambodia people are beginning to migrate into the sparsely populated lower parts of the river basins (COWI 2006a).

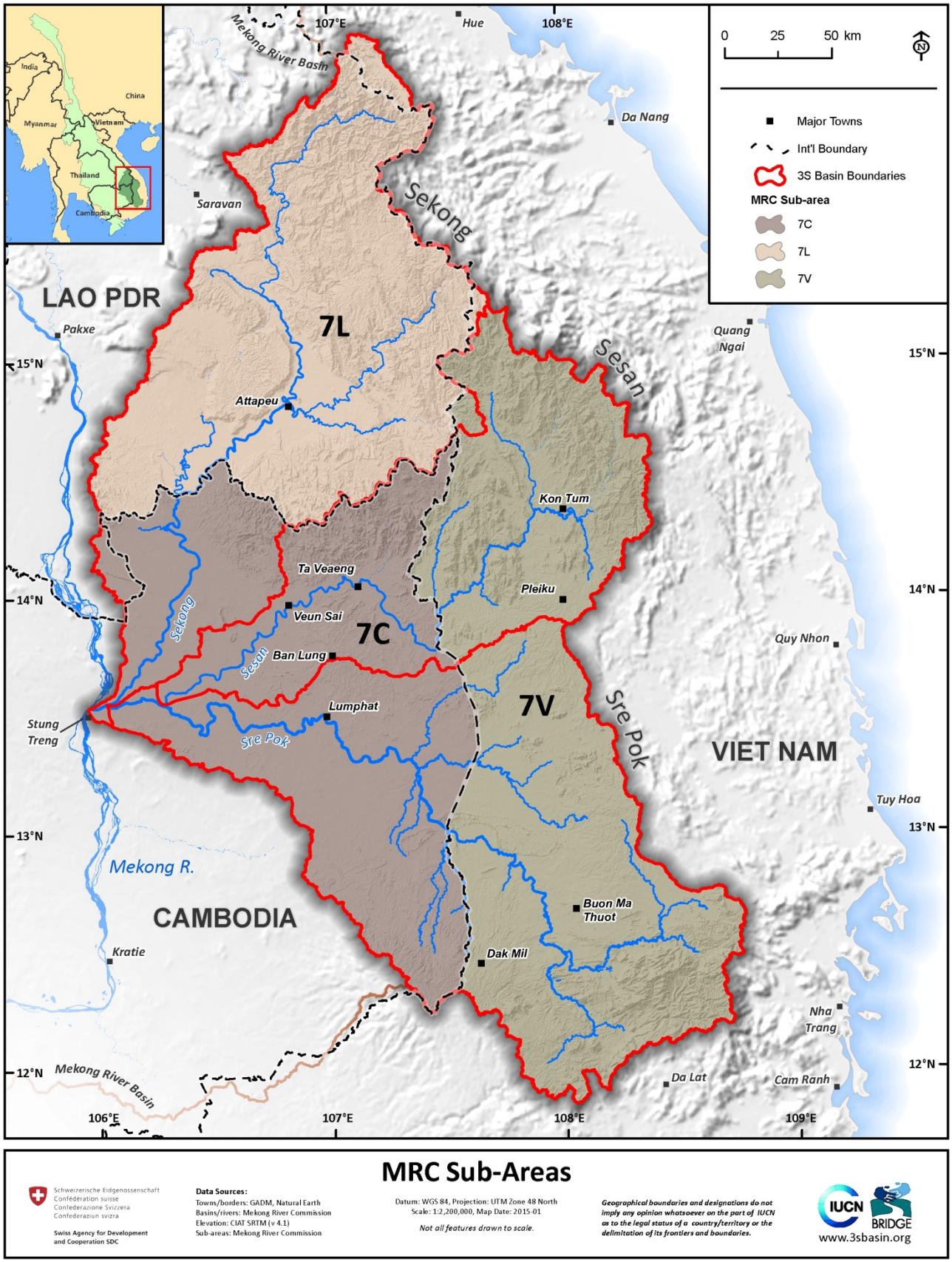


Figure 3. The Sekong, Sesan and Sre Pok Basins shared by Cambodia, Lao PDR and Viet Nam (IUCN).

In contrast, the Vietnamese part of the 3S Basins have been rapidly populated by the immigration of over two million people over the past 20 years, and people continue to migrate into the area from other parts of the country. Though Viet Nam's share of the land is only one third, it now holds about 85% of the total population, at a density of about 80 people per km^2. The development of the basin in Viet Nam has contributed to rapid economic development. Nevertheless, the incidence of poverty remains relatively high compared to other parts of the country.

Ethnic diversity is large throughout the 3S Basins which host about 60 ethnic groups alongside the dominant Khmer, Lao Loum and Kinh populations of Cambodia, Lao PDR and Viet Nam, respectively. The largest number of minority groups and people are found in the Central Highlands of Viet Nam, where the ethnic diversity has increased by immigration of many small minority communities from central and northern Viet Nam, while people who are indigenous to the area dominate the populations in both Cambodia and Lao PDR.

5. Trends in water resources development

Geographically, the development strategy of water and natural resources has been uneven, with the Cambodian and Laotian areas of the 3S Basins lagging behind the Vietnamese areas. Rapid water resources development in the Viet Nam Highlands since the beginning of the 1990s has contributed much to social and economic development in this part of the basins while large scale water resources development commenced only recently in Lao PDR and Cambodia in the Sekong and in Sesan River Basins.

The following summarizes the main sectoral developments that impact the 3S Basins' water and related resources. The information is assembled from various information sources that are listed in the references. It should be noted that a complete and accurate assessment of existing, ongoing and planned development in water and related resources in the 3S Basins is not available at present.

Hydropower development. The hydropower potential of the 3S Basins is high and has attracted attention for more than 50 years, but early development was limited to a few small plants in the highlands of Viet Nam. Hydropower development in the 3S Basins started to accelerate in the 1990s in Viet Nam, was followed in the 2000s in Lao PDR, and more recently on the lower Sesan River in Cambodia. Figure 4 shows the location of the existing, ongoing and planned hydropower projects in the basins. All projects are large scale (> 10 MW) except for the O Chum 2 project in Cambodia.

In general, hydropower locations have been identified and assessed solely for the development of hydropower and offer few opportunities for multi-purpose operations for flood control and irrigation. It is therefore understandable that subsequent hydropower planning to a large extent considers the rivers as hydraulic systems to be operated for maximum hydropower generation with limited consideration of other potential uses and

the “healthy life of rivers.” The situation is amplified by the central and sector-oriented development and management of hydropower projects.

Table 3 provides the trends in hydropower development in terms of the number of existing, ongoing and planned hydropower projects and the total installed capacity and net storage (based on MRC hydropower database). Table 3 and Figure 4 show that there will be in total 20 large hydropower projects in operation in the near future, most of them located in the Central Highlands of Viet Nam. By 2035 the number of projects is expected to reach 49, with most of the 29 new projects located in the Lao and Cambodian portions of the 3S Basins. By the same period, hydropower development would be more or less evenly distributed across the three rivers and countries.

Table 3. Hydropower development in the 3S Basins (MRC hydropower database).

	Cambodia			Viet Nam		Lao PDR	
	Sekong	Sesan	Sre Pok	Sesan	Sre Pok	Sekong	Total
Number of hydropower projects							
Baseline (2000)	0	1	0	0	1	1	3
Definite Future (2020)	0	1	0	7	8	4	20
Foreseeable Future (2035)	1	6	3	7	9	23	49
Installed capacity (MW)							
Baseline (2000)	0	1	0	0	12	150	163
Definite Future (2015)	0	1	0	1,849	787	435	3,072
Foreseeable Future (2035)	190	799	416	1,849	845	2,726	6,825
Net storage (million m^3)							
Baseline (2000)	0	0	0	0	2	527	529
Definite Future (2015)	0	0	0	2,129	624	644	3,397
Foreseeable Future (2035)	134	704	4,041	2,129	1,037	7,272	15,317

Notes:
- The Baseline includes the water infrastructure that was in place in the Mekong Basin in the year 2000 (including hydropower, irrigation, flood protection, and public and industrial water supply).
- The Definite Future includes the water infrastructure within the Baseline plus the infrastructure built within the Mekong Basin since 2000, under construction, or already firmly committed.
- The Foreseeable Future includes all water infrastructures within the Definite Future plus the water resources development plans of the LMB countries.

Nearly all hydropower plants are designed for maximizing energy production[2]. Some hydropower projects have significant inter-seasonal storage to distribute water from the wet to dry season in order to generate more electricity throughout the year. By 2035, active storage as a percentage of annual flow (Table 3) will range from 15% in the Sesan to 25% in the Sekong. This will result in considerable increases in dry season flows in all rivers if the additional water is not used by irrigation. The wet season flows will decrease at the start of the wet season when the reservoirs are being filled.

[2]The majority of the sites already developed or under development does not appear to have great potential for multipurpose use of water, but the potentials have not been thoroughly investigated (COWI 2006a).

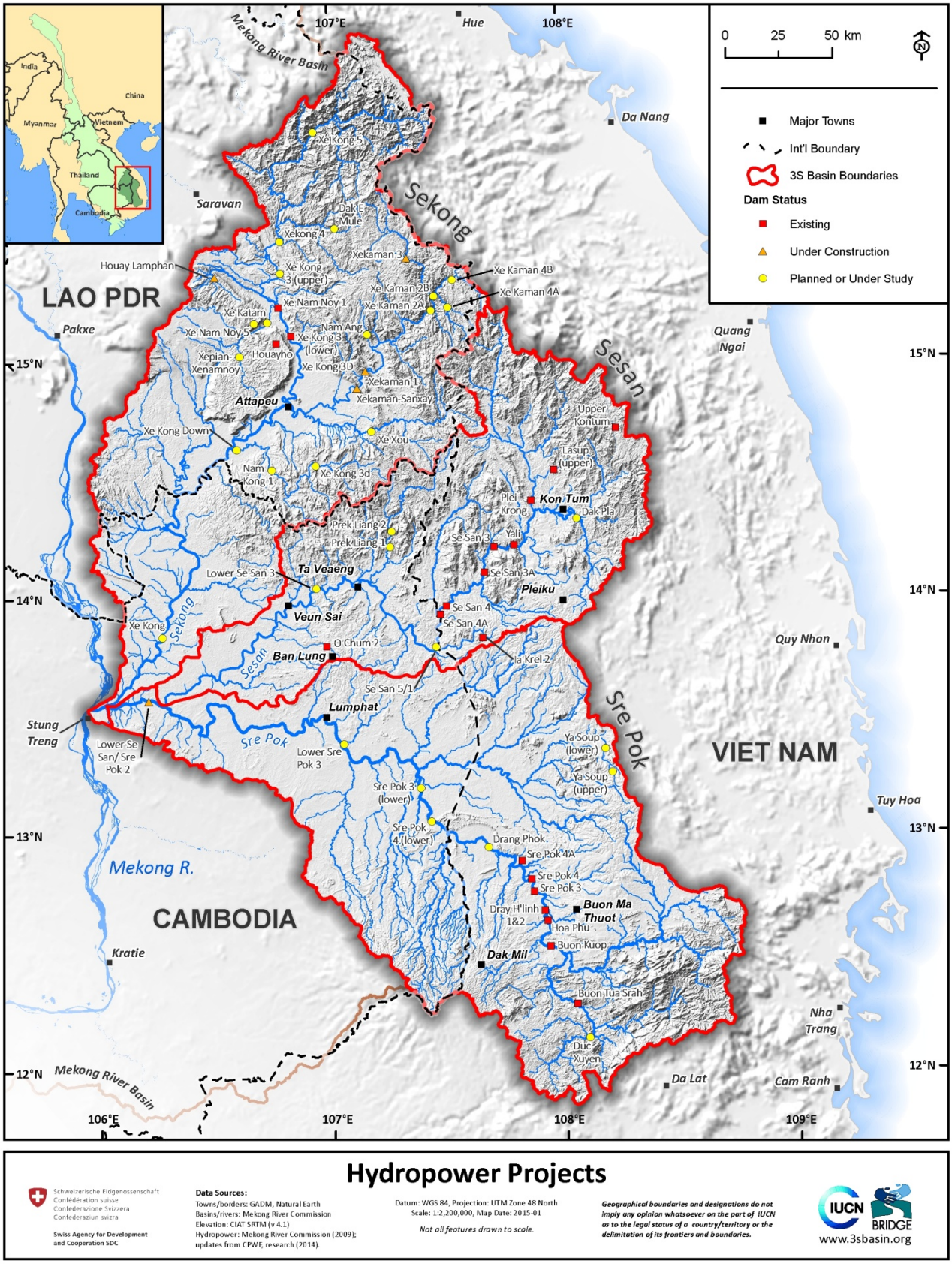


Figure 4. Map of existing, under-construction and planned hydropower projects in the 3S Basin (IUCN).

Irrigation development. The irrigation sector in the 3S Basins is particularly developed in the upper Sre Pok, which covers some 40,190 ha and, to a lesser extent, in the upper Sesan with some 17,591 ha in Viet Nam (ADB 2010 and MRC/BDP 2010). It is marginal in the Sekong Basin in Lao PDR (2,743 ha) and even lower in the Cambodia portion of the 3S Basins (520 ha). The irrigation of commercial upland cultivation of coffee and other perennial crops in the Viet Nam Highlands is considerably larger than the traditional lowland paddy rice cultivation, which is mainly for subsistence. About 30% of the total coffee area is irrigated by pumping from groundwater.

The trends in irrigated agriculture in the 3S Basins are uncertain. The MRC irrigation database, as well as a range of other references, demonstrates gaps and contradicting data. The estimated existing and potential future areas with dry season irrigation are given in Table 4. Planned irrigation projects have been re-classified as potential projects due to the absence of critical data of planned irrigation development. In all three countries, the total dry season irrigated area remains below 10% of the total agricultural land (which amounts to only 10 - 15% of the total area of the 3S Basins).

Table 4. Trends in irrigation development in the dry seasons

Trends in irrigation (ha)	Cambodia (Sekong, Sesan and Sre Pok)	Viet Nam (Sre Pok and Sesan)	Lao PDR (Sekong)
Existing irrigation schemes	500 - 1,000	60,000 - 90,000 (2/3 in Sre Pok)	3,000
Planned/potential schemes	3,000 – 30,000	0 - 200,000 (mainly in the Sre Pok)	11,000

In Viet Nam, further irrigation development is constrained by trade-offs with the hydropower sector. Further dry season irrigation development in the Sesan Basin is limited because potential areas are situated upstream of hydropower projects. There may be opportunities for further irrigation expansion downstream of the hydropower cascade on the Sre Pok Basin up to the border with Cambodia. The opportunities for further irrigation development are enhanced by ongoing programmes to apply and develop modern irrigation technologies including sprinkler and drip systems.

Dry season irrigation in Cambodia could be increased to about 3,000 ha at 82 existing small irrigation schemes (MRC/BDP 2011). A few potential areas in all three river basins have been identified where large scale, commercial irrigated agriculture could be developed, linked to flood protection and possibly to hydropower development. The potential irrigated area may amount to 30,000 ha. In Lao PDR the planned increase in the dry season irrigated area in the Sekong Basin is about 11,000 ha.

Mining. The mineral resources of the 3S Basins in each of the three countries are very rich, but they have not yet been exploited to a great extent (ADB, 2010). These resources include base metals such as lead and copper, light metals such as aluminium, and

precious metals such as gold and silver. There are also gemstones and some coal deposits. Sand and gravel are extracted from the river beds in all three countries. The main opportunities for mineral extraction in the basin are for bauxite (aluminium) mining in all three countries. Some 50 mining exploration concessions have been awarded in the Lao and Cambodian portions of the 3S Basins covering an area of almost one million ha (MRC/BDP, 2011a and MRC/BDP, 2011b).

Public and industrial water supply. Development in the Viet Nam Highlands has been boosted by the large volume of migration to the area. In the expanding urban areas, the migrants have brought diverse skills in small scale industry and commerce, thus contributing to diversification of the economy, and with it more water use. Currently, it is estimated that public and industrial water supply may amount up to 25% of the total water consumption in Sre Pok and Sesan Basins in Viet Nam. In comparison, the Cambodian and Lao portions of the 3S Basins, the urban areas and public and industrial water supplies are still small. Increased hydropower production offers substantial potential for the location of power consuming industries which can exploit the off-peak energy production during day time.

Tourism and eco-tourism. Tourism is still undeveloped in the 3S Basins and the area receives only a small fraction of each country's yearly visitors. However, cultural and eco-tourism are expected to grow steadily in coming years as efforts are made to improve roads, water and sanitation, electrification, accommodations, and park management.

Navigation. The Sekong, Sesan and Sre Pok Rivers have limited potential for commercial navigation due to rapids. This is further reduced by on-going and planned hydropower development. However, until the road infrastructure has been considerably improved in the longer term, water transport will remain a principal means of local travel, especially in Lao PDR and Cambodia. Locating their communities on or near waterways has enabled isolated communities to supplement their livelihoods with fisheries and has provided them limited access to markets.

Flood protection. Flooding is a major problem in the 3S Basins, in particular in the highlands. Flood protection programmes to address flood issues in build-up areas include flood dykes and the construction of reservoirs. The protection of agricultural land in general is not considered to be economically viable. Farmers have already adapted through the choice of crop varieties and supplementary irrigation to enable early harvesting. There will be some future opportunities in all three countries to provide all year round flood protection of large scale agriculture developments. In the near term, flash floods are an increasing problem.

Fisheries. The 3S Basins is still rich in biodiversity and natural resources, including fish and their connection to the Mekong mainstream. A large number of fish species exhibit active migration patterns around the Stung Treng and 3S Basins and they support major fisheries both in the region and throughout the lower basin. Some 329 (42% of all Mekong species in 10% of the area of the basin) have been recorded associated with the 3S system. Fourteen of these are endangered. Eighty six fish species migrate from Tonle

Sap and Cambodian floodplains into the 3S Basins. This highlights the importance of maintaining connectivity throughout the system.

Little information is available on fisheries development in the 3S Basins. Capture fisheries is an important source of protein for the local diet. Both river and pond fisheries are important contributions to household sustenance and economy for rural communities, especially in Cambodia and Lao PDR. Catch from capture fisheries is decreasing due to the development physical barriers, such as hydropower dams (see next section). On the other hand, hydropower and irrigation reservoirs offer opportunities to enhance capture fisheries and develop aquaculture as demonstrated in highlands of Viet Nam. In-stream aquaculture is insignificantly developed, due in part to large variations in flow.

6. Impacts of basin development

This section reviews the impact of past, ongoing and planned water resources development and use in the 3S Basins, based on many of the references provided at the end of this report. It should be noted that a comprehensive assessment of the benefits, impacts and risks and how they are distributed across countries and population groups has not yet been developed for the 3S Basins.

Watershed degradation and flash floods. The 3S Basins have seen considerable deterioration of watersheds due to rapid land use changes, depletion of forest cover and quality during the past 40 years, caused by a combination of war, commercial and illegal logging, mining activities, immigration, hydropower development, and clearing of land for agriculture. In some areas half of the original forest cover has been lost (ADB 2010). This has led to soil erosion on steep slopes and measurable increase in the frequency of flash floods, particularly in the more developed and populated Viet Nam Highlands. There are indications of declining low flows during the dry season due to watershed degradation (ADB 2006).

Continued deforestation is likely to aggravate these trends and may eventually lead to soil erosion on a scale that will constitute a significant risk for rapid siltation of in the increasing number of reservoirs. The only feasible protection against flash floods is restoration of degraded watersheds, which has commenced in the Central Highlands. All three governments now have policies in place to restore watersheds and improve their management and protected area coverage is increasing in all three countries. The improved integration of agriculture and forestry and the development of a stable forest cover are important to support the traditional livelihood of the indigenous population, to develop wood processing industries, and to regulate the runoff and soil erosion from the critical watersheds in the upper parts of all three river basins.

Changes in stream flow. The water flows in the 3S Rivers have been quite predictable with seasonal flows resulting from natural annual rainfall patterns. The natural flow regime has been changing since 2000 as a result of rapid development in the Central Highlands.

In stakeholder workshops in Viet Nam, participants expressed concern about observed decreases in water flows (ADB 2010). In downstream Cambodia, communities living along the Sesan River have suffered from unusual flooding events during construction and subsequent operations (during peaking mode) of the Yali dam (Hirsh and Jensen 2006). This issue has been addressed through trans-boundary cooperation (see below) and the construction of re-regulation by the downstream Sesan 4 and Sesan 4A dams in Viet Nam.

The available assessment of future changes in the flow regime of the 3S Rivers have shortcomings due to the assumptions made or the lack of available data. Studies that focus on climate change and land use changes predict increasing water shortages during the dry season of around 20-40% in the Sre Pok Basin by 2050, mainly as a result of increasing irrigated areas (Kawasaki et al. 2010 and Takamatsu et al. 2012). Conversely, studies that focus on climate change and hydropower development predict major increases of dry season flows in the 3S Rivers with a cumulative increase at the basin outlet at Stung Treng of almost 100% and a reduction of wet season flows by 25% by 2050 (Piman et al. 2013).

Given the interplay between the hydropower and irrigation sectors, and the implementation of demand management measures in Viet Nam, it can be expected the future changes in the seasonal flow regimes will be considerably smaller than the above studies suggest (MRC/BDP 2011). A significant increase in the dry season flows can be expected only in the Sekong Basin as planned irrigation development is small in comparison with the redistribution of water from the wet to the dry season by ongoing and planned hydropower development in this basin. The daily water level fluctuations due to peaking operations will be larger in some parts of the basin if not mitigated by downstream re-regulation.

Changes in water quality. In general, water quality complies with the national standards in all three countries. But there are indications that dry season water quality is deteriorating in the Sesan and Sre Pok Rivers in Viet Nam, mainly as result of waste water discharges (MRC/BDP 2010a). There is no clear evidence of deteriorating water quality in Lao PDR and Cambodia (MRC/BDP 2011b). There is currently little evidence of trans-boundary water quality issues, although concerns were reported in the past. However, all three basin countries expect that water quality will come under pressure due to diffuse pollution from increasing agricultural activities and point source pollution from increasing mining activities and urban sources.

There is still time to further develop water quality management in the 3S Basins. It is important to regulate waste water discharges and the use of agro-chemicals. This requires the (further) development and implementation of a water use license system for the main water abstractions and waste water discharges. The environmental fees generated by such a system could be used to finance the operating costs of water resources management in the 3S Basins, including water resources monitoring, water use licensing, compliance assurance and enforcement, and data and information management. Furthermore, regulation that bans the use of chemical pesticides that could have significant effects on the environment and are not effective against pests can be enacted.

Reduction in capture fisheries. A reduction of annual fish catch is reported in all three river basins. The cause is not scientifically apparent but may be related to loss of riverine connectivity through infrastructure development (dams, roads, drains, canals, barrages etc.), and fishing pressure, illegal fishing methods and habitat fragmentation. The upstream part of the Sre Pok and Sesan Rivers has already been intensively developed in Viet Nam, and a large dam is already under construction near the confluence with the Mekong (Sesan 2). Only the Sekong remains free flowing. The annual reduction in capture fisheries due to planned dam development in Lao PDR and Cambodia may amount to 20%, mainly due to blockage of fish migration by planned dams, and change in flow regime, flooding patterns and sediment concentrations. Planned dam construction should consider establishing fish bypasses or passages to support fish migration.

Most of the adverse impact on fisheries will be caused by the planned dams on the Sekong (in Lao PDR and Cambodia). Alternative development scenarios for the Sekong have been proposed by Cowx (2014) including more intensive development of tributaries and elimination of the planned Sekong dams (to keep the Sekong free flowing). However, the dams planned on the Sre Pok and Sesan in Cambodia will cause considerable damage, and alternative locations or alternative designs which allow the construction of bypass channels (for fish and sediment) could be considered. Fish migration from the Tonle Sap system will be considerably affected. Due to its location in the most downstream portion of the 3S Basins, most of the adverse impacts will felt in the Cambodia. Some of the fisheries losses in Cambodia can be offset by changes in the location and design of dams, and by fisheries production in the new reservoirs and the in the expanded irrigated areas (if the irrigation systems are planned and managed in a fish-friendly way).

Sediments. Sediment transport is not only critical for stable and productive rivers in the 3S Basins but also for the Mekong mainstream and for nutrient delivery to the delta since the 3S Basins is a significant contributor to sediment transport in the Mekong mainstream (estimates range from 10 to 25 Mt/year or 10-20%). In the Definite Future Scenario, trapping of sediments in the 3S Basins is expected to be in the order of 50% (USAID, 2014a) and it is expected that in a few years from now the basins' contribution of sediments to Mekong mainstream will be halved. In the Foreseeable Future Scenario (2030), sediment trapping by dams in the 3S Basins increases to more than 75%, further reducing the sediment replenishment of critical ecosystems within and outside the basins. About half of the sediments would be trapped by the four most downstream dams in Cambodia because of their size and location within the 3S Basins. In USAID, 2014b it is estimated that the discharged sediment load from the 3S Basins could be reduced to 1.6 Mt/year.

A sediment management strategy is needed for each of the three rivers to stabilize the 3S River system and increase sediment discharge to the Mekong mainstream. Since most dams will be operating in cascades (with some dams less than 10 km apart), sediment management at individual dams needs to be coordinated to minimize sediment trapping, extend the life of the dam and reservoir, and reduce the risk of blocking intakes and damaging turbines. Watersheds located upstream of reservoirs should be prioritized for reforestation and protection, possibly by using the dam developer's funds.

Degradation of aquatic ecology. Bio-monitoring and other research suggest that aquatic ecology is still in a fairly good condition, particularly in the less-developed Lao and Cambodian portions of the 3S Basins. The implementation of the development plans described in Section 4 will change this favourable situation and all the above impacts will contribute to a substantial degradation of aquatic ecology. All the identified environmental hotspots will be highly impacted (MRC/BDP, June 2010). Most riverine floodplains will degrade or disappear due to development. Most deep pools in the Sekong, Sesan, and Sre Pok Rivers in Cambodia will disappear due to bank erosion and sedimentation. The rich biodiversity with an extensive variety of riverine birds and fish species will be reduced considerably. Also, most natural parks will be impacted by development within and outside the parks.

High economic benefits. The overall incremental economic benefits of ongoing and planned water resources developments are large in each of the three countries in the 3S Basins. The Net Present Value (NPV) of the hydropower and irrigation development in the Foreseeable Future Scenario (2030) amounts to USD1.3 billion in the Cambodian portion, 2.2 billion in Lao portion, and 3.3 billion in Vietnamese portion of the 3S Basins. Hydropower development is the biggest contributor. There would be large increases in the benefits from irrigation in the long-term scenarios (2060).

Increasing risks for vulnerable natural resource users. The development of planned hydropower, large-scale agriculture, mining and forestry may require the resettlement of 50,000-100,000 people, many of them in Lao PDR and Cambodia, where most new development is planned. Vulnerable natural resource users in these countries are going through a period of social change, and growing uncertainty with increasing external pressures on the resource base that has supported traditional livelihoods. These vulnerable resource users will be affected in various ways, including through reduced access to the productive resources that are essential for their livelihoods.

Ongoing and planned development creates substantial job opportunities in the region but many of these require skills that the affected communities do not have because of limited access to welfare services, such as health and education. There may be few off-farm employment opportunities within their localities and labour migration requires going further afield. A key issue therefore is how the generated benefits from water related development will be used to prevent or mitigate adverse impacts and to compensate and share benefits with affected communities.

In order to anchor hydropower and other major water resources development projects with the local population in the Laotian and Cambodian portions of the 3S Basins, more innovative project concepts will be required than are currently considered by the centralized and sector-oriented project development. Examples of untapped potentials, which could increase benefits for the local population and especially those directly affected by the projects include: reservoirs fisheries and aquaculture, cultivation of the reservoir bed, upland watershed management, pumped irrigation (using surplus power during part of the day), water supply, recreation and tourism and ecotourism.

7. Trends in water resources management

Water resources management strategy in the Lower Mekong Basin (LMB) is a mix of a "cooperative and coordinating model" at the basin-scale, facilitated through the MRC, and four national models, where individual sovereignty, customs and administrative systems dominate. The MRC, through the 1995 Mekong Agreement, acts as a focal point for the cooperation and assists the Member Countries in achieving their basin-scale aims through provision of shared information, technical guidance and mediation.

At the Mekong Basin scale, Integrated Water Resources Management (IWRM) is becoming a reality with the 5-yearly updated IWRM-based Basin Development Strategy, facilitated by the MRC. The Strategy sets out the development opportunities for basin and national implementation and medium term Strategic Priorities and Priority Actions. The MRC will implement Strategic Priorities and Actions through its five-yearly MRC Strategic Plan in according with its core functions. Also a range of other actors at the regional, national and project level have important roles to play in the implementation of the Strategy.

At the national level, the implementation of the Basin Development Strategy for 2011-2015 has been at the heart of promoting IWRM as it involved communication and information sharing among sectors and sub-basins. The countries have prepared National Indicative Plans (NIPs) to mainstream basin perspectives, priorities and core functions into national strategies, plans, policies and systems. The NIPs are also promoting joint projects with other countries and national projects of basin-wide significance among national planning and sector agencies. Monitoring and evaluation of NIP implementation is undertaken within the common MRC framework under the MRC Strategic Plan.

Each of the countries that share the 3S Basins is embracing IWRM adapted to its needs, with clear statements of national water policy and strategy supported by strengthened institutional and regulatory frameworks, and clearer definitions of responsibilities for water resources management. All countries now have a dedicated agency responsible for water resources management: Ministry of Natural Resources and Environment in Viet Nam, Ministry of Water Resources and Meteorology in Cambodia, and Ministry of Natural Resources and Environment in Lao PDR. River basin organizations/committees are being established or considered for participatory water management at the sub-basin level.

Challenges at the national level. Increasing development pressures and private sector engagement in the water resources sector will require the further strengthening of water resources management, not only between countries, but also within countries in the 3S Basins. Main challenges at the national level include: the implementation and enforcement of policies, laws, regulations and procedures (including relevant MRC Procedures); the improvement of water related monitoring networks and databases; and the establishment of appropriate levels of coordination and data and information exchange between vertical and horizontal levels of government.

Water Resources Management. At the local scale in the 3S Basins, a recent in-depth review of water resources management processes is not available. Although the three countries are at different levels of economic development and their institutional capacities are not the same, all countries are facing similar water resources management challenges related to inter-agency coordination, the implementation of the basic water resources management needs (monitoring, licensing, enforcement), financing of water resources management, and institutional and human resources development, especially at local and trans-boundary levels. Most of these challenges are being addressed, with support from the national governments and bilateral support from Development Partners.

Establishment of River Basin Organizations (RBOs). Water resources management is most developed in the Viet Nam portion of the 3S Basins where there are significant issues related to sectoral water allocation, floods, water shortages, water quality, and other impacts from rapid development. Therefore, the first RBO was set up in 2005 in Viet Nam to advise on the development, management and protection of water resources management in the Sre Pok Basin and to promote the coordination among various national sector agencies. More recently, Lao PDR and Cambodia have established the first RBOs in river basins outside the 3S Basins.

Development Partner and Non-Governmental Organization (NGO) supported projects have been playing an important role in improving water resources management in the 3S Basins. They prepared river basin profiles, conducted assessments, strengthened institutions, provided training and demonstrations, and facilitated stakeholder dialogues to raise awareness of issues and build consensus on potential solutions. NGOs have built local stakeholder networks and used these to strengthen local water resources management, including flood warning, the monitoring of impacts from development, and bringing government authorities, projects developers and other stakeholders together to address issues.

Future outlook. It can be expected that water resources management will continue to improve in the 3S Basins, benefitting from increasing budgets and strengthened institutional and human capabilities. The newly established water and environment ministries and their local departments will increasingly coordinate, guide and monitor water-related development, while the long established sector agencies do most on-the-ground planning but in a way the maintains the most acceptable balance between development and protection. RBOs might be established at the national level in critical river basins where serious water management problems exist or are predicted.

Trans-boundary water cooperation in the 3S Basins will need to be enhanced to increase benefits and reduce adverse trans-boundary impacts and risks of the planned water resources developments, as elaborated in the next sections.

8. Experiences with trans-boundary water cooperation

Until the second half of the 1990s, trans-boundary water cooperation in the 3S Basins was limited to information sharing during bilateral and multilateral meetings organized by Association of Southeast Asian Nations (ASEAN), Greater Mekong Sub-region (GMS) and others, which were mostly concerned with broader issues beyond the water sector. Large-scale development of water resources, including hydropower and irrigation developments, had just begun and development pressures and trans-boundary pressures and impacts were acknowledged and addressed to some degree. The signing of the 1995 Mekong Agreement, which established the MRC, was timely as it provides the essential IWRM framework to support sustainable water resources development in the Mekong Basin.

Trans-boundary water cooperation in the 3S Basins started to increase in the second half of 1996, as a result of observed adverse trans-boundary impacts. In 1996, Cambodian people in Ratanakiri Province began to experience unusual flood events, which were attributed to releases from the Yali hydropower project that was under construction on the Sesan River in the Central Highlands, some 60 km upstream. According to reports, unusual flooding continued in the following years to impact the areas downstream of the dam and studies were carried to assess the damages and losses. However, since it involves a tributary dam, the MRC did not take an active role in determining effects of the dam over the Cambodian border (Hirsch et al. 2006).

In 2000, a coalition of NGOs established the Sesan Working Group. This group (which later became the Sesan Protection Network) conducted studies to investigate impacts, held workshops and gained the support of government officials at the provincial and district levels in Cambodia. Responding to concerns of civil society groups, MRC undertook “fact-finding” research in the affected areas and coordinated dialogues between the Vietnamese and Cambodian governments. The MRC also facilitated the establishment of the Cambodia-Viet Nam Joint Committee for the Management of the Sesan River.

The two governments organized three meetings of the Joint Committee to negotiate a solution for the trans-boundary water issue. They agreed on the establishment of a system for advance warning of unusual water releases. The Joint Committee was subsequently dissolved in 2004. The committee did not deal with compensation issues or respond to community demands for a moratorium on further dam construction on the river before issues arising from Yali Dam had been dealt with. After Yali Dam became operational in 2006, its use as a peaking power plant caused regular daily floods downstream. More recently, this issue has been addressed by Viet Nam through the construction of re-regulating capacity downstream of Yali Dam, which reduces the downstream daily water level variations.

Since 2000, MRC’s Basin Development Plan Programme and other programmes and projects have prepared river basin profiles, organized trans-boundary meetings, and conducted studies that have increased the knowledge base of the critical issues at stake

in the 3S Basins. Trans-boundary cooperation has been mostly limited to participation in meetings and workshops. The increased knowledge has been used to make assessments of the impact of land and water related changes in the 3S Basins. Joint assessments of development opportunities, trade-offs and risks for achieving greater overall benefits in the 3S Basins itself (through coordinating and/or modifying nationally planned development) have not been conducted yet at the basin level.

In 2005, the National Mekong Committees of Cambodia and Viet Nam singed a MOU to set up mechanisms for coordination with national agencies that are planning or implementing water related activities in their common border areas in order to maximize mutual benefits and minimize possible negative impacts on each other.

The Asian Development Bank and World Bank (ADB/WB) Mekong Water Resources Assistance Strategy (2006) identified the need for strategic collaboration in the 3S Basins. A major technical assistance and investment programme was identified in the areas of water governance, water for social development, water for economic development, and watershed and water resources protection and management (COWI 2006a). Only small, national elements of the programme were implemented. Subsequently, the ADB supported a smaller trans-boundary project aimed at strengthening cross-border cooperation in the 3S Basins. The project prepared a road map based on a visioning exercise and dialogues with stakeholders. The road map included useful trans-boundary activities, including institution building with the long-term objective of establishing a 3S Basins management institution (ADB 2010).

The MRC Mekong IWRM Project, launched in 2012, included interlinked regional, trans-boundary and national components. Under the national component, the hydro-meteorological and data management systems in the Cambodia-Viet Nam border areas in the 3S Basins will be improved and training will be provided. Also, a water resources modelling package will be developed and support will be provided for modelling in the 3S Basins. The activities will be supported by the development of coordination mechanisms.

In addition, there have been other support programmes and projects by international organizations, such as a project by the International Union for Conservation of Nature (IUCN), aiming to help improve of cooperation and planning in the 3S Basins. Most of these programmes and projects have provided greater opportunities for trans-boundary dialogues, shared learning and networking. However, they have not engaged in trans-boundary assessments that could lead to alternative plans and joint projects between the countries to increase water, food, and energy security, reduce risks and protect environmental assets across the 3S Basins. Thus stakeholders have not been able yet to fully examine development options, costs, benefits and trade-offs that may need to be considered by riparian governments, individually and collectively.

9. Need and mechanisms for trans-boundary water cooperation

9.1. General

National agendas and sectoral approaches. Each country in the 3S Basins is developing the water resources of the shared rivers based on national development agendas without significant coordination with the other countries. Furthermore, large water infrastructure has been planned and developed through a central and sector-oriented approach without much communication and joint effort between the line agencies. As a result, the existing, under-construction and planned development in the 3S Basins may be sub-optimal from a basin-wide perspective.

Integrated approaches at the national level. The need for more "integration" of national water resources planning is recognized by all three countries. In the Vietnamese portion of the Sre Pok and Sesan river basins, where significant water related problems exist (see Section 5), RBOs have been established to support the implementation of integrated approaches to water resources development and management in consultation with the line agencies and other stakeholders. The resulting improvement of water resources management will also help minimize potential harmful effects in the downstream countries.

In the much less developed Lao and Cambodian portions of the 3S Basins, the establishment of RBO is premature. However, there is a need for a stronger role from the water management agencies (MOWRAM and MONRE) and their provincial departments

Levels of trans-boundary water cooperation

It should be recognized that countries that share a river basin will always have a national agenda. They will cooperate if it serves that national agenda.

Increased trans-boundary cooperation does not always create more benefits to the basin countries. The optimal type of trans-boundary cooperation will vary depending on hydrologic and environmental conditions, the investment opportunities, and other factors that determine the potential benefit sharing mechanisms in a river basin. In some basins, simple information sharing may be all that is needed to facilitate optimal trans-boundary cooperation. In other basins, joint actions on river regulation, water storage and drought and flood mitigation would yield significant net benefits. In yet other basins, joint ownership and management of infrastructure would increase basin-wide benefits and reduce trans-boundary costs.

A major challenge is to identify the right type of cooperative effort--one in which the benefits of cooperation outweigh the costs, and where the process and outcome is politically and socially acceptable. In a particular basin, the appropriate level of cooperation can be explored through a Cooperative Regional Assessment (CRA) (see next Box).

which need to coordinate and steer an integrated multi-sector planning and management process. Potentially, this could result in higher economic benefits and lower environmental impacts than the currently planned development.

Trans-boundary water cooperation. In addition to the above national efforts to move towards more integrated water resources management, the 3S Basins countries have supported initial studies aimed at strengthening trans-boundary cooperation. These studies have not yet clearly and fully identified the right type and level of trans-boundary water cooperation in terms of concrete needs and opportunities that could enhance the benefits to be gained from water resources development and minimize harmful costs and effects (see Section 7). Identifying the right type of cooperative effort is a major challenge in every international river.

The appropriate level of cooperation in a particular trans-boundary basin can be explored through a Cooperative Regional Assessment (CRA). The undertaking of a CRA is long overdue in the 3S Basins and is prioritized in this report (see Section 9).

Cooperative Regional Assessment (CRA)

CRA is a technique that has been designed as a flexible and powerful instrument to bring riparian countries together to identify the full range of options and choices that are available to optimise and share the benefits of cooperation. The benefits identified by CRAs could then motivate countries to continue or intensify their cooperative efforts to capture those benefits.

The CRA process is underpinned by three elements: institutional strengthening, process design and trans-boundary assessment.

- **Trans-boundary cooperative assessment** of the distribution of benefits, impacts and risks of existing and planned development in a basin, as well as of alternative development scenarios, including joint projects and national projects of trans-boundary significance, and taking account of the wider Mekong region context;
- **Distribution analysis** of costs and benefits that will accrue across countries and sectors under existing and alternative development scenarios, taking into account the wider context of the Mekong region; and
- **An institutional analysis** of the possible levels and modes of cooperation necessary to capture the greatest net benefits, taking account of the costs of cooperation within the wider context of the Mekong region.

The CRA can be implemented for the entire 3S Basins or for one or two of its river basins such as the Sekong River Basin. The implementation of a CRA could be initiated by the relevant NMCs and overseen by a trans-boundary coordination group with representatives of the provinces, NMCs, line agencies and others. The results of the CRA will indicate the best coordination mechanisms for water and related resources development and management in the 3S Basins.

The assessment process maintains the Mekong Spirit and is to be used to build further trust and confidence among the 3S Basins countries. This will set the stage for developing a shared understanding of the path to meeting longer term needs and move towards more optimal and sustainable development.

9.2. Evaluation of trans-boundary water cooperation in the 3S Basins

Although a CRA has not been implemented in the 3S Basins, an initial evaluation can be made on the need for trans-boundary actions, based on existing information (as summarized in the previous sections) and expert judgment. In addition to the implementation of a CRA, the following cooperative actions are identified.

Maintenance of flow. The earlier observed significant daily fluctuations of water flows in the Sesan River as a result of peaking operations in Viet Nam have been mitigated by re-regulation dams upstream of the Cambodian border. Trans-boundary issues related to daily water fluctuations in the Sre Pok and Sesan Rivers are not expected in future as the construction of re-regulation dams is becoming common practice in the Mekong region to dampen downstream water fluctuations. Also, trans-boundary issues are not expected regarding changes in the seasonal flow pattern, since it is predicted that trans-boundary dry season flows will most likely not decrease in the Sre Pok and Sesan and will likely increase in the Sekong. These predictions have to be validated by improved flow monitoring throughout the 3S Basins and the sharing of the monitoring data, as described below under the section “Monitoring of water resources.”

Management of water quality. Section 5 suggests that water quality could become a significant national issue with possible trans-boundary implications if not managed adequately at the national level. All three countries have policies in place to improve water quality management, including the further development and implementation of a water use license system for the main water abstractions and waste water discharges in the energy, agriculture, industrial, mining and public water supply and sewerage sectors. The results need to be validated by improved water quality monitoring throughout the 3S Basins and the sharing of monitoring data, as described below under the section “Monitoring of water resources.”

Monitoring of water resources. Monitoring of water resources (flow, water quality including sediment flow) is essential for water resources management. Currently, Viet Nam and Cambodia initiated the improvement of their water resources monitoring network in their border areas in the 3S Basins with support from the World Bank under the Mekong IWRM Project (VNMC NIP, 2014). Monitoring data will feed into the water information system which is being established and improved. At the same time, there is an urgent need to improve water resources monitoring in the Laotian and Cambodian portions to support the development and management of water resources in this part of the 3S Basins.

Trans-boundary cooperation on water resources monitoring and the sharing of the obtained data and information between the three countries are needed for development planning, flood forecasting, hydropower operations and for management of water and related resources. The MRC would be well placed to facilitate such trans-boundary water cooperation by extending its current water resources monitoring services to the entire 3S

Basins. The exchange of data and information can take the form of a website that provides similar information as is currently exchanged for the Mekong mainstream. The World Bank-supported Mekong IWRM Project will provide opportunities to initiate discussions among the three countries on the harmonization of methods, tools and quality assurance methods for water resources monitoring to enable the exchange of reliable data among the three countries.

Coordination of hydropower development. Figure 4 shows that the 3S Basins countries are developing a cascade of hydropower plants on the Sre Pok, Sesan and Sekong Rivers. In general, the coordination of planning and design of cascading hydropower plans is highly beneficial in terms of overall water utilization efficiency, optimization of installed capacity, reduced spillway capacity, and dam safety aspects. In some international river basins, a Technical Inter-Governmental Commission (TIGC) is set up to capture these benefits by overseeing the design and development of the cascade, and enforce its operation under the agreed design (see Appendix 1).

In the 3S Basins, the set-up of a TIGC may not be realistic; Viet Nam already developed its hydropower potential in the Sre Pok and Sesan Basins where downstream Cambodia plans several dams; Cambodia is planning only one run-of-river dam in the downstream portion of the Sekong Basin where upstream Lao PDR is developing 23 hydropower plants. But it may be realistic for Cambodia to conduct a joint study with Lao PDR in the Sekong Basin to assess the options for optimizing the development of the full potential sustainable benefits to both countries and the prevention of wasteful use of the Sekong waters, as envisioned in the 1995 Mekong Agreement. There might be development scenarios that better balance a range of desired outcomes (on hydropower, fisheries, irrigation, etc.) and can be sustained for the long-term.

In the absence of joint planning and design, the burden is on each new hydropower plant to be designed under the constraints imposed by the plants already under construction or operation. This includes designing downstream plants for the water resources modified by existing upstream plants and designing upstream plants so as to not create an adverse impact on downstream plants. The MRC would be well placed to enforce these principles; the primary role would be: (1) the determination that new upstream plants do not divert water from existing downstream plants and (2) the determination of the need for re-regulation of peaking flows by new upstream plants in the special conditions discussed under short-term interaction for power production.

Coordination of hydropower operations. If the above principles are adhered to, there is no requirement for coordination between the 3S countries but a requirement for information sharing to assist in the smooth operation of the three cascades, including communication on planned peak releases and sediment flushing. Therefore, a communication system among plants in the three cascades needs to be developed, probably in the form of a website. The communication system is particularly necessary during flood conditions or in the event of equipment or structural failure that could result in extraordinary flow releases (see Appendix 1).

The communication system would essentially provide routine communications and emergency communications. The routine communications would include: reservoir storage at all times and maximum storage level; expected and actual inflows to reservoirs; storage-area curves and average monthly rainfall and evaporation at reservoir location; planned reservoir rule curves for the next 12 months; expected inflows for the next 24 hours; expected hourly releases for the next 24 hours; hourly record of past releases; and schedule of planned sediment flushing including hourly releases relative to arriving flows. The emergency communications would include: hourly expected flood flows; hourly expected reservoir storage if above maximum normal operating level; and hourly expected flow release.

Management of sediment. Section 5 indicates that the 3S Basins contribute 10-20% of the sediments in the Mekong mainstream. This contribution will reduce to 1-2% when all dams are built as planned. Given the importance also of adequate sediment management in the 3S Basins itself (for smooth hydropower operations [see above], river stabilization and maintaining important ecological functions), a joint sediment management strategy could be developed by the three countries. The strategy would establish a current and possible future basin-wide sediment budget by considering changes in watershed management, changes in locations and designs of dams, alternative flushing scenarios and other factors.

Management of fisheries and biodiversity. Capture fisheries reduction (and by extension, biodiversity) in the Cambodian and Lao portions of the 3S Basins (and downstream in the Lower Mekong Basin) may be very significant due to the planned hydropower development in these countries (see Section 4). In the upstream part of the basin, Viet Nam has already developed its hydropower potential and will not be significantly impacted by under-construction and planned development in Cambodia and Lao PDR. Alternative development scenarios for the Sekong River have been proposed and alternative locations and design could also be considered for the planned dams on the Sre Pok and Sesan Rivers in Cambodia.

This would require the coordinated planning and design of hydropower development on the Sekong River by Cambodia and Lao PDR, similarly to what is proposed above for the optimization of hydropower benefits. In addition, information on capture fisheries productivity in the various habitats (river floodplains and wetlands, rainfed wetlands, and reservoir fisheries) and migration routes could be shared by all three countries for all three 3S Rivers, with a view to sharing experiences and joint learning.

Flood management. The increasing problem of (flash) floods can be addressed at the national level through restoration of watersheds and best practice design and construction of water infrastructure such as levees and dams. Although clearly a trans-boundary issue, flood forecasting and early warning in each of the three river basins are mainly dealt with on the national level. Only in case of emergency, Viet Nam and Cambodia have established a system for advance warning of unusual water releases and flood situations (see Section 6). However, the results obtained by this mechanism are still limited.

Improved trans-boundary cooperation for flood management is needed between Cambodia and Viet Nam in the Sesan and Sre Pok Basins and between Cambodia and Lao PDR in the Sekong Basin. The aim would be to set-up an effective flood forecasting system as well as an adequate data exchange mechanism to enable early warning of threatened communities. With support from the World Bank, the flood forecasting and warning system in the Viet Nam Central Highlands is being improved (VNMC NIP, 2014). This may provide opportunities to initiate trans-boundary cooperation on flood management, including on the harmonization of methods and tools.

Opportunities for benefit sharing. Existing information and ongoing work on regional benefit sharing suggests that there are trans-boundary opportunities, where two or three countries could develop joint projects that provide substantial benefits that could be shared. A few examples of this already exist in the 3S Basins, including a joint investment by Viet Nam and Lao PDR in a hydropower plant in the Sekong Basin. Other examples may be joint projects between Cambodia and Lao PDR that reduce adverse negative impacts in the Cambodian portion of the 3S Basins. The MRC is in a position now to identify joint and/or basin-wide development and cost and benefit sharing options. The proposed CRA may identify further benefit sharing options.

10. Strategic priorities for trans-boundary water cooperation

The previous section indicates that the development of sustainable benefits from the 3S Rivers requires first and foremost the strengthening of water resources planning and management at the national level. At this level, the national agencies responsible for water resources management will play their most challenging role by coordinating and steering an integrated multi-sector planning and management process. The long established sector agencies can continue to do most on-the-ground planning but in a way that maintains the most acceptable balance between development and protection. RBOs might be needed at the national level in critical river basins where serious water management problems exist or are predicted, such as in the Central Highlands in Viet Nam.

The strengthening of national water resources management will go a long way for realizing higher economic benefits and lower environmental impacts in the 3S Basins. Nevertheless, it follows from the evaluation in the previous chapter that there are a few pertinent areas where trans-boundary cooperation is needed. They include:

- Water resources monitoring and the exchange of data;
- Flood forecasting and early warning;
- Coordination among cascading hydropower plants; and
- The implementation of a Cooperative Regional Assessment (CRA).

Water resources monitoring and the exchange of data. Trans-boundary cooperation on water resources monitoring and the sharing of the obtained data between the three countries is needed for development planning, flood forecasting, hydropower operations, and for water resources management in the 3S Basins. As a minimum, data on water flows, water quality and sediment of the Sre Pok, Sesan and Sekong rivers must be exchanged between the countries, probably in the form of a website that provides similar information as is currently exchanged for the Mekong mainstream.

There is an urgent need to improve water resources monitoring in all three river basins and establish or improve the data management system. Viet Nam has begun this improvement in its part of the 3S Basins (including the border areas with Cambodia and Lao PDR) with a loan of the World Bank under the Mekong IWRM Project. Meanwhile, Cambodia and Lao PDR are improving their water resources monitoring. This offers opportunities to initiate discussions among the three countries on the harmonization of methods, tools, and quality assurance for water resources monitoring and data management in order to enable the exchange of reliable data and information.

The trans-boundary water cooperation project could be initiated and coordinated by the National Mekong Committees (NMCs) of the 3S countries. The project would be implemented by the national water resources management agencies with support from the MRC Secretariat.

Flood management and early warning. Viet Nam and Cambodia have established a system for advance warning of unusual water releases from reservoirs and natural flood situations on the Sesan and Sre Pok Rivers. However, there is scope for improvement and the system must be extended to the Sekong River. The aim would be to set-up an effective flood forecasting system as well as an adequate communication system to enable early warning of threatened communities in each the three 3S River Basins.

Viet Nam started to improve its flood forecasting and early warning system in the Central Highlands, with a loan of the World Bank under the Mekong IWRM Project (which will also support the improvement of water resources monitoring (see above). This may provide opportunities to initiate trans-boundary cooperation between the 3S countries on flood management, including the harmonization of methods and tools.

The proposed cooperation could be initiated and coordinated by the NMCs of the 3S countries. The responsible national agencies would implement the cooperative actions, facilitated and supported by MRC's Regional Flood Management and Mitigation Centre.

Coordination among cascading hydropower plants. In the absence of joint planning and design, the burden is on each new hydropower plant to be designed under the constraints imposed by the plants already under construction or operation in each of the three river basins. Amongst others, this requires some coordination and oversight to ensure the design of upstream plants does not significantly impact existing downstream plants and the determination of the need for re-regulation of peaking flows by new upstream plants (see previous section). Since Viet Nam mostly developed its hydropower potential in the upstream portions of the Sesan and Sre Pok, coordination for the design of

cascading hydropower plants is most relevant for the Sekong Basin where Cambodia and upstream Lao PDR are planning new hydropower plants.

To assist in the smooth operation of emerging hydropower cascades on each of the three 3S Rivers, there is the requirement for information sharing, including communication on planned peak releases and sediment flushing. Therefore, a communication system among plants in the three cascades needs to be developed, probably in the form of a website. The communication system is particularly necessary during flood conditions or in the event of equipment or structural failure that could result in extraordinary flow releases. The communication system would essentially provide the routine communications and emergency communications listed in Section 8.

The coordination related to the design and operations of cascading hydropower plants could be provided the MRC. The countries involved through their own regulatory agencies should ensure accurate and timely information sharing among the cascading plants.

The implementation of a CRA. The joint assessment by the three 3S Basins countries of the impacts (positive and negative) of existing and planned development, and the identification of opportunities for achieving greater benefits through cooperation is long overdue (see previous section). Based on existing information, it can be expected that regional benefit sharing, including 'national projects of basin-wide significance' and the development of 'joint projects' will likely play a role in moving 3S Basins development towards more optimal and sustainable outcomes.

The proposed assessment process can be used to build further trust and confidence among the 3S countries. This will set the stage for a common point of departure to discuss the assessment results, make initial decisions on trade-offs, and consider various options for increasing the benefits and reducing the costs of water-related development, such as joint projects. The development of such projects, and the sharing of their benefits, will lead inevitably to higher levels of trans-boundary water cooperation, benefiting many sectors, including the socio-economic and environmental sectors.

The CRA can be implemented in the entire 3S Basins or for one or two of its river basins, such as the Sekong River Basin. The implementation of the CRA could be initiated by the NMCs of the 3S Basins countries. The responsible national agencies would implement the CRA with support from MRC's Planning Division and other divisions. The implementation of a CRA could be overseen by a trans-boundary coordination group with representatives of the provinces, NMCs, line agencies and others. The results of the CRA will indicate the best coordination mechanisms for water and related resources development and management in the 3S Basins.

The implementation approach and methodologies would build on those used by the MRC/BDP Programme for its cumulative assessment of the national water resources development plans of the Mekong Basin countries. The NMCs could use the results to further initiate joint activities and projects and promote the required adaption of the national plans.

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12. Supplementary information

The need for trans-boundary cooperation for cascading hydropower plants

Contents

A. Introduction

This paper addresses the institutional and managerial aspects of coordination among cascading hydroelectric plants. The term applies to plants that share a water resource and generally are located along the same river.

The subject has two very different aspects. One is the coordination of the planning and design of cascading plants as part of the optimization of the use of water resources in a catchment or a river reach. The other is the coordination of the operation of such plants.

1. Optimization of planning and design

There is no doubt that coordination of planning and design of plants in the same basin or river reach is highly beneficial to the overall efficiency in utilizing the water resource. Indeed, one increasingly evident defect of market-driven private hydroelectric development is the tendency to under-utilize the water resource due to lack of incentives to coordinate cascade design.

It is possible to promote such coordination even if the plants are privately owned but the problem becomes much more complex in trans-boundary basins since the optimization of development requires compromises between optimality at national level versus optimality of the basin as a whole.

2. Operational interactions

In examining the need or advantage of operational coordination among cascading hydroelectric plants it is useful to first separately analyze the different benefits that are sought from managing water storage in a hydroelectric project. The focus will be on interaction among plants instead of on uses of water between plants or for purposes other than water control.

B. Power production interactions

The management of storage in a hydroelectric reservoir has important power benefits primarily because it allows the capture of high flows during the wet season for use during the dry season. In addition, it allows the hourly harmonization of power production with a fluctuating energy demand. In this section we will address the need for operational coordination among cascading hydroelectric plants exclusively for the purpose of maximizing such power benefits.

There are two distinct types of interaction related to power production: short-term interactions derived from the control of flows during hours or, at most, one week and long-term interactions derived from monthly, seasonal or annual flow control.

1. Short-term power production interactions

A potentially adverse short-term interaction arises when three conditions exist simultaneously:

1. An upstream plant is used in a daily peaking mode. This means that the plant will drastically reduce releases during hours or days of low electricity demand (off-peak hours and weekends) and use that water during the hours of high electricity demand (peak hours in working days);
2. A downstream plant has a reservoir that is too small to regulate the hourly and daily flow fluctuation created by the upstream plant under condition 1 above; and
3. There is either (a) a major difference in the peak and off-peak times between the systems served by the two plants or (b) there is such a distance between the plants that flows released upstream during peak hours arrive at the downstream plant during off-peak hours.

Unless all these conditions coexist there is no potential for adverse effects of short-term flow control but downstream plants must be aware of releases made upstream in order to make preparations to either store the water or to use it.

2. Long-term power production interactions

Longer term flow regulation (monthly or seasonal) is not adverse to downstream plants with low storage capacity since any long-term regulation will always improve their power production. A special case is the initial filling of an upstream seasonal reservoir that may cause major reduction in flows downstream but this case belongs to a subject to be discussed later in the context of fundamental principles of non-interference with existing plants.

However, a downstream plant with monthly or seasonal storage must take into account the modality of storage management of all upstream plants in order to optimize its own storage management. Thus any change in storage management strategies must be communicated to downstream plants to allow them to adjust their respective storage management strategies accordingly.

3. Coordinated design

Coordinated design of a cascade for power production is very common at a national level. Almost every inventory of national hydropower potential includes some form of cascade optimization in each river reach and some of the largest hydropower developments in the world consist of carefully planned cascades. Such optimized design implies also an optimized operation that will take into account the short- and long-term interactions described above. The most common situation is to develop a large seasonal reservoir in the upper parts of the basin to regulate waters for a series of run-of-river cascading plants below. Such arrangement allows the run-of-river plants to attain much higher capacity factors (i.e. energy produced per unit of capacity installed) than if they had been designed independently.

C. Flood routing interactions

A reservoir will dampen the severity of a flood wave by temporarily storing some of its volume. The peak outflow is less than the peak inflow even if spillway gates are left open and there is no human intervention. However, if there is improper gate operation, such as waiting too long to release floodwater then the opposite may occur, creating a released peak flow greater than the arriving peak flow. Good engineering practice requires designers to account for this risk.

1. Coordinated design

Coordinated design of a cascade may considerably reduce the cost of downstream projects by requiring spillways with less capacity than if they were planned alone. Furthermore, safeguards against improper gate operations can be put in place so that downstream plants at risk may be able to take action in case an upstream plant operates gates in an unsafe manner.

2. Operational aspects

In terms of operation, whether the design was coordinated or not, each plant will follow its proper procedure which involves maintaining the reservoir within certain guidelines. Therefore, while prompt communication among cascading plants is highly desirable during flood events, there is no real need for coordination if all plants are properly designed and operated.

D. Sediment transport interactions

Any reservoir will trap sediment transported, either in suspension or as bed load. The trapping efficiency depends very much on the size of the reservoir and on the design of the water release works and it is always desirable to minimize it, both to preserve the storage capacity of the reservoir and to prevent riverbed degradation downstream. For small reservoirs loss of storage is the primary concern but for any power plant a major concern is the accumulation of sediment near the intake.

1. Coordinated design

Generally, projects in rivers with very substantial sediment loads use sluiceways or bottom outlets that release excess water at river bed level as an alternative or to complement spillways that release water over the top. For projects where the powerhouse is located at the dam and the turbine flows are mixed with the excess flows there is not much difference on how a cascading project would be designed to control sediment, whether it is built independently or in coordination.

For diversion type hydroelectric projects, on the other hand, a coordinated design could significantly reduce the cost. Diversion projects have long waterways and normally include desanding facilities immediately after the intake to remove sediments that may be deposited in the waterway and damage the turbines. Desanding facilities can be an important part of the cost of a project and it is not uncommon to find cascading plants that are designed so that all of the water released by an upstream plant goes directly into the waterway of the downstream plant thus using only one desanding facility for one or more plants.

2. Operational aspects

Since upstream plants, particularly those with more water storage, are the ones that trap more sediment, it is likely that they may attempt sediment flushing procedures. This consists of drawing down the reservoir at the end of the dry season (more than required to maximize power production and in some cases even shutting down the plant to draw down below the intake level) and waiting until well into the wet season to start the fill up. The first floods of the wet season will therefore find the reservoir close to empty and carry much of the sediment accumulated near the dam or that which was deposited in shallow water at the tip of the reservoir.

Such flushing operation could result in substantial and rapid deposition of sediment in any downstream plant that does not adopt the same strategy. A similar problem occurs in rivers subject to freezing where winter cascade operations need to be carefully coordinated to avoid ice jams.

E. Institutional arrangements

1. Coordinated design and operation

There is no doubt that coordinating the design of cascading hydroelectric plants improves the benefits and lowers the cost of the full utilization of the water resource. Thus, at a national level it is definitely recommended since it is purely a matter of internal regulation without adverse economic impact on the country.

At a trans-boundary level the improvement in benefits and reduction in cost also exist but may not be evenly distributed among countries. If all countries sharing a catchment or river reach agree that a jointly designed cascade is advantageous to all of them then they would set up a jointly funded Technical Inter-Governmental Commission (TIGC) to implement its development along the following steps:

Project preparation phase

The TIGC would oversee the work of experts as follows:

1. Define the criteria to optimize the design of the cascade for a given river reach or catchment;
2. Plan the cascade, at prefeasibility level, for maximum benefit under the defined criteria;
3. Define the operating rules for the cascade; and
4. Define sequencing order as some downstream projects may not be safe or efficient before the upstream ones are in place.

Cascade development phase

At this stage each country will proceed with the development of projects in their respective territories. The development could be based on inviting private developers to make offers for the right to build and operate the projects over a long-term (30 or 40 years).

The TIGC role during this stage will be to ensure that projects are built in accordance with the optimum cascade plan and that they follow the required sequence.

Cascade operation phase

At this stage the TIGC roles will be to provide arbitration in case of claims between cascade operators for breach of agreed operation rules and to periodically review the operation rules to ensure the original objectives are maintained.

Caveats

Such arrangements are only realistic when all countries involved agree that they will all derive some incremental benefit, or at least will not suffer any significant adverse effect, from designing the cascade jointly over designing independently. If not, such coordinated development probably would need to establish a mechanism for compensation between the winners and losers of joint optimization and that is likely to delay the development in a way that may erode the benefits of coordinated development.

2. Coordinated operation of independently developed plants

In the absence of joint planning and design the burden is on each new plant to be designed under the constraints imposed by the plants already under construction or operation. This includes designing downstream plants for the water resources modified by existing upstream plants and designing upstream plants so as to not create an adverse impact on downstream plants. The ideal watchdog for enforcing these principles is MRC and the primary role would be (a) the determination that new upstream plants do not divert water from existing downstream plants and (b) the determination of the need for re-regulation of peaking flows by new upstream plants in the special conditions discussed under short-term interaction for power production.

Based on the discussion of power, flood and sediment aspects of the operation of cascading plant it can be concluded that, if the principles above are adhered to, there is no requirement for coordination but a requirement for information sharing to assist in the smooth operation of the cascade. It seems that what is then needed is a communication system among plants in the cascade, probably in the form of a website that would essentially provide the following:

Routine Communications

- Reservoir storage at all times and maximum storage level
- Expected and actual inflows to reservoirs
- Storage area curves and average monthly rainfall and evaporation at reservoir location
- Planned reservoir rule curves for the next 12 months
- Expected inflows for the next 24 hours
- Expected hourly releases for the next 24 hours
- Hourly record of past releases
- Schedule of planned sediment flushing including hourly releases relative to arriving flows

Emergency Communications

- Hourly expected flood flows
- Hourly expected reservoir storage if above maximum normal operating level
- Hourly expected flow release

F. Conclusions

Q: What kind of trans-boundary coordination is (likely) needed to coordinate the operation (flow and sediment) of the cascade of dams on each of the three rivers (assuming that dams will be built)?

A: For operation alone the need is only one of information sharing rather than coordination. For achieving greater benefits through harmonized cascade design then a Technical Inter-Governmental Commission (TIGC) is needed to plan and design the cascade and enforce its operation under the design.

Q: What would be the role of the various parties in the Mekong Basin context? Who will initiate such coordination, who regulates, who implements, who oversees and reports, and who else will need to be engaged/informed etc.)?

A: In the absence of a TIGC then MRC should enforce fundamental principles of non-modification of the water resource by new upstream plants in a manner adverse to existing downstream plants. In the case of operation of independently designed projects the countries involved through their own regulatory agencies and through MRC promotion should ensure accurate and timely information sharing among the cascading plants.

Q: Can the same set up of the trans-boundary coordination be used for addressing trans-boundary emergency situations related to the hydropower projects?

A: Yes, the information sharing mechanism is particularly necessary during flood conditions or in the event of equipment or structural failure that could result in extraordinary flow releases.

Q: When would such trans-boundary coordination need be in place?

A: In the case of operation of independently designed dams the information sharing system should be started with the first plant in operation. In the case of a coordinated cascade design the TIGC should be set up as early as possible to be able to complete the first stage (design criteria) of the preparatory phase.

Q: Is it advantageous for the design of the Cambodian dams that trans-boundary coordination is set up in the near term?

A: Yes. Downstream countries are the most likely beneficiaries of coordinated design as it may allow them to plan for reduced spillway capacity and optimize their installed capacity for an expectation of upstream regulation. If the conditions described under short-term power are to be expected then coordinated design may provide an even greater benefit to Cambodia.

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