Draft

Mekong River Commission

Basin Development Plan Programme, Phase 2

Assessment of basin-wide development scenarios

Technical Note 1

Synthesis of initial findings from assessments

(Work in Progress)

February 2010

Note to the reader

This series of technical notes is prepared to serve facilitation and discussion on the assessment of basin-wide development scenarios of the Mekong Basin by stakeholders in the basin countries. The assessment process is continuing and feedback on the initial findings is requested.

Mekong River Commission

Basin Development Plan Programme, Phase 2

Assessment of basin-wide development scenarios

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Glossary

ADB	Asian Development Bank
AIFP	Agriculture, Irrigation and Forestry Programme
BDP	Basin development programme
BDP1	BDP Phase 1
BDP2	BDP Phase 2
BS	Baseline scenario
DF	Definite future scenario
DSF	Decision support framework
EP	Environment Programme
FMMP	Flood management and mitigation programme
FMMP-C2	Component 2 of FMMP
FP	Fisheries Programme
HP	Hydropower Programme
IBFM	Integrated basin flow management
IQQM	Discharge modelling software
ISIS	Proprietary river modelling software
IKMP	Information and knowledge management programme
IWRM	Integrated water resources management
LMB	Lower Mekong Basin
LMD	Mainstream dams in LMB
LTD	Long term development scenario
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NMC	National Mekong Committee
NP	Navigation Programme
PIN	Project Identification Note
PDS	Project Description Sheet
PNPCA	Procedures for Notification, Prior Consultation and Agreement
PWUM	Procedures for Water Use Monitoring
RTWG	Regional technical working group
SWAT	Open source hydrological modelling software
TMD	Thai mainstream dams
ToR	Terms of reference
UMB	Upper Mekong basin
UMD	Upper mainstream dam scenario
VHD	Very high development scenario
WB	World Bank
WUP	Water utilisation programme
WUP-A	WUP component for DSF development

Preface

Basin Development Planning

The second phase of MRC's Basin Development Plan Programme (BDP2) is designed to provide an integrated basin perspective through the participatory development of a rolling Integrated Water Resources Management (IWRM) based Basin Development Plan. The plan will comprise the following elements:

- **Basin-wide Development Scenarios**, which will provide the information that Governments and other stakeholders need to develop a common understanding of the most acceptable balance between resource development and resource protection in the Lower Mekong Basin, taking into account developments in the upper Mekong Basin. The results will guide the formulation of the IWRM-based Basin Development Strategy.
- **An IWRM-based Basin Development Strategy**, which provides a shared vision and strategy of how the water and related resources in the LMB could be developed in a sustainable manner for economic growth and poverty reduction, and an IWRM planning framework that brings this strategy into the various transboundary and national planning, decision-making and governance processes.
- **A Project Portfolio** of significant water resources development projects and supporting non-structural projects that would require either promotion or strengthened governance, as envisioned in the 1995 Mekong Agreement.

The preparation of the Plan will bring all existing, planned and potential water and related resources development projects in a joint basin planning process, through a combination of sub-basin and sector activities, and a basin-wide integrated assessment framework.

Formulation and assessment of scenarios

The formulated basin-wide development scenarios represent different levels and combinations of sectoral development and consider the many development synergies and trade-offs among the different water-related sectors, such as irrigation and hydropower synergies and hydropower and fisheries tradeoffs. The table overleaf summarises the scenarios agreed by the countries.

First the development scenarios are assessed on a range of hydrological indicators to evaluate future water availability and use, and the flow changes caused by different levels of water use, taking into account the existing and planned developments in the Upper Mekong Basin. The scenarios for the foreseeable and the long term future will be assessed with and without consideration of climate change impacts. The results are then fed into the 'assessment of the transboundary economic, social and environmental impacts and IWRM requirements'.

In these assessments, the development scenarios are evaluated against 13 main criteria that can measure how well each scenario achieves the countries' objectives of economic development, social development and environmental protection. As well, a basin wide 'equity' indicator is included that measures the degree of 'equitable development' between each country that each scenario produces, taking into account benefits from existing water use and further planned investments in each country.

After basin-wide consultations on the assessment results, the countries will determine which development scenario would provide the most acceptable balance between economic, environmental, and social outcomes in the LMB, and would bring mutual benefits to the LMB countries. It is noted that in choosing a development scenario, the LMB countries are not committing to a particular set of projects (which are in any case subject to feasibility studies, EIAs etc.), but are identifying a development space within which they can plan and work. Conflicts and trade-offs may occur, but within the agreed vision and outcome of the IWRM-based Basin Development Strategy.

Current status of assessment

Basin-scale hydrological assessments have so far been completed for the Baseline, Definite Future and Foreseeable Future Scenarios using the DSF. The hydrological assessment of the Mekong delta flood management scenario under the Foreseeable Future Scenario however is based on local models set up and run by FMMP. Further hydrological assessments of the Long term future situation and of climate change are in the process of being set up.

Based on these assessments preliminary assessments of the *economic, environmental and social impact assessment of basin-wide water resources development scenarios* have been undertaken and are discussed in this report. The proposed methodologies for these assessments were presented 2nd Regional Stakeholder Consultation and Dialogue of the Basin Development Programme held in Chiang Rai in December 2009.

Although these assessments should be considered preliminary, they nevertheless enable an initial overview of the findings to be made from which some significant conclusions may be drawn. These early assessments also prompt consideration of a number of important issues which the countries may wish to discuss and consider further.

Scenarios under consideration

No.	Short Title	Full Title	Development Period	Interventions/Projects
Baseline situation				
1	**BS**	Baseline Scenario		**Year 2000 infrastructure including existing HEP dams**
Definite future situation				
2	**2015-UMD**	Upper Mekong Dam Scenario	2000 - 2015	**Baseline extended to include the full HEP cascade on the Lancang**
3	**2015-DF**	Definite Future Scenario	2000 - 2015	**2015-UMD plus 25 additional HEP dams in LMB and 2008 irrigation and flood measures**
Foreseeable future situation				
4	**2030-20Y**	LMB 20-Year Plan Scenario	2010 - 2030	**2015 DF plus 11 LMB mainstream dams and planned tributary dams, irrigation, and water supply**
5	**2030-20Y-w/o MD**	LMB 20-Year Plan Scenario without mainstream dams	2010 - 2030	**As above, excluding 11 LMB mainstream dams**
6.1	**2030-20Y-w/o LMD**	LMB 20-Year Plan Scenario with 6 mainstream dams in Northern Lao PDR	2010 - 2030	**As above plus 6 LMB mainstream dams in upper LMB**
6.2	**2030-20Y-w/o TMD**	LMB 20-Rear Plan Scenario with 9 mainstream dams	2010 - 2030	**2030-20Y, excluding the two Thai mainstream dams**
6.3	**2030-20y-w/o CMD**	LMB 20-Rear Plan Scenario with 9 mainstream dams	2010-2030	**2030-20Y, excluding the two Cambodian mainstream dams**
7	**2030 – 20Y Flood**	Mekong Delta Flood Management Scenario	2010 - 2030	**Baseline plus 3 options for flood control in Cambodia and Vietnam Delta**
Long term future situation				
8	**2060-LTD**	LMB Long-term Development Scenario	2030-2060	**2030-20Y plus all feasible infrastructure developments in LMB**
9	**2060–VHD**	LMB Very High Development Scenario	2030-2060	**As above, extended to full potential infrastructure developments**

Overview of initial findings

1 Scenarios under consideration

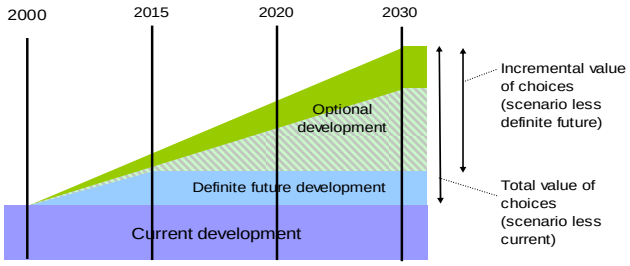
The basin-wide development scenarios under current consideration by the BDP2 assessment team contain a range of economically-driven developments that will or may be taken up within the next 20 years. Further scenarios examining possible longer-term developments (over the next 50 years) and the potential impacts of climate change on both short and long term developments will be assessed in the near future (but are excluded from these initial findings).

The scenarios (see Figure 1 overleaf) have been formulated to help build an understanding of the potential economic, environmental and social impacts (in relation to current conditions) of:

- **The Definite Future Scenarios** – developments within the Upper and Lower Basins that are already under implementation and expected to be in place within the next 5 years (by 2015). These include the completion of six of the cascade of hydropower dams on the Lancang River, referred to as the Upper Mekong Dam Scenario (UMD), and the completion of 25 hydropower projects in the tributaries of Lower Mekong Basin (LMB), which together with the UMB comprise the Definite Future Scenario).

- **The Foreseeable Future Scenarios** – which comprise the developments in the DF plus the developments which each country has put forward as being within their plans to implement within the next 20 years. These comprise further hydropower development in the tributaries and on the mainstream and irrigation development. The scenarios have been structured to investigate the alternative impacts of these developments with and without different combinations of mainstream dams. In addition the Foreseeable Future Scenarios also consider various flood management projects within the Cambodian – Viet Nam floodplain.

Thus, in principle, the assessment of these different scenarios enables an understanding to be built about what changes will occur within the next 5 years, which are already set in motion by past decisions, and what other developments may be taken up, about which there are choices that can still be made.



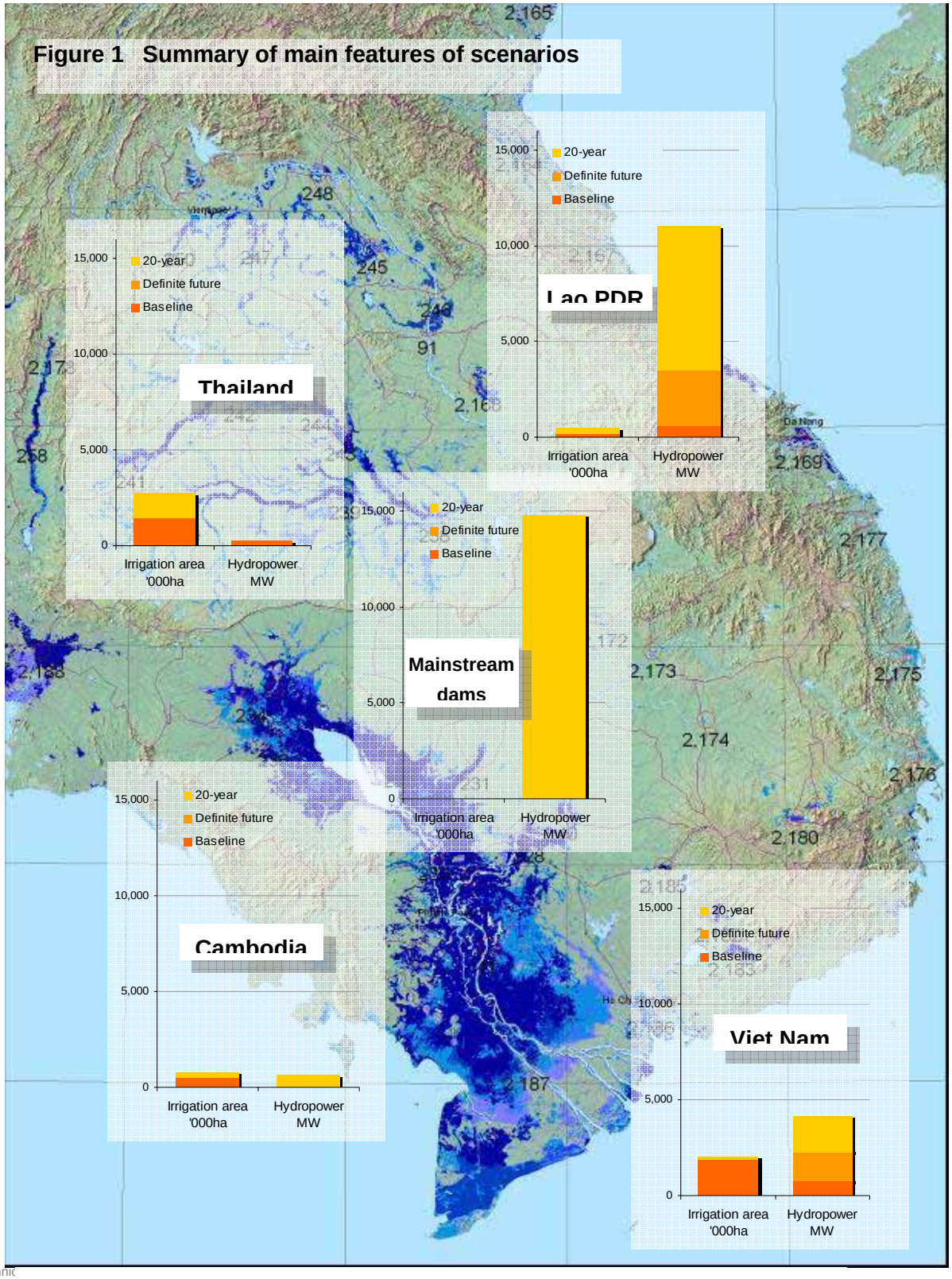
The positive and negative impacts of the Definite Future Scenarios will be shown as incremental values over and above the Baseline Scenario. The Definite Future Scenario can be considered as a new baseline since its changes are inevitable. Therefore, the positive and negative impacts of the Foreseeable Future Scenarios will be shown as:

1) Cumulative values over and above the Baseline Scenario (thus including the impacts of the Definite Future Scenario.

2) Incremental values over and above the Definite Future Scenario.

The assessment of these scenarios is being undertaken following the *Assessment Methodology* presented in draft in October 2009 (see process chart in Appendix A). The assessments are in progress. These initial findings are preliminary in nature and intended to promote discussion and feedback on the emerging key issues. Comments and suggestions on how the assessments may be improved are welcomed.

Figure 1 Summary of main features of scenarios



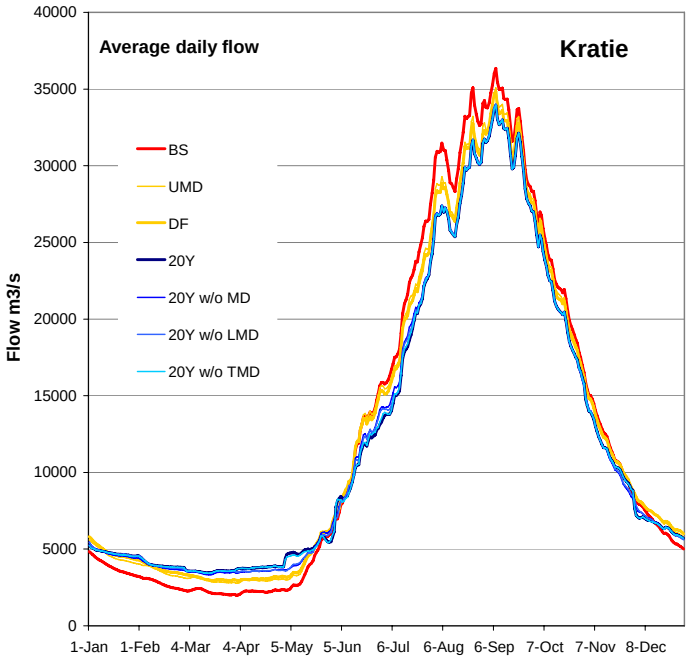
Note: Country charts exclude mainstream hydropower, which is shown separately as above

2 Impacts on river system

The starting point of the assessments has been to determine the impacts of the developments set out in the scenarios on the river system in terms of flow changes caused and the geomorphological changes prompted by these flow changes, by disruption to the natural sediment flows and direct impact of engineered structures.

Changes in the next 5 years

The dams in the UMB under construction will together introduce an additional storage of 23.2 BCM into the basin, which together with the completion of 25 hydropower projects in the LMB with a total active storage of 13.4 BCM, will increase the total active storage in the basin by 379% to an amount equivalent to 10% of the mean annual runoff (MAR). This will have a substantial impact on the natural flow regime of the mainstream, which hitherto has seen no observed change since records begun in 1915.



These changes will manifest in an increase in dry season flows at Kratie of 19% on average raising water levels in the lowest flow month (April) by typically 0.8m. In contrast wet season discharges will reduce by about 4% on average with peak daily flows reduced on average by 7%. Total annual flooded areas will reduce on average by about 6% (Lao 17%, Thailand 19%, Cambodia 5% and Viet Nam 1%). Salinity intrusion will also reduce with the area potentially affected each year being 15% less than currently observed. Flow reversal in the Tonle Sap river will also be affected with reversal occurring typically on average 3 days earlier and with slightly increased variability and 7-8% less flow into Tonle Sap lake.

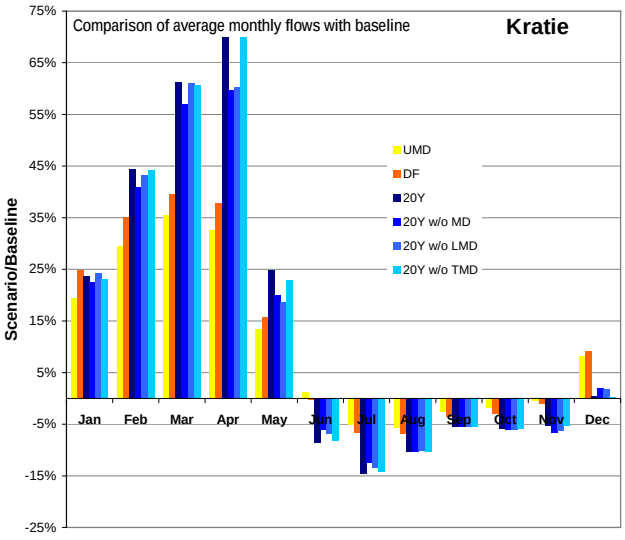
Currently some 40% of the sediments in the mainstream system derive from the UMB, with a further 40% it is believed from the 3-S basin. The impoundments under current implementation will prompt a significant reduction in sediments entering the river system, which will set in process an irreversible change as the river seeks to restore its sediment balance by initially scouring loose sediment deposits and thereafter adjusting its slope to compensate for the reduced sediment load when the loose deposits become exhausted. These changes are unlikely to be significant in the next five years and may only become noticeable beyond 20 years. Due to the reduced wet season discharges, bank erosion may be slightly reduced.

Thus developments under the Definite Future Scenario, which are already in process, will lead to a significant change in the mainstream flow regime within the next 5 years. This change creates opportunities for increased abstractions, will reduce flood damages and the cost of future flood protection works and increase the productivity of in the delta area. At the same time, the reduction in flooding will reduce the productivity of the wetlands systems. All of these things can be confidently expected to happen.

Further changes in the following15 years

The developments included in the Foreseeable Future Scenarios include the rapid expansion of irrigation by 50% over and above current levels (as included in the Definite Future Scenario) and the construction of a further 27 hydropower dams with an additional active storage of 23.1 BCM (representing a 50% increase over the Definite Future Scenario), raising total active storage in the basin to 15% of the MAR. In addition the Foreseeable Future Scenarios include all or some of the 11 identified mainstream dams in the LMB. These are run-of river dams and potentially add in total only a further 3.1 BCM of active storage.

Being run-of-river the mainstream dams would have only marginal effect on the overall mainstream flow regime (although there would clearly be local effects on water levels). At the same time the 68% increase in irrigation abstractions over current levels would be largely offset by the planned increase in active storage.



Overall, compared to the new flow regimes established under the Definite Future Scenario, the different Foreseeable Future Scenarios would cause an average further net increase of dry season flow volumes of typically 3-4% with about a further 4% reduction in wet season flow. Peak daily discharges however would remain largely unchanged. The extent of annual flooding would be marginally decreased from the Definite Future Scenario by typically 1% and potentially affected saline areas reduced by about a further 2%.

These marginal changes from what is expected to occur within 5 years is predicated on the assumption that the envisaged 1.9 million hectares irrigation expansion will occur in parallel with the construction of a further 27 hydropower dams in the LMB tributaries. If the dams were not built, dry season flows in the mainstream could fall below current levels (with consequent impacts on saline intrusion). If the irrigation was not constructed, dry season flows would rise and flooding would be further reduced. The countries may wish to investigate these risks further by looking at alternative scenarios.

As discussed above, the timeline for geomorphological change initiated by the Definite Future Scenario is such that generally these impacts will not become evident within the next 20 years.

However there is some risk that bed levels at Vientiane may start to fall with increased risk of bank erosion.

Beyond 20 years bed level incision in erodible reaches is likely to become more evident and sandbars will start to diminish from the upper reaches progressing to the lower. The geomorphological changes in Cambodian and Viet Nam will be strongly influenced by both engineering works (river containment) and by sea level rise. The strategy for flood plain management will need to take these issues into full account.

3 Environmental impacts

Environmental impacts will arise as a result of the changes in the flow, sediment and nutrient regimes induced by the interventions described above. The potential impacts are discussed below. Studies are continuing and the assessments will be refined as part of this process.

Sandbars, rapids and deep pools and floodplain sedimentation

Understanding how sandbars, rapids and deep pools, which form important habitats for a variety of fish and other aquatic animal species, and floodplain sedimentation are potentially impacted by changes in river flows is founded on the geomorphological findings above.

In broad terms the environmental utility of rapids and deep pools is unlikely to change significantly as a result of flow changes over the next 20 years.

On the other hand sandbars are expected to disappear progressively over time starting from the upstream end, becoming noticeable in the next 20 years. Similarly sedimentation rates on the flood plains are not expected to change very much in this time frame either, but may become more significant in the long term. Other than the direct impacts of sedimentation rates of flood control works, both issues are driven by events in the Definite Future Scenario and only marginally impacted by subsequent developments.

Construction of the mainstream dams under the LMB 20-Year Plan Scenario will heavily affect sandbars, rapids and deep pools. Nearly 60% of the river stretch between Sambor at km 575 and Houei Xai (at km 2,300) will change in character from a free flowing river to a cascade of impoundments. Sandbars and rapids in these impoundments will drown and deep pools will gradually start to fill in. This will have very significant negative impacts on the species diversity. Fish and water birds will be affected most

Bank erosion

The areas currently affected by bank erosion in Lao and Thailand reaches of the mainstream have been identified and are estimated to be of the order of 24 ha/year and 20 ha/year respectively. As discussed above, the vulnerability of these areas will not change significantly within the next 20 years and, if anything, may slightly reduce due to the lower wet season discharges. Similar data for Cambodia and Viet Nam are being sought.

Water quality

Water quality changes will occur due to three main mechanisms, as follows.

Sediment flows and the nutrients associated with these will be largely unaffected in the next 20 years by the entrapment of run-off as described above, since the reductions due to dams will compensated for by scour of loose deposits already in the river. In the longer term, sediments and nutrients may well reduce as a consequence of the storage introduced during the Definite Future Scenario with only marginal reductions attributable to subsequent developments in the Foreseeable Future Scenarios.

The second mechanism is the increased likelihood of **agro-chemical residues** entering the river system as a consequence of agricultural intensification. This intensification is expected to be mainly associated with the expansion of irrigation areas and increased use of agro-chemicals, which are related to the developments associated with the Foreseeable Future Scenarios. The analysis indicates that the Chi-Mun, 3-Ss and Tonle Sap basins are the most likely areas where significant increase residue runoff will occur. However, due to the fact that dry season flows of the main river will increase in the Foreseeable Future, N and P concentrations will most probably remain below threshold values.

The third potential growth is rising **wastewater discharge** due to population growth and increase clustering in urban centres and expanding rural villages and towns. Not only will the volume of waste increase, but also so will its concentration at points of entry to the river system. Nutrient loads from wastewater discharges are small compared with nutrient loads from irrigated agriculture. This, in combination with the fact that sanitation levels in the region are excepted to increase, leads to the conclusion that impacts on water quality of increasing wastewater discharges will only locally be of importance

These pollution sources need to be addressed locally. At the basin-scale it is important that monitoring for any transboundary pollution is continued. All scenarios under consideration increase dry season flows and thus dilute pollution. Reduced inflows to Tonle Sap, and population growth together with economic developments around the lake, suggest water quality in the lake must continue to be carefully monitored.

Inundated areas

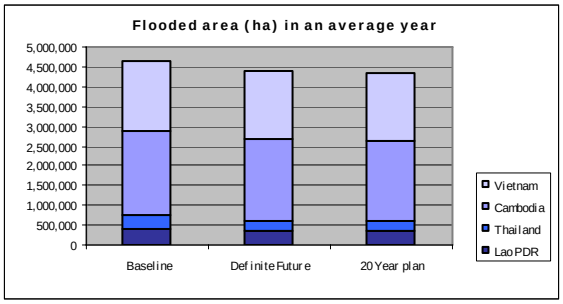
The total area inundated by the mainstream flooding in an average hydrological year reduces from 4.7 million ha to 4.4 million ha (-7%) going from the Baseline to the LMB 20-Year Plan

Inundated area	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	395,035	362,781	2,132,686	1,773,495	4,663,997
Definite Future	331,792	296,012	2,029,312	1,755,508	4,412,623
Change from baseline (ha)	-63,243	-66,769	-103,374	-17,987	-251,374
Change from baseline (%)	*-16.0*	*-18.4*	*-4.8*	*-1.0*	*-5.4*
20 Year plan	328,696	286,808	1,990,988	1,748,251	4,354,743
Change from Definite Future (ha)	-3,096	-9,204	-38,324	-7,257	-57,880
Change from Definite Future (%)	*-0.9*	*-3.1*	*-1.9*	*-0.4*	*-1.3*
Change from baseline (ha)	-66,339	-75,973	-141,698	-25,244	-309,254
Change from baseline (%)	*-16.8*	*-20.9*	*-6.6*	*-1.4*	*-6.6*

Scenario. Changes are biggest in Thailand (-21%) and Lao (-17%), moderate in Cambodia (-7%) and small in Vietnam (-1.5%). In a dry year changes in Lao PDR and Thailand are smaller, only about 3%, in Cambodia bigger: 9%. The impacts are mostly caused by the Definite Future Scenario with relatively small incremental impacts caused by the Foreseeable Future Scenarios.

Inundated forest areas

Inundated forests comprise both seasonally inundated riverine forests and seasonally inundated floodplain forests. Small pockets of floodplain forest in Lao and Thailand are included in the wetland category marshes/seasonal wetlands. Under the Definite Future and LMB 20-Year Plan Scenarios, changes in forest areas in an average year are expected to be small. In Cambodia the presently flooded area will be reduced by about 1%. However, areas of shallow flooding will increase at the expense of deep flooded areas with the average flood depth decreasing by 0.4 to 0.6 m. Average flood duration may also decrease by up to one month in some areas. In dry years the changes are larger than in average hydrological years, in a wet year changes are smaller.



Inundated forest	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	0	0	451,799	45,770	497,569
Definite Future	0	0	449,062	45,551	494,613
Change from baseline (ha)	0	0	-2,737	-219	-2,956
Change from baseline (%)	*0.0*	*0.0*	*-0.6*	*-0.5*	*-0.6*
20 Year plan	0	0	446,794	45,362	492,155
Change from Definite Future (ha)	0	0	-2,269	-189	-2,458
Change from Definite Future (%)	*0.0*	*0.0*	*-0.5*	*-0.4*	*-0.5*
Change from baseline (ha)	0	0	-5,006	-408	-5,414
Change from baseline (%)	*0.0*	*0.0*	*-1.1*	*-0.9*	*-1.1*

Marshes and inundated grasslands

Under the Foreseeable Future Scenarios the area of marshes flooded in an average year decreases by about 18% in Lao PDR and Thailand as compared with the baseline. Most of these changes can already be attributed to the developments in the Definite Future Scenario. In Cambodia marsh areas flooded by the average flood decrease by about 4% under the Foreseeable Future Scenarios as compared to the Baseline Scenario.

Inundated grassland	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	8,989	49,315	315,057	54,775	428,136
Definite Future	5,297	41,816	307,691	54,715	409,519
Change from baseline (ha)	-3,692	-7,499	-7,366	-60	-18,617
Change from baseline (%)	*-41.1*	*-15.2*	*-2.3*	*-0.1*	*-4.3*
20 Year plan	4,664	40,659	303,731	54,691	403,745
Change from Definite Future (ha)	-633	-1,157	-3,960	-24	-5,774
Change from Definite Future (%)	*-12.0*	*-2.8*	*-1.3*	*0.0*	*-1.4*
Change from baseline (ha)	-4,325	-8,656	-11,326	-84	-24,391
Change from baseline (%)	*-48.1*	*-17.6*	*-3.6*	*-0.2*	*-5.7*

Inundated marshes	Lao PDR	Thailand	Cambodia	Vietnam	LMB
Baseline	7,944	11,771	506,580	0	526,295
Definite Future	6,286	9,882	493,062	0	509,230
Change from baseline (ha)	-1,658	-1,889	-13,518	0	-17,065
Change from baseline (%)	*-20.9*	*-16.0*	*-2.7*	*0.0*	*-3.2*
20 Year plan	6,475	9,623	488,499	0	504,597
Change from Definite Future (ha)	189	-259	-4,563	0	-4,633
Change from Definite Future (%)	*3.0*	*-2.6*	*-0.9*	*0.0*	*-0.9*
Change from baseline (ha)	-1,469	-2,148	-18,081	0	-21,698
Change from baseline (%)	*-18.5*	*-18.2*	*-3.6*	*0.0*	*-4.1*

Inundation of grassland will decrease considerably in Lao PDR and Thailand under the Foreseeable Future Scenarios as compared with the Baseline Scenario. Changes in flooded

grassland areas in Cambodia and Vietnam are smaller. Again, where flooded area decreases, so also does the flood depth and duration of the grasslands and changes are bigger in a dry year than in an average or wet year.

Salinity intrusion

The areas affected by salinity intrusion will decrease mainly as a result of the Definite Future Scenario with marginal further changes associated with the Foreseeable Future Scenarios. An assessment is ongoing of the likely impact on land productivity within the saline-affected areas. These are based on estimates of the productivity of land under different salinity conditions and the changes of areas under different salinity classes. The preliminary findings are that the predicted reductions in salinity intrusion will contribute to an increase in agricultural production in the delta area of 470,000 tons under the Definite Future Scenario and a further 27,000 tons under conditions in the Foreseeable Future Scenarios.

Bio-diversity and eco-tourism

Bio-diversity is affected significantly by the predicted reductions in wetlands, changes in sediment and water quality, impoundment of large parts of the main channel under the LMB 20-Year Plan Scenario, as discussed above. Migratory fish species will be highly affected by the expansion of mainstream dams and some tributary dams. This complex subject is still under review as the different assessments being undertaken are brought increasingly together and an overview becomes more possible.

At present, emphasis is being given to the sustainability of four flagship species. Preliminary findings are as follows. The *Mekong Dolphin* and the *Giant Catfish*, which are already under threat from human activity, are both migratory and depend upon access to deep pools. The presence of mainstream dams in the LMB will cut off their access to these pools and hasten the likelihood of their extinction. The *Siamese Crocodile* is currently under threat in the wild, but the changes in the flow regime will cause only small change to its natural habitats. Breeding programmes may ensure the sustainability of this species. The fourth flagship species is the *Sarus Crane*, which depends upon the availability of inundated grassland. This habitat is expected to diminish slightly, but not to the extent that it will threaten the sustainability of this graceful bird.

Flagship species	Baseline	Definite Future	20-Year Plan
Mekong River Dolphin, Irrawaddy Dolphin	High	High	Extinct
Mekong Giant Catfish	High	High	Extinct
Siamese Crocodile	Moderate	Moderate	Moderate
Eastern Sarus Crane	Low	Low	Moderate

Of the 32 identified 'environmental hotspots' (Ramsar Sites, Biosphere Reserves, Protected Areas, and Important Bird Areas) in the impact area, 9 will be moderately and 1 highly affected under the Definite Future Scenario. Due to the large impacts on biodiversity of the Lower Mainstream Dams, the number of highly affected hotspots increases to 12 under the LMB 20- Year Plan Scenario (with mainstream dams).

	No of impacted Hotspots		
	Low	Medium	High
Definite Future Scenario	22	9	1
LMB 20-Year Plan Scenario	11	9	12

Eco-tourism is an economic activity of increasing importance and the disappearance of flagship species and deterioration of environmental hotspots in particular would be expected to have a negative impact on this growing industry. Estimates of the value of this impact are being prepared.

Impacts on the Tonle Sap system

Impacts on the ecologically very important Tonle Sap system can be summarized as follows:

- Reduction of the total flooded area with 60,000 ha (4.5 %) in an average year, and as much as 100,000 ha (9%) in a dry year;
- Reduction of the area of flooded forest with 5,000 ha (1.1%) in an average year to 23,000 ha (5.3 %) in a dry year;
- Reduction of the area of inundated grasslands with 8,500 ha (3.2%) in an average year to 25,000 ha (10 %) in a dry year;
- Reduction of the area of flooded marshes with 3,000 ha (1.0%) in an average year to 5,500 ha (1.8 %) in a dry year;
- Reduction of the area of flooded rice fields of 41,000 ha (18%) in an average year and 48,000 ha (28 %) in a dry year;
- Reduction of flood depth of just over 0.5 m in an average and dry year;
- Reduction of flood duration of the flooded forest area with generally less than 2 weeks in an average year, but up to 1 month in a dry year;
- Reduction in flood duration with generally less than 1 month in an average year in 70% of the inundated grassland area, but an increase of flood duration with up to 1 month in 25% of the area. A similar pattern is to be seen in dry years, even with a bit more pronounced increase;
- A reduction of the reverse flow with 8 (Definite Future) to 13% (LMB 20-Year Plan Scenario);
- Increase of the water level in the dry season with about 30 cm, resulting in a volume increase of 780 MCM, or an increase with over 50%;
- Shift of the flow reversal date of 3 to 8 days (earlier);
- Reduction of sediment inflow in the system of at least 8 to 13%;
- An overall increase in nutrient (and other agro-chemical) inflow into the lake; and
- Blockage of the migration paths (by mainstream dams under the LMB 20-Year Plan Scenario) of a large number of ecologically and commercially important fish species.

Most of the flow related changes are inevitable and will be caused by the Definite Future Scenario. The water quality related impacts would be caused by the agricultural developments in the Cambodian tributaries that discharge into the Tonle Sap Lake under the Foreseeable Future Scenarios (with or without mainstream dams). The resulting changes in environmental conditions in the area will have considerable impacts on the biota. Overall productivity of the system will reduce significantly, as will biodiversity. Under the LMB 20-Year Plan Scenario, white fish production in the area may be halved and the possibilities for local people to collect timber and non-timber products from the wetlands will reduce.

4 Impacts on fisheries

The total consumption of fish and other aquatic animals (OAAs) in the LMB is currently estimated (2008) to be about 2.8 Mt (million tonnes), of which 2.1 Mt is from capture, including some stocked and feral fish. The total production of fish and OAAs in the LMB exceeds 2.8Mt, as a considerable amount is produced by aquaculture and export elsewhere within the MRC countries (but outside the LMB) and to international markets. Current estimates are that total aquaculture is of the order 2.0 Mt, of which more than half is exported outside the basin.

Wild fish yield (catch) covers a very wide range of species and occurs in different habitats. A preliminary assessment has been made to estimate the likely impacts of developments and flow change on the current productivity of fisheries. This has been based on considering broad categories of fish based on their general habitats and the relevance of the fish to consumption patterns. The habitats considered in the preliminary estimates are (i) reservoirs, (ii) rain-fed wetlands and (iii) river-floodplain wetlands.

- The expansion of **reservoirs** is expected to enable an increase in fisheries production and catch in these areas. Current yield is estimate provisionally at about 40,000 tonnes annually. This increase will thus be felt across all scenarios that include dam construction. Yield relationships appear to relate to both reservoir area and depth and data are being reviewed to refine these relationships and estimates.

- **Rain-fed wetlands** comprise principally rice fields and associated small ponds, canals and ditches as well as some remnant marshes and small watercourses. Some rain-fed land is irrigated from storages. Most rain-fed habitat is in Thailand and, to a lesser extent, Lao and is also found in the Cambodia surrounding floodplains and in the Viet Nam delta outside the main flood zone. Rain-fed habitats are large disconnected by various barriers from the main river-floodplain wetlands, so are not vulnerable to dam impacts. The yield of these areas is relatively low per unit area, but due to their extent the total yield is estimated to be in the order of 1.1 million tonnes. Increases are forecast with the expansion of irrigation and the spread of paddy fields.

- **River-floodplain wetlands include all the rivers and floodplains within the major flood zone, defined as all land inundated during the Year 2000 flood.** This land includes recession rice fields, flooded forests, swamps and other floodplain water bodies. A significant proportion of this land is irrigated in the dry season. Fisheries yield per unit area is much higher than in the rain-fed zone, but the river-floodplain zone is much smaller so total yield from the two main zones is similar. Yield from these areas is estimated to be of

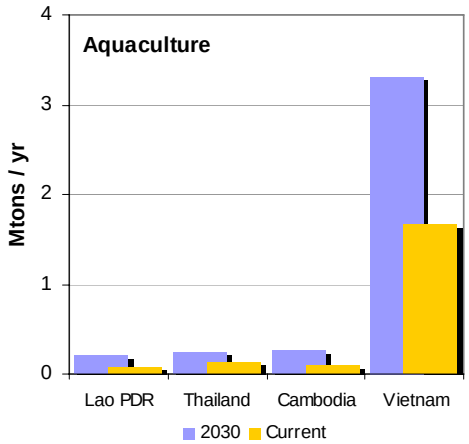
the order of 0.9 million tonnes. They are vulnerable to, *inter alia*, changes in the extent, duration and depth of flooding, changes in the nutrient flows, changes in migration triggers and dislocation of migratory paths by dam construction in both the mainstream and the tributaries and by flood control works. It should be noted that most of this habitat in Thailand is already disconnected by dams and weirs, so is not vulnerable to dams on the mainstream.

Not all the fish in the river-floodplain wetlands need to migrate along rivers, and it has been provisionally estimated that about half the total catch may be vulnerable to changes in the aquatic environment caused by dams; these including barrier effects, alterations to flows and other higher-order effects on water quality and food chains. A large proportion of the catch of fish from the river-floodplain zone are resident on floodplains in water bodies or are locally resident (black or grey fish) so are considered likely to be much less-affected by dams than white fish or other fish that live only within the main river channels. Thus in total it is provisionally estimated that less than about 22% of the total wild fish catch basin wide could be lost wild as a result of mainstream dams. Current estimates are founded on an assumption that all vulnerable fishes will be lost if all eleven dams are constructed, reducing to about 5% if only the mainstream dams in the northern reaches of Lao (where fewer migrations would be dislocated) are constructed.

Taking into account changes in flooding patterns, growth in both reservoir areas and rain-fed wetland areas, the preliminary estimates indicate that only a relatively small change will occur in the Definite Future Scenario. This relates to the decrease in wetland areas, partly offset by minor increases in reservoir areas. The overall loss is only marginally increased in the LMB 2-Year Plan Scenario without mainstream dams.

Unsurprisingly the more significant changes (21% of total yield tonnage) come as a result of the introduction of mainstream dams. However as may be seen, with the current construct of the analyses, the losses are much less if only the most northerly six are constructed (5% of total yield tonnage).

These overall figures mask the inequitable distribution of losses between the four countries. Cambodia risks losing 43% of its wild fish yield and Viet Nam 23%. By contrast, impacts on fisheries in Thailand are likely to be relatively small and Lao may see gains of up to 25%.



The above does not take into account aquaculture which according to Government plans is set to increase to about double the current level over the next 20 years, to the order of 4.0 million tonnes. Aquaculture growth will be driven in part by market prices and it seems probable that the sector has the capacity to step in and replace wild fishery losses. However, whilst the availability of protein may not therefore be an issue, access of the vulnerable poor to these alternatives cannot be assumed as most of the aquaculture production is and will continue to be from the Viet Nam delta.

It is fully recognised that there are many different views on the impacts of development on capture fisheries in the LMB and that some may view these preliminary estimates as understating the problem. However, what is clear is that:

- Without mainstream dam construction the impacts of developments will be both marginally positive and negative, with overall a small decline that will be noticeable as a consequence of the Definite Future Scenario and slightly worsened by further developments in the Foreseeable Future Scenarios.

- With mainstream dams, there will be a significant decline in capture fisheries in Cambodia and Viet Nam if all the mainstream dams are constructed, and that proactive steps will be required to manage the social impacts that will inevitably arise. However, at this stage of the assessment, what is less clear is the extent to which this impact is reduced if mainstream dam construction is limited to the northern reaches of the LMB.

- The preliminary estimates reveal that, in comparison with the Baseline Scenario, the LMB 20-Year Plan Scenario and the LMB 20-Year Plan Scenario without the Thai mainstream dams would cause a large reduction in capture fisheries yield in Cambodia (43%) and Viet Nam (23%), whereas these scenarios may slightly increase capture fisheries yield in Thailand and Lao, mainly due to increases in rice field fisheries and in the case of Lao increases in reservoirs.

- The preliminary estimates also suggest that the LMB 20-Year Scenario with mainstream dams only in Northern Lao PDR would cause only a small reduction in capture fisheries yield in Cambodia (7%) and Vietnam (2%), a finding that is under careful review.

- Aquaculture will continue to grow and overall the tonnage of fish available within the basin is likely to increase in response to demand. However for the many affected, aquaculture *per se* will not mitigate the impacts on livelihoods caused by the loss of wild fish.

- Finally, it is important to understand that the large naturally driven yield from the basin has continued through many decades of intensification of land-use and in spite of a general lack of any kind of management for fisheries production over most of the basin. There is little doubt that large increases in capture fisheries could be achieved by managing water and habitat, by re-instating fish passage across the thousands of existing barriers, by integrating fisheries with agriculture, by stocking and by regulating fishing activities. On the other hand, quite aside from the impacts of dams, intensification of land-use is likely to negatively impact fisheries production unless appropriate measures are taken, for example to control pesticide use and to prevent pollution from agro-processing and other industries.

5 Social impacts

An initial assessment of social impacts in terms of the number of people exposed to changes in the river water resources and connected wetlands, and the number of people who are dependent on these resources for their livelihoods has been done for Cambodia and Lao PDR. The other aspects of the social assessment: exposed people's sensitivity to changes and their resilience, or

available coping strategies, have not yet been addressed. Updated social statistics for Vietnam and Thailand have not been received yet. The work is ongoing following the methodology outlined in the social assessment methodology paper.

The initial overall findings for Cambodia and Lao PDR are presented in the table below.

Specific development objective	Indicator	Unit	Country	Definite Future	20 Year Plan	20 Year Plan w/o MD	20 Year Plan w/o LMD
3.1 Maintain livelihoods of vulnerable resource-users	No. of people affected	000 people		80	1000	12	
Issues: Health, food and income security	Severity of impact on health, food and income security	Trend	Cambodia	-	-----	---	
3.1 Maintain livelihoods of vulnerable resource-users	No. of people affected	000 people		250	900	550	750
Issues: Health, food and income security	Severity of impact on health, food and income security		Lao PDR	---	---	---	---

Cambodia

The main data sources that have been used for the social assessment are:

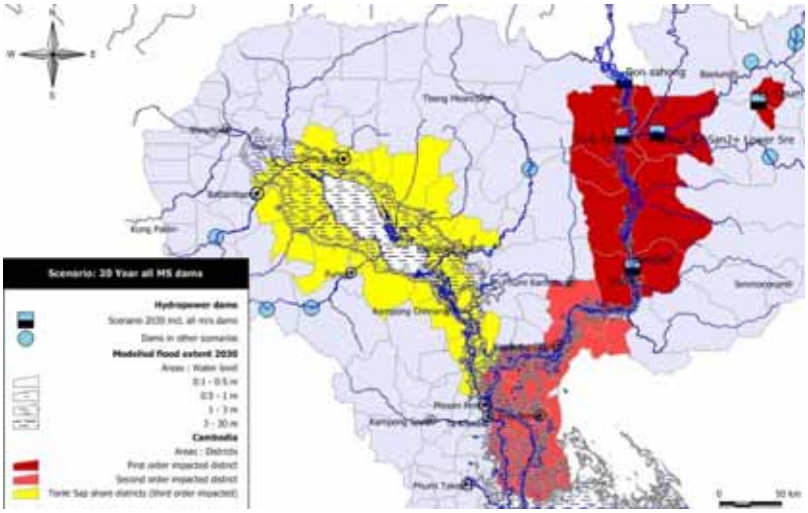
- Cambodia Census 2008 (obtained from NIS in December 2009)
- Commune Database 2007 from NCDD Program (obtained in September 2009)
- Commune Poverty Rate 2007 (obtained from WFP in September 2009)
- Statistical Yearbook of Cambodia 2008 (obtained from Economic Planning Department in 2009)

Definite Future

The number of vulnerable water resource users who are dependent on water resources for their livelihoods - mainly fishing - and who are exposed to changes in the Definite Future are assessed to be 80,000 people. The Definite Future Scenario only impacts Cambodia through loss of fisheries from upstream dams, and a small number of people in a Krong Ban Leung district where a dam will be constructed. The loss of fisheries is initially assessed by the Fisheries Program to be 8 percent of current river fish production. Based on analysis of the Census data, described below, it is assessed that 1 million people are dependent on river fisheries in Cambodia. At this stage of the analysis the 8 percent loss in fisheries production is simply assumed to affect 8 percent of the fisheries dependent population, i.e., 80,000 people.

LMB 20-Year Plan Scenario (with all mainstream dams)

This scenario includes the Sambor Dam, Stung Treng Dam, Lower Se San 2 and Lower Srepok 2 Dam, and the Ou Chum Dam. The Don Sahong dam in Lao PDR almost on the border to Cambodia will also have an effect downstream in Cambodia. The Districts exposed to changes in the river system due to these dams have been selected as the Districts on both sides of the mainstream and around the Tonle Sap. They have grouped into first, second and third order impacted Districts, for a later refinement of the analysis. The Districts and the grouping are shown in the map.



The Districts between Don Sahong and Sambor dams are considered impacted of the first order since they will be between two dams blocking all fish migration into and out of that stretch of river. The Districts adjacent to the river below Sambor and to the border to Vietnam are considered second order impacted since most of the water comes through the Sambor dam, but there are large floodplains which can provide habitats for fish and the area is still linked to the Tonle Sap system. Tonle Sap itself is considered third order impacted. However, it is not known exactly how the dams in the LMB 20-Year Plan Scenario will affect the fish and aquatic animals. The preliminary fisheries assessment estimates that 265,349 tons of fish production will be lost in Cambodia's connected wetlands in this scenario, which is considered a severe negative impact.

Cambodia

Key statistics	First order impacted districts	Second order impacted districts	Tonle Sap shore 3rd order impacted districts	Total
Nos Districts in LMB	10	27	20	57
Total Population Census 08	285,876	2,504,509	1,675,117	4,465,502
Rural Population	220,504	2,342,970	1,635,234	4,198,708
Nos HHs - total	76,309	568,042	348,699	993,050
Nos HHs fishing main occupation	1,298	13,087	15,443	29,828
Male Fisheries Employment	659	11,903	20,603	33,165
Female Fisheries Employment	307	6,418	14,447	21,172
Nos HHs participating in fishing community	14,858	11,024	31,657	57,539
Nos rowing boats used for fishing	10,783	60,853	53,662	125,298
Nos motorboats used for fishing	4,297	18,508	19,554	42,359

Vulnerable population	HHs	High (total) Nos. people	Low value	Low Nos. people	Middle value	Comments
Fishing Main Occupation	29,828	147,623	100%	147,623		Proxy for Large scale fishing
Participating in Fishing Community*	57,539	284,769	50%	142,385		Proxy for Medium scale fisheries
Subsistence fisheries in river/connected wetlands	125,298	620,118	50%	310,059		Proxy is nos. rowing boats used for fishing: 1 per HH
Totals	212,665	1,052,510		600,067	800,000	
Add secondary occupations dependent on fisheries (yet to be calculated					200,000	
Overall preliminary assessment					**1,000,000**	
Assessment: severity of impacts: severe:					-----	

The vulnerable population is defined as households (HHs) with fishing as a main occupation, with a workforce of males and females employed in fisheries, with HHs who participate in the fishing community and HHs who own a rowing boat for fishing (used as a proxy for subsistence fisheries in water bodies that are linked to river system). Adding all people in households with fishing as main occupation, households participating in the fishing community and households owning a rowing boat used for fishing, a total high estimate of 1,000,000 people engaged in fishing activities is arrived at. Assuming some overlap between households with fishing as main occupation and households participating in the fishing community and thus reducing the latter to 50%, and further assuming only 50% of the people in households owning a rowing boat used for fishing are dependent on fishing, a conservative estimate of 600,000 people engaged in fishing activities is arrived at. The middle value between the high and low estimates of 800,000 people is then used. To this is added an estimated 200,000 people (around 45-50,000 households) that are in other occupations and livelihoods that are dependent on fisheries. The total is thus vulnerable 1,000,000 people.

Further analysis will be made on the number of people involved in occupations that are dependent on the inland fisheries in Cambodia. The severity of the social impacts through the impacts on the fisheries is dependent on what those impacts will be. For example, there is a big difference between a 20% reduction and a 50% reduction in the fish catches in Tonle Sap. The range in possible impacts on fisheries gives a range in impacts on livelihoods. It is however likely that the large-scale and medium scale fisheries would be hardest hit, whereas subsistence fisheries could increase effort and/or fish in alternative habitats to the main river system.

<u>LMB 20-Year Plan Scenario without mainstream dams</u>

In this scenario only two dams, both located in Sesan District, are in included, and the social impacts are assessed to be relatively limited. The resettlement of 4,700 people is an issue, however, it is – optimistically – assumed that adequate social safe guards would be implemented.

Sesan District	HHs	Nos people	Comments
Nos HHs participating in fishing community	277	1,523	Average HH size 5.5
Nos of rowing boats used for fishing	1,080	5,940	Assuming 1 boat per HH
To be resettled		4,700	
Sub-total		12,163	
Rounded nos. of vulnerable affected people		**12,000**	

Lao PDR

A preliminary social assessment of impacts in Lao PDR has been made using the Census 2005 and the LECS4 of 2007/08. The latter survey covers the whole of Lao PDR with a sample of more than 8,000 households. It includes information on the involvement in fisheries.

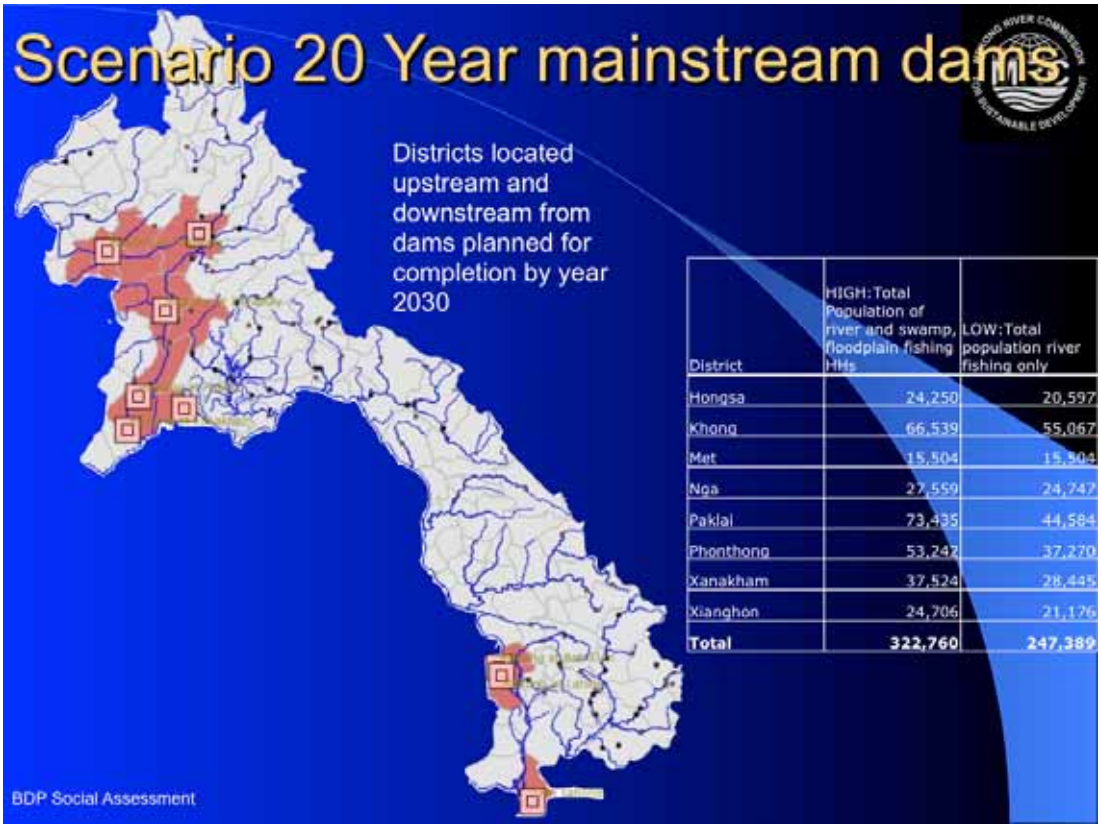
The LECS4 data shows that the population in Lao PDR overwhelmingly is engaged in capture fisheries with 74% of all households in the country having fished in the previous last 12 months. Of these 78% catch fish in rivers. This compares to 19% of all households that catch fish in rice fields.

LECS4 2007/8 Data on fisheries

Variables	Nos HHs	Percent of total	Percent of fishing HHs
Nos of HHs engaged in fishing	6,338	77%	
Pond fish culture	1,210	15%	19%
Cultivated rice field fish culture	398	5%	6%
Cage fish culture	177	2%	3%
Integrated pond fish culture	131	2%	2%
Community fish culture	88	1%	1%
Fish seed culture	26	0%	0%
Capture fishing last 12 months	6,096	74%	96%
River capture fishing	4,914	60%	78%
Lake reservoir fishing	2,733	33%	43%
Swamps, floodplains fishing	1,566	19%	25%
Rice field fishing	1,529	19%	24%
Sample nos of households - nationwide		*8248*	

It should be noted that the importance of capture fisheries varies between households. However, the LECS4 also reports on households' capture fisheries in the last 24 hours (before the time of interview), and this shows that 21% of households had been fishing during that limited period of time, spending on average 2.8 hours on this activity (refer to graph and statistical report below). This indicates a general high importance of capture fisheries for subsistence and food security.

With the planned number of dams in Lao PDR, the natural fish yield in the dammed rivers is expected to decline dramatically, which will affect a large part of the population using these rivers. The social assessment uses the same approach as for Cambodia by identifying the Districts, which will be exposed to the changes in the river flows in each of the scenarios, and thereby assess how many people will be affected. Simple selection criteria based on upstream and/or down-stream location from dams have been applied. The following map show an example of the GIS based analysis.



District	HIGH: Total Population of river and swamp, floodplain fishing HHs	LOW: Total population river fishing only
Hongsa	24,250	20,597
Khong	66,539	55,067
Met	15,504	15,504
Nga	27,559	24,747
Paklai	73,435	44,584
Phonthong	53,242	37,270
Xanakham	37,524	28,445
Xianghon	24,706	21,176
Total	**322,760**	**247,389**

The number of vulnerable resource users in the various scenarios has then been calculated as shown in below table. A 'high' figure has been obtained by including both households that have fished in rivers and floodplains/swamps, and a 'low' figure by including only river fishing households; the middle value of these two figures has then been used.

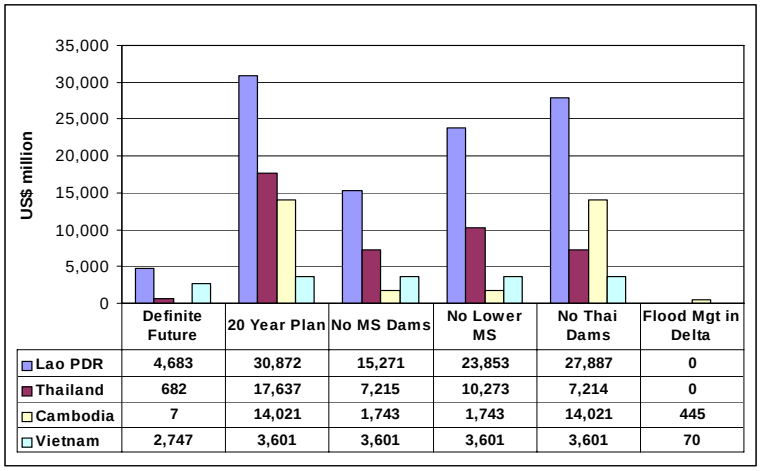
Scenario	Middle value reported to main table	HIGH: Total Population of river and swamp, floodplain fishing HHs	LOW: Total population river fishing only
Definite Future			
Rounded	250,000	300,000	300,000
20 Year Plan Scenario			
20 Y tributary districts up-downstream of dams		643,526	544,616
Mainstream districts affected by dams		322,760	247,389
Sub-total 20Y scenario		966,286	792,005
Rounded	900,000	1,000,000	800,000
20 Year Plan Scenario w/o MD			
20 Y tributary districts up-downstream of dams			
Rounded	550,000	600,000	500,900
20 Year Plan Scenario w/o LMD			
20 Y tributary districts up-downstream of dams		643,526	544,616
Mainstream districts affected by dams		322,760	247,389
Subtract districts affected by mainstream dams in the lower part		-119,782	-92,337
Total scenario		846,504	699,668
Reounded	**750,000**	**800,000**	**700,000**

6 Economic impacts

Economics impacts have been evaluated for all scenarios following the methodologies set out in the October 2009 draft report. Results are included in the tables 1-5 at the end of this report and are summarised here by scenario, sector and country.

The investment costs range from approximately US$8 billion in the Definite Future Scenario to US$65 billion in the LMB 20-Year Plan Scenario. The major part comprises investments in hydropower developments.

Investment costs by country and development and scenarios



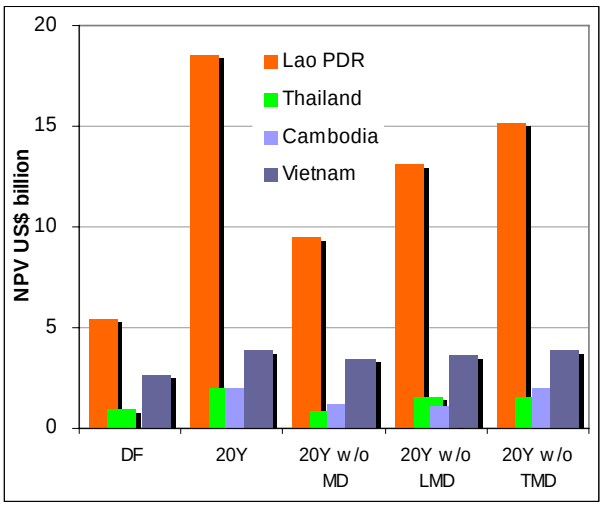
	Definite Future	20 Year Plan	No MS Dams	No Lower MS	No Thai Dams	Flood Mgt in Delta
Lao PDR	4,683	30,872	15,271	23,853	27,887	0
Thailand	682	17,637	7,215	10,273	7,214	0
Cambodia	7	14,021	1,743	1,743	14,021	445
Vietnam	2,747	3,601	3,601	3,601	3,601	70

Comparison of total economic NPV by development scenario, sector and country

US$ million

	3000 DF	4000 20Y	5000 20Y w/o MD	6000 20Y w/o LMD	6100 20Y w/o TMD	7000 Flood management
Hydropower	8,200	26,335	14,037	18,596	22,821	
Irrigated Agriculture	0	86	86	86	86	
Flood Management	0	0	0	0	0	224
Reservoir Fisheries	429	456	428	451	445	0
Aquaculture	0	679	679	679	679	0
Capture Fisheries						
NPV fish catch losses	-392	-1,480	-239	-350	-1,480	0
NPV wetland area lost	-21	-17	0	0	0	0
Flood Mitigation	777	367	0	0	0	0
Saline Intrusion	77	n	n	n	n	0
Riverbank erosion	0	n	n	n	n	0
Navigation	64	n	n	n	n	0
Total LMB	**9,133**	**26,427**	**14,991**	**19,462**	**22,551**	**224**
Lao PDR	5,450	18,549	9,497	13,102	15,178	
Thailand	989	1,946	865	1,581	1,550	
Cambodia	-21	2,012	1,197	1,158	1,974	254
Vietnam	2,715	3,920	3,432	3,621	3,849	-30
Total LMB	**9,133**	**26,427**	**14,991**	**19,462**	**22,551**	**224**

The evaluations demonstrate the overwhelming significance of hydropower as an economic driver within the water resources sector of the LMB. On top of current developments in the Definite Future Scenario, the 27 tributary hydropower dams in the Foreseeable Future Scenarios have a net present value (NPV[1]) of US$5.8 billion in economic terms, and the eleven mainstream dams potentially would add a further US$12.3 billion to this. In contrast all other productive sectors generate at most 12% of the hydropower NPV and losses incurred in wetlands and fisheries are at most 7% of the hydropower NPV. From a purely economic standpoint, the case for pursuing a hydropower orientated strategy is very strong at basin scale.



It should be noted however that investment decisions in hydropower are generally made on financial grounds and are greatly influenced by the tariffs that the energy generated can command. Analyses conducted in the BDP2 study of hydropower benefits suggest that, notwithstanding their economic

[1] NPV: the current worth of benefits incurred in the future less capital and recurrent costs discounted in this case at 10%. A project with a zero NPV would equate to one with a 10% internal rate of return.

attractiveness, it can be expected that somewhere in the order of 20% of the installed capacity in the Foreseeable Future Scenarios may be difficult to finance. Further more, from the analyses undertaken, these 20% represent some 69% of the incremental storage associated with this scenario.

Economic losses in the fisheries sector, whilst offset by increases in reservoir fisheries and potential increased productivity in aquaculture, are of the order of US$ 0.4 billion NPV, considerably greater than the predicted gains from irrigation. With mainstream dams these losses rise to US$ 1.6 billion NPV. The point here is not that this is small compared to the hydropower benefits but that this loss would have to largely borne by the rural fishing community, many of whom are the vulnerable poor.

Economic benefits from irrigation are modest due to the negative NPV for the large increase in irrigation in Thailand. The reason is a too low cropping intensity as there is limited scope for dry season cropping in the absence of storage reservoirs.

The distribution of net economic benefits between countries is substantially determined by the value of economic benefits accruing to each country. This is based on a conventional approach whereby both the power generator and the power user both benefit from the power generated. Lao as the largest potential power generator benefits economically the most under these assumptions in all scenarios. Under the LMB 20-Year Plan Scenario, the economic benefits to Cambodia are relatively low due to the adverse impact on capture fisheries and the negative NPV of the Stung Treng mainstream dam.

7 Initial findings

The assessment of the scenarios is continuing. As reported here, there are areas where further work is needed to refine and improve the impact estimates. There are also further important scenarios to consider, including long term perspectives and the potential impacts of climate change, particularly that of sea level rise.

However, it is possible from the work undertaken to date to identify some important findings which are unlikely to be changed by further studies. These are summarised below.

The Definite Future Scenario

- The developments under the Definite Future Scenario will have a significant impact on the natural regime of the river, which has hitherto remained substantially unchanged since records begun. Dry season flows will increase and flood flows will decrease and the river will commence an irreversible process of geomorphological adjustment, with predicted significant adverse impacts in the longer term.

- The increase in dry season flows will make possible increased abstractions from the mainstream without causing flows to fall below the historic low flow regime and without causing an adverse movement in saline intrusion in the delta. However, as defined, the scenarios as yet do not confirm the feasible extent of these incremental abstractions, but

they are expected to be significant. Some significant improvements to navigation are likely, particularly in the upper reaches of the mainstream.

- The reduction in wet season flows will have benefit in reducing flood damage and the cost of flood protection works.

- On the other hand, the irreversible changes caused by this scenario will result in a reduction in natural flooding will occur which will diminish the productivity of wetlands, seasonally flooded forests and capture fisheries, as well as species diversity. This will have impacts on rural communities whose livelihoods are dependent on the wetlands.

The LMB 20-Year Plan Scenario without mainstream dams

- The combination of the additional dry season flows generated by the firm developments in the Definite Future Scenario with the proposed 27 additional tributary storages will enable the development of the 1.9 million hectares of irrigation in the scenario without causing flows to fall below the historic low flow regime and without causing an adverse movement in saline intrusion in the delta. In fact, analyses suggest that there will still be a small amount of surplus water under these developments. Thus, from the single perspective of water availability, the consumptive water uses in the Foreseeable Future Scenarios can be sourced by the 'new' water that will become available through the redistribution of water from the wet to the dry season by the hydropower developments in the scenario.

- Under this scenario, there will be a small further decrease in flooding compared to that achieved in the Definite Future Scenario with small, but similar, incremental benefits and disbenefits. The tributary dams will have a negative and largely local impact on capture fisheries offset in yield terms by the opportunity to increase reservoir fisheries but still having a degree of social impact, particularly with regard to food security amongst local people along stretches of the rivers. Construction activities will also have significant local social impacts.

- Considerable changes in the ecology of the Tonle Sap Lake would be induced by a combination of a decrease in reverse flow (mainly caused under the Definite Future Scenario) and increased discharge of nutrients (and other agro-chemical) into the lake from tributaries in Cambodia. The resulting consequences in terms of capture fisheries yield and biodiversity might be felt throughout the Mekong Basin.

- Substantial net economic benefits (NPV US$ 6.3 billion) will be derived from the proposed developments with only a small change in losses to capture fisheries (NPV US$ 0.03 billion) compared to the Definite Future Scenario.

The LMB 20-Year Plan Scenario

- The construction of mainstream dams will have little effect on the prevailing regional flow regime of the mainstream, notwithstanding that there may be local effects that need to be addressed during project design. Some benefit may be gained in stabilising bed level changes induced by the trapping of sediments in the Definite Future Scenario.

- This scenario would severely affect capture fisheries production in Cambodia and Viet Nam, with the scale of impact increasing from the upstream dam locations to the downstream dam locations. The construction of all proposed dams is currently forecast to reduce capture fisheries by 0.45 million tonnes, felt mostly in Cambodia, risking 43% of its wild fish yield, and Viet Nam, risking 23%. The reduction in fisheries will have substantial negative social consequences in the affected areas, especially in Cambodia where conservatively the livelihoods of 600,000 to a million people are directly dependent upon capture fisheries. The social impacts in Lao PDR are in the same order of magnitude. Construction activities will have significant local social impacts.

- From a total production perspective, the large reduction of capture fisheries production under this scenario could be offset by increases in aquaculture (including rice field and reservoir fisheries), as is currently demonstrated in the Vietnam Delta and Northeast Thailand, where water resources development has increased the benefits from fisheries. This perspective does not take into account distributional concerns and without adequate, proactive Government policies and programmes, the predicted increases in aquaculture would not benefit the poor people, who would lose their wild fishing and currently have no access to land, water and capital.

- Two of the four flagship species would be very severely impacted, raising the spectre of extinction. Twelve out of the 32 environmental hotspots would be highly impacted and another 9 moderately impacted. Construction of the mainstream dams will change 60% of the free flowing river channel between Kratie and Houei Xai to a series of connected impoundments. Important habitats like deep pools, rapids and sandbars will be lost largely, resulting in severe loss of biodiversity. Construction of mainstream dams in the northern reaches of the LMB is expected to have significantly less impacts on both capture fisheries and flagship species.

- The conditions in the Tonle Sap area will change considerably, leading to a loss of primary production of 20-30%, a possible loss of white fish production of some 50%, a significant loss in biodiversity, and loss of harvestable forest and non-forest products for local people.

- The LMB 20-Year Plan Scenario without the two Cambodian mainstream dams would have less severe impacts. Fish migration up the 3Ss-Basin would still be possible and the ecologically very valuable stretch between Kratie and the Cambodia-Lao border would maintain its natural character.

- The 11 LMB mainstream dams together have a substantial economic value ((NPV US$ 12.3 billion), the benefits of which would be felt throughout the LMB. In economic terms, the LMB 20-Year Scenario would benefit all LMB countries more than the other considered foreseeable future scenarios.

Sharing benefits, risks and impacts.

The Foreseeable Future Scenarios will require very large investments (of the order of US$ 30-65 billion across all countries) and will produce very substantial benefits, of the order of US$

15- 25 billion. These benefits will benefit all countries but will be spread unevenly across the four countries, depending on which of the various components of the LMB 20-Year Plan Scenario are aggregated. But generally, Lao PDR will gain most as the largest hydropower operator but others will benefit also as both producers and consumers of electricity. Irrigation gains will also be significant. Under the LMB 20-Year Plan Scenario, Cambodia will benefit less than other countries, due to adverse impacts on capture fisheries and, in one case, a less attractive hydropower development (Cambodia is also the only country that will have to cope with an overall economic loss from the Definite Future Scenario).

With such a variance in the distribution of benefits, it becomes important to consider the overall 'equity' between countries of basin wide developments, to look closely at how adverse impacts are also distributed. Which country suffers more than others, what type of disbenefits occur, which sectors and which groups of the basin communities are effected, how do these disbenefits relate to the longer term socio-economic plans of the countries and for regions/provinces within countries – these are all questions that must be considered and discussed in the wider context of basin wide benefit and impact sharing, and country to country trade-offs debates.

Benefit and impact sharing in international (or transboundary) water resources management is not a new concept. How it could be implemented will vary with the particular basin-wide circumstances (size, nature and spread of both benefits and impacts) and the political and socio-economic issues that apply to the countries in a basin. Many of the existing transboundary benefit sharing agreements relate more to specific development projects and how both benefits and impacts from the project are shared across governments and across affected communities.

In the case of the BDP and the basin-wide development scenario approach, we are operating above the individual project level and considering 'packages of projects' (i.e., the various scenarios), which relate more to 'cumulative development impacts' rather than a single project basis. This may lead to a much broader consideration of benefits and impacts and may need particular techniques and concepts that are more suited to this scenario assessment approach.

A background paper will be prepared on benefit and impact sharing that will provide a wider view on this issue to assist the countries with the difficult discussions on scenario assessment results that will occur when the final results are available. This paper will also take account of the on-going work within the MRCS hydropower initiative that is looking at benefit sharing within the context of hydropower projects.

Risks and uncertainties

There are inevitable risks and uncertainties associated with the accuracy of forecasted impacts and the assessment team will need to remain conscious of these. As the assessment proceeds the effect of varied assumptions will need to be considered and addressed in a transparent manner.

Separate to these computational issues, the assessments undertaken so far have identified four key risks as outlined below (others may later emerge as the assessments advance).

- As noted above, the viability of hydropower dams is largely determined on financial grounds, an issue not addressed in the agreed assessment criteria. Preliminary analyses suggest that not all of the hydropower dams will readily attract financing, putting at risk the assumption that all new storages will be constructed within the envisaged time horizon.

- The above risk is compounded by consideration of the rate of investments required. The very large expenditure required is substantially above historic levels which will pose considerable institutional challenges to deliver the infrastructure on time and manage associated safeguards processes. In addition access to bank credit may remain an issue for developers in the near term at least.

- Both of the above raise the possibility that not all the additional storage (28 BCM) will be provided under the Foreseeable Future Scenarios as currently proposed. As may be seen for conditions at Kratie in January, the infrastructure added between the Definite Future Scenario and the 20-year Foreseeable Future includes 1.9Mha of irrigation. These two parallel investments cause the January flows at Kratie to stay almost the same (in fact a slight reduction occurs) notwithstanding the additional 4.7 BCM abstracted to service the new irrigation area. Given that the flows in the river remain the same then it follows that this additional abstraction is made possible by the incremental storage. Thus, in very rough terms, if the incremental storage was not installed but the incremental irrigation was, then this would lead to an approximate 2.4 BCM deficit (23%) compared to the baseline.

- The new dams in the UMB will have a major impact of the availability of surplus dry season flows. The flow augmentation they will provide has been discussed with experts from China and there are grounds to consider that conservative estimates have been made about the operation of the new dams. Nevertheless it should be recognised that the assessments now being made assume continued cooperation on the part of the dams' operators. Although this may be deemed as a low risk, the reliance that may be in the future placed upon these flows prompts that a more formal understanding is reached with China to ensure security of flows.

It is important that risk areas are carefully monitored and reviewed on a regular basis. Particular attention needs to be given not only to flow and water quality data, but also to water use monitoring particularly with regard to infrastructure development[2]. By adopting a five-year review period for the IWRM-based Basin Development Strategy, there are sufficient checks and balances to incorporate the above uncertainties in future planning reviews.

[2] In this regard the Project Master Database discussed with RTWG last year would be a valuable tool. At regular intervals, say 1-or 5-yearly the developments of all countries could be updated with refreshed baselines using the Projects Database and these tested using the DSF in similar fashion as it has been used to support the current assessments reported on here.

8 Recommendations

The assessment results summarized in this note are preliminary and incomplete. The environmental and socio-economic assessment of the basin-wide scenarios for the definite and foreseeable futures is ongoing. The long-term scenarios, which, amongst others, study alternative management strategies for the floodplains, are being formulated. Also the potential impacts of climate change have yet to be modelled.

Nevertheless, the provided results offer a first opportunity to 'rise above' the mere impact figures and take a 'overarching view' of the preliminary results in terms of: the critical differences between scenarios; the options for basin development; emerging synergies, trade-offs, and options for benefit sharing; the key weaknesses in the assessment methodology; and suggestions for the ongoing assessment process. It is recommended that the 8th RTWG and national and regional processes during February 2010 will aim at initiating the development of such an overarching view. Achieving this aim would comprise a major step forward in the ongoing basin planning process.

The immediate next milestones are:

- End February 2010 – Model run of climate change scenarios and long term scenarios
- End March – early April 2010 - Interim findings from scenario assessment (all scenarios, with and without climate change impact)
- June, 2010 – Draft final scenario assessment report

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Table 1 Summary of assessments – Lower Mekong Basin

Assessment Criteria				Scenarios									
Specific development objective	Issue	Indicator		1000	2000	3000	4000	5000	6000	6100	7000	7001	7002
		Description	Unit	BS	LMD	DF	20Y	20Y w/o MD	20Y w/o LMD	20Y w/o TMD	FMMP1	FMMP2	FMMP3
1. Economic development													
1.1 Increase irrigated agricultural production	Irrigable area, production tonnage and value	Incremental area	'000 ha			No change in area	1,991	1,991	1,991	1,991	438		438
		Incremental crop production	'000 tpa				8,058	8,058	8,058	8,058			
		Net incremental economic value	NPV US$m				86	86	86	86	264		264
1.2 Increase hydropower production	Hydropower capacity, power generated and value	Incremental installed capacity	MW			6,032	27,506	11,241	20,248	24,556			
		Incremental power generated	GWh/year			27,543	119,476	51,541	85,076	117,460			
		Net incremental economic value	NPV US$m			8,200	26,335	14,037	18,596	22,821			
1.3 Improve navigation	River transport	Incremental IWT tonnage in dry season	'000 tpa			+	+	+	+	+			
		Net incremental economic value	NPV US$m			64	64	64	64	64			
1.4 Decrease damages by floods	Extent and duration of annual flooding by class	Average flooded area reduction	'000 ha			200	237	237	237	237	875	1,300	2,175
		Incremental net economic value of flood damage avoided	NPV US$m			455	367	367	367	367	-37	0	-37
1.6 Maintain productivity of fishery sector	Capture fisheries and aquaculture production	Incremental annual average capture fish availability	'000 tpa			-30	-339	10	13	-349			
		Incremental annual average aquaculture production	'000 tpa			715	2,055	2,055	2,055	2,055			
		Net incremental economic value	NPV US$m			1,969	-345	869	777	-356	-3		-3
2. Environmental protection													
2.1 Maintain water quality and acceptable flow conditions	Water quality	Water quality incl. sediment in transport in mainstream	Trend	Baseline	Hydrological assessment only	–	---	----	-----	-----	N	N	N
	Flow characteristics	Key flow characteristics	Trend			N	N	N	N	N	N	N	N
	Protection of forests around Tonle Sap	Forest flooded for specified depth duration at Tonle Sap	'000 ha			449	447	447	447	447			
		Net incremental economic values	NPV US$m										
2.2 Maintain wetland productivity and ecosystem services	Productivity of wetland ecosystems	Incremental wetlands with required depth-duration	'000 ha			1,329	1,317	1,317	1,317	1,317			
		Net incremental economic value	NPV US$m			-21	-17	-17	-17	-17	-1		-1
2.3 Manage salinity intrusion in the Mekong delta	Impact of salinity intrusion on land use potential	Area within delta within thresholds of salinity levels	'000 ha			1,580	1,540	1,540	1,540	1,540			
		Net incremental economic value	NPV US$m			+	+	+	+	+			
2.4 Minimize channel effects on bank erosion and deep pools	River bank erosion	Incremental area at risk to erosion	'000 ha										
		Vulnerability to bank erosion	Trend			+	N	+	N	N	N	N	N
		Net incremental economic values	NPV US$m			N	N	N	N	N	N	N	N
	Impact of flow and sediment transport changes on deep pools	Sediment loads at specified locations on mainstream	Trend			N	N	N	N	N	N	N	N
		Water levels at specified locations on mainstream	Trend			N	N	N	N	N	N	N	N
		Net incremental economic values	Trend			N	N	N	N	N	N	N	N
2.6 Conservation of biodiversity	Impacts of flow management changes on endangered species	Incremental area of suitable habitats	'000 ha			4,437	4,397	4,397	4,397	4,397			
		Estimated number of species affected	no.										
		Incremental net economic value of habitat areas	NPV US$m			-	—	-	--	--			
3. Social development													
3.1 Maintain livelihoods of vulnerable resource-users	Health, food and income security	No. of people affected	'000 people			330	2,100	890	1,000				
		Severity of impact on health, food and income security	Trend			-	—	-	--	--	N	N	N
3.4 Increased employment generation in water related sectors	Incremental sustainable employment from water resource interventions	Incremental number of people engaged in:											
		Agriculture	'000				212	212	212	212	15	2	17
			'000										
		Water-related service industries	'000										
		Fisheries	'000			309	532	500	507	528			
4 Equitable development													
4.1 Ensure that all four LMB countries benefit from the development of water and related resources	Aggregate benefits by country	Summation of incremental net economic benefits	NPV US$m			10,668	26,480	15,408	19,873	22,966	223	0	223
		Summary of non-quantifiable impacts	Social			-	—	--	-	N	N	N	N
			Environmental			N	-	-	-	-	N	N	N

Table 2 Summary of assessments – Lao PDR

Assessment Criteria				Scenarios									
Specific development objective	Issue	Indicator		1000	2000	3000	4000	5000	6000	6100	7000	7001	7002
		Description	Unit	BS	LMD	DF	20Y	20Y w/o MD	20Y w/o LMD	20Y w/o TMD	FMMP1	FMMP2	FMMP3
1. Economic development													
1.1 Increase irrigated agricultural production	Irrigable area, production tonnage and value	Incremental area	1000 ha			No impact in area	285	285	285	285			
		Incremental crop production	1000 ton				1,994	1,994	1,994	1,994			
		Net incremental economic value	NPV US$m				322	322	322	322			
1.2 Increase hydropower production	Hydropower capacity, power generated and value	Incremental installed capacity	MW			3,502	18,449	7,939	15,418	16,974			
		Incremental power generated	GWh/year			16,435	83,596	36,879	69,285	83,058			
		Net incremental economic value	NPV US$m			5,072	17,892	8,930	12,555	14,648			
1.3 Improve navigation	River transport	Incremental IWT tonnage in dry season	1000 ton			N	N	N	N	N			
		Net incremental economic value	NPV US$m										
1.4 Decrease damages by floods	Extent and duration of annual flooding by class	Average flooded area reduction	1000 ha			62	66	66	66	66			
		Incremental net economic value of flood damage avoided	NPV US$m			175	128	126	126	126			
1.5 Maintain productivity of fishery sector	Capture fisheries and aquaculture production	Incremental annual average capture fish availability	1000 ton			5	34	37	34	31			
		Incremental annual average aquaculture production	1000 ton			72	128	126	126	126			
		Net incremental economic value	NPV US$m			218	211	246	225	208			
2. Environmental protection													
2.1 Maintain water quality and acceptable flow conditions	Water quality	Water quality incl. sediment in transport in mainstream	Trend	Baseline	Hydrological assessment only	-	--	--	--	--			
	Flow characteristics	Key flow characteristics	Trend										
	Protection of forests around Tonle Sap	Forest flooded for specified depth duration at Tonle Sap	1000 ha										
		Net incremental economic values	NPV US$m										
2.2 Maintain wetland productivity and ecosystem services	Productivity of wetland ecosystems	Incremental wetlands with required depth-duration	1000 ha			12	11	11	11	11			
		Net incremental economic value	NPV US$m			-3	-2	-2	-2	-2			
2.3 Manage salinity intrusion in the Mekong delta	Impact of salinity intrusion on land use potential	Area within delta within thresholds of salinity levels	1000 ha										
		Net incremental economic value	NPV US$m										
2.4 Minimize channel effects on bank erosion and deep pools	River bank erosion	Incremental area at risk to erosion	1000 ha										
		Vulnerability to bank erosion	Trend			N	N	+	N	N			
		Net incremental economic values	NPV US$m			N	N	N	N	N			
	Impact of flow and sediment transport changes on deep pools	Sediment loads at specified locations on mainstream	Trend			N	N	N	N	N			
		Water levels at specified locations on mainstream	Trend			N	N	N	N	N			
		Net incremental economic values	Trend										
2.5 Conservation of biodiversity	Impacts of flow management changes on endangered species	Incremental area of suitable habitats	1000 ha			326	329	329	329	329			
		Estimated number of species affected	no.			-	----	--	---	----			
		Incremental net economic value of habitat areas	NPV US$m			-	--	-	-	--			
3. Social development													
3.1 Maintain livelihoods of vulnerable resource-users	Health, food and income security	No. of people affected	1000 people			250	1,100	800	1,000				
		Severity of impact on health, food and income security	Trend			---	--	--	--				
3.4 Increased employment generation in water related sectors	Incremental sustainable employment from water resource interventions	Incremental number of people engaged in:											
		Agriculture	1000				72	72	72	72			
			1000										
		Water-related service industries	1000										
		Fisheries	1000			70	143	131	139	139			
4 Equitable development													
4.1 Ensure that all four LMB countries benefit from the development of water and related resources	Aggregate benefits by country	Summation of incremental net economic benefits	NPV US$m			5,468	18,660	9,822	13,227	16,308			
		Summary of non-quantifiable impacts	Social			---	---	---	---				
			Environmental			N	-	N	-	-			

Table 3 Summary of assessments – Thailand

Specific development objective	Assessment Criteria: Issue	Indicator: Description	Indicator: Unit	1000	2000	3000	4000	5000	6000	6100	7000	7001	7002
				Scenarios: BS	UMD	DF	20Y	20Y w/o MD	20Y w/o LMD	20Y w/o TMD	FMMP1	FMMP2	FMMP3
1. Economic development													
1.1 Increase irrigated agricultural production	Irrigable area, production tonnage and value	Incremental area	'000 ha			No crops in area	1,307	1,307	1,307	1,307			
		Incremental crop production	'000 ton				4,807	4,807	4,807	4,807			
		Net incremental economic value	NPV US$m				-348	-348	-348	-348			
1.2 Increase hydropower production	Hydropower capacity, power generated and value	Incremental installed capacity	MW			309	1,784	309	1,837	309			
		Incremental power generated	GWh/year			532	2,008	532	1,661	532			
		Net incremental economic value	NPV US$m			572	2,027	992	1,723	1,757			
1.3 Improve navigation	River transport	Incremental IWT tonnage in dry season	'000 ton			+	+	+	+	+			
		Net incremental economic value	NPV US$m			64	64	64	64	64			
1.4 Decrease damages by floods	Extent and duration of annual flooding by class	Average flooded area reduction	'000 ha			69	76	76	76	76			
		Incremental net economic value of flood damage avoided	NPV US$m			169	125	125	125	125			
1.5 Maintain productivity of fishery sector	Capture fisheries and aquaculture production	Incremental annual average capture fish availability	'000 ton			5	8	25	24	5			
		Incremental annual average aquaculture production	'000 ton			40	116	116	116	116			
		Net incremental economic value	NPV US$m			225	144	219	207	141			
2. Environmental protection													
2.1 Maintain water quality and acceptable flow conditions	Water quality	Water quality incl. sediment in transport in mainstream	Trend	Baseline	Hydrological assessment only	-	--	--	--	--			
	Flow characteristics	Key flow characteristics	Trend										
	Protection of forests around Tonle Sap	Forest flooded for specified depth duration at Tonle Sap	'000 ha										
		Net incremental economic values	NPV US$m										
2.2 Maintain wetland productivity and ecosystem services	Productivity of wetland ecosystems	Incremental wetlands with required depth-duration	'000 ha			12	11	11	11	11			
		Net incremental economic value	NPV US$m			-5	-3	-3	-3	-3			
2.3 Manage salinity intrusion in the Mekong delta	Impact of salinity intrusion on land use potential	Area within delta within thresholds of salinity levels	'000 ha										
		Net incremental economic value	NPV US$m										
2.4 Minimize channel effects on bank erosion and deep pools	River bank erosion	Incremental area at risk to erosion	'000 ha										
		Vulnerability to bank erosion	Trend			N	N	+	N	N			
		Net incremental economic values	NPV US$m			N	N	N	N	N			
	Impact of flow and sediment transport changes on deep pools	Sediment loads at specified locations on mainstream	Trend			N	N	N	N	N			
		Water levels at specified locations on mainstream	Trend			N	N	N	N	N			
		Net incremental economic values	Trend										
2.5 Conservation of biodiversity	Impacts of flow management changes on endangered species	Incremental area of suitable habitats	'000 ha			326	329	329	329	329			
		Estimated number of species affected	no.			-	----	--	--	---			
		Incremental net economic value of habitat areas	NPV US$m			-	--	-	-	--			
3. Social development													
3.1 Maintain livelihoods of vulnerable resource-users	Health, food and income security	No. of people affected	'000 people										
		Severity of impact on health, food and income security	Trend										
3.4 Increased employment generation in water related sectors	Incremental sustainable employment from water resource interventions	Incremental number of people engaged in:											
		Agriculture	'000				119	119	119	119			
			'000										
		Water-related service industries	'000										
		Fisheries	'000			66	129	129	129	129			
4 Equitable development													
4.1 Ensure that all four LMB countries benefit from the development of water and related resources	Aggregate benefits by country	Summation of incremental net economic benefits	NPV US$m			1,026	2,009	1,049	1,788	1,738			
		Summary of non-quantifiable impacts	Social										
			Environmental			N	-	-	-	-			

Table 4 Summary of assessments – Cambodia

Specific development objective	Assessment Criteria: Issue	Indicator: Description	Indicator: Unit	Scenarios: 1000 BS	2000 LMD	3000 DF	4000 20Y	5000 20Y w/o MD	6000 20Y w/o LMD	6100 20Y w/o TMD	7000 FMMP1	7001 FMMP2	7002 FMMP3
1. Economic development													
1.1 Increase irrigated agricultural production	Irrigable area, production tonnage and value	Incremental area	'000 ha			No changes in area	274	274	274	274	438		438
		Incremental crop production	'000 ton				616	616	616	616			
		Net incremental economic value	NPV US$m				4	4	4	4	264		264
1.2 Increase hydropower production	Hydropower capacity, power generated and value	Incremental installed capacity	MW			1	4,761	461	461	4,761			
		Incremental power generated	GWh/year			3	22,055	2,315	2,315	22,055			
		Net incremental economic value	NPV US$m			7	2,780	1,255	1,255	2,780			
1.3 Improve navigation	River transport	Incremental IWT tonnage in dry season	'000 ton			N	N	N	N	N			
		Net incremental economic value	NPV US$m										
1.4 Decrease damages by floods	Extent and duration of annual flooding by class	Average flooded area reduction	'000 ha			54	72	72	72	72	875		875
		Incremental net economic value of flood damage avoided	NPV US$m			51	49	49	49	49	2	-9	-7
1.5 Maintain productivity of fishery sector	Capture fisheries and aquaculture production	Incremental annual average capture fish availability	'000 ton			-27	-272	-38	-47	-273			
		Incremental annual average aquaculture production	'000 ton			82	158	158	158	158			
		Net incremental economic value	NPV US$m			-27	-809	-60	-105	-810	-3		-3
2. Environmental protection													
2.1 Maintain water quality and acceptable flow conditions	Water quality	Water quality incl. sediment in transport in mainstream	Trend	Baseline	Hydrological assessment only	---	----	---	---	---			
	Flow characteristics	Key flow characteristics	Trend										
	Protection of forests around Tonle Sap	Forest flooded for specified depth duration at Tonle Sap	'000 ha			449	447	447	447	447			
		Net incremental economic values	NPV US$m										
2.2 Maintain wetland productivity and ecosystem services	Productivity of wetland ecosystems	Incremental wetlands with required depth-duration	'000 ha			1,250	1,240	1,240	1,240	1,240			
		Net incremental economic value	NPV US$m			-13	-12	-12	-12	-12	-1		-1
2.3 Manage salinity intrusion in the Mekong delta	Impact of salinity intrusion on land use potential	Area within delta within thresholds of salinity levels	'000 ha										
		Net incremental economic value	NPV US$m										
2.4 Minimize channel effects on bank erosion and deep pools	River bank erosion	Incremental area at risk to erosion	'000 ha										
		Vulnerability to bank erosion	Trend			+	N	+	N	N			
		Net incremental economic values	NPV US$m			N	N	N	N	N			
	Impact of flow and sediment transport changes on deep pools	Sediment loads at specified locations on mainstream	Trend			N	N	N	N	N			
		Water levels at specified locations on mainstream	Trend			N	N	N	N	N			
		Net incremental economic values	Trend										
2.5 Conservation of biodiversity	Impacts of flow management changes on endangered species	Incremental area of suitable habitats	'000 ha			2,029	1,991	1,991	1,991	1,991			
		Estimated number of species affected	no.			-	----	---	---	---			
		Incremental net economic value of habitat areas	NPV US$m			-	---	-	-	---			
3. Social development													
3.1 Maintain livelihoods of vulnerable resource-users	Health, food and income security	No. of people affected	'000 people			80	1,000	90					
		Severity of impact on health, food and income security	Trend			-	----	---					
3.4 Increased employment generation in water related sectors	Incremental sustainable employment from water resource interventions	Incremental number of people engaged in:											
		Agriculture	'000				6	6	6	6	15		15
			'000										
		Water-related service industries	'000										
		Fisheries	'000			33	123	102	102	123			
4 Equitable development													
4.1 Ensure that all four LMB countries benefit from the development of water and related resources	Aggregate benefits by country	Summation of incremental net economic benefits	NPV US$m			18	2,012	1,238	1,191	2,011	282	-9	268
		Summary of non-quantifiable impacts	Social			-	----	---					
			Environmental			N	-	-	-	-			

Table 5 Summary of assessments – Viet Nam

Specific development objective	Issue	Indicator: Description	Indicator: Unit	1000 BS	2000 UMD	3000 DF	4000 20Y	5000 20Y w/o MD	6000 20Y w/o LMD	6100 20Y w/o TMD	7000 FMMP1	7001 FMMP2	7002 FMMP3
1. Economic development													
1.1 Increase irrigated agricultural production	Irrigable area, production tonnage and value	Incremental area	'000 ha			No impact in area	125	125	125	125			
		Incremental crop production	'000 ton				642	642	642	642			
		Net incremental economic value	NPV US$m				108	108	108	108			
1.2 Increase hydropower production	Hydropower capacity, power generated and value	Incremental installed capacity	MW			2,220	2,512	2,512	2,512	2,512			
		Incremental power generated	GWh/year			10,578	11,815	11,815	11,815	11,815			
		Net incremental economic value	NPV US$m			2,549	3,636	2,860	3,063	3,636			
1.3 Improve navigation	River transport	Incremental IWT tonnage in dry season	'000 ton			N	N	N	N	N			
		Net incremental economic value	NPV US$m										
1.4 Decrease damages by floods	Extent and duration of annual flooding by class	Average flooded area reduction	'000 ha			16	23	23	23	23		1,300	1,300
		Incremental net economic value of flood damage avoided	NPV US$m			60	67	67	67	67	-39	9	-30
1.5 Maintain productivity of fishery sector	Capture fisheries and aquaculture production	Incremental annual average capture fish availability	'000 ton			-13	-109	-15	2	-113			
		Incremental annual average aquaculture production	'000 ton			522	1,655	1,655	1,655	1,655			
		Net incremental economic value	NPV US$m			1,553	109	464	460	105			
2. Environmental protection													
2.1 Maintain water quality and acceptable flow conditions	Water quality	Water quality incl. sediment in transport in mainstream	Trend	Baseline	Hydrological assessment only	-	---	---	---	---			
	Flow characteristics	Key flow characteristics	Trend			N	N	N	N	N			
	Protection of forests around Tonle Sap	Forest flooded for specified depth duration at Tonle Sap	'000 ha										
		Net incremental economic values	NPV US$m										
2.2 Maintain wetland productivity and ecosystem services	Productivity of wetland ecosystems	Incremental wetlands with required depth-duration	'000 ha			55	55	55	55	55			
		Net incremental economic value	NPV US$m										
2.3 Manage salinity intrusion in the Mekong delta	Impact of salinity intrusion on land use potential	Area within delta within thresholds of salinity levels	'000 ha			1,580	1,540	1,540	1,540	1,540			
		Net incremental economic value	NPV US$m			+	+	+	+	+			
2.4 Minimize channel effects on bank erosion and deep pools	River bank erosion	Incremental area at risk to erosion	'000 ha										
		Vulnerability to bank erosion	Trend			N	N	N	N	N			
		Net incremental economic values	NPV US$m			N	N	N	N	N			
	Impact of flow and sediment transport changes on deep pools	Sediment loads at specified locations on mainstream	Trend			N	+	N	N	N			
		Water levels at specified locations on mainstream	Trend			N	N	N	+	N			
		Net incremental economic values	Trend										
2.6 Conservation of biodiversity	Impacts of flow management changes on endangered species	Incremental area of suitable habitats	'000 ha			1,756	1,748	1,748	1,748	1,748			
		Estimated number of species affected	no.			-	---	---	---	---			
		Incremental net economic value of habitat areas	NPV US$m			-	--	-	-	--			
3. Social development													
3.1 Maintain livelihoods of vulnerable resource-users	Health, food and income security	No. of people affected	'000 people										
		Severity of impact on health, food and income security	Trend										
3.4 Increased employment generation in water related sectors	Incremental sustainable employment from water resource interventions	Incremental number of people engaged in:											
		Agriculture	'000				14	14	14	14		2	2
			'000										
		Water-related service industries	'000										
		Fisheries	'000			139	138	138	138	138			
4 Equitable development													
4.1 Ensure that all four LMB countries benefit from the development of water and related resources	Aggregate benefits by country	Summation of incremental net economic benefits	NPV US$m			4,162	3,920	3,489	3,888	3,918	-39	9	-30
		Summary of non-quantifiable impacts	Social										
			Environmental			N	-	-	-	-			

Appendix A Flow chart of assessment process

Overview of assessment methodology and processes