Mekong River Commission

Climate Change and Adaptation Initiative

Summary of the basin-wide assessments of climate change impacts on water and water-related resources in the Lower Mekong Basin

June 2017

Overview of basin-wide climate change impact assessments

It is widely recognised that global climate change is occurring and that this a result of the influence of human activities increasing the concentration of greenhouse gases in the atmosphere. Climatic change is also evident across the Lower Mekong Basin, with rising temperatures, increasing precipitation and rising sea-levels evident over the historical record. The impact of these changes on natural resources and socio-economic systems is currently less clear, but anticipated to become more visible and significant over time, particularly as the projected future climate change across the Lower Mekong Basin is extreme under some scenarios. The expected perturbations on water and water-related sectors from regional climate change have the potential for serious negative impacts on peoples' livelihoods and food security, especially those people in vulnerable communities with a heavy reliance on natural resources and the traditional bounty of the Mekong River and its tributaries.

The approach to assessing the basin-wide impacts of and vulnerability to climate change undertaken by the Mekong River Commission (MRC) has been to examine a wide range of potential, and equally plausible, future climate scenarios. This approach recognises there is inherent uncertainty associated with considering future circumstances and allows for the consideration of adaptation options which respond to a wide range of potential future climatic conditions.

The MRC's suite of basin-wide studies conducted by the Climate change and Adaptation Initiative include an assessment of climate change impacts on hydrology, flood, drought, hydropower, ecosystems and biodiversity, fisheries, and agriculture production. Taken together, the latter two are used to consider climate change impacts on regional food security (Figure 1). The main objective of the these basin-wide assessments is to provide information on the impacts of potential future climate change on water and water related natural resources and economic sectors in a way which supports decision-making on climate change adaptation measures at regional and national levels within the MRC Member Countries. The assessments support the preparation of the Mekong Adaptation Strategy and Action Plan (MASAP) in conjunction with a regional review of policy for climate change and adaptation in the LMB. The scope of assessments is the entire Lower Mekong Basin (Figure 2).

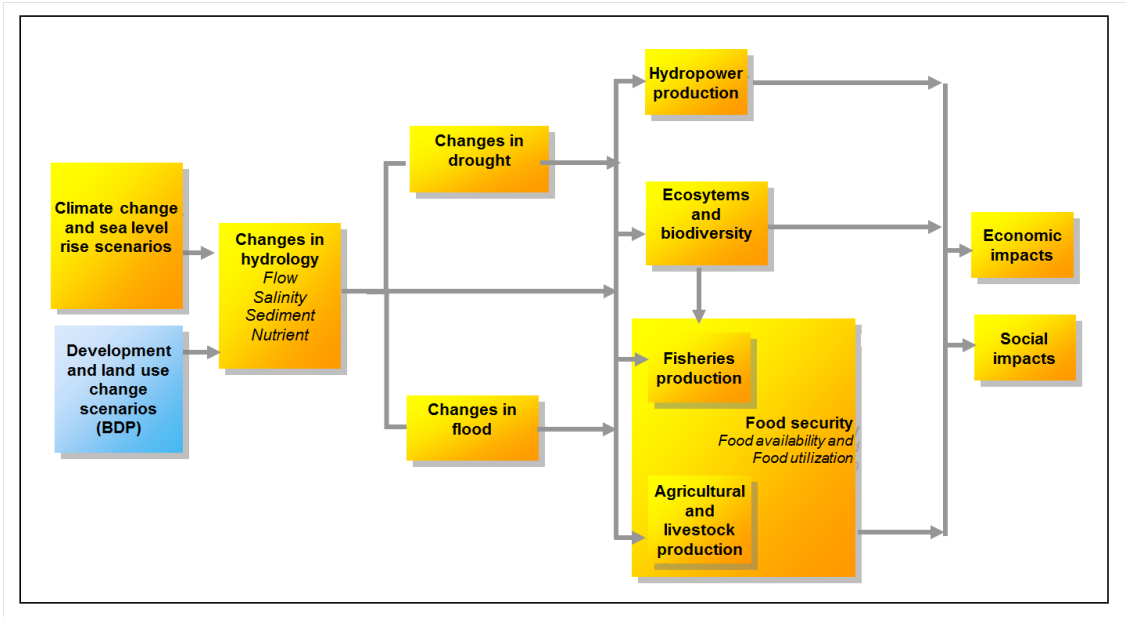


Figure 1: Elements of the basin-wide assessments of climate change impacts on water and water related sectors in the Lower Mekong Basin (MRC, 2014).

Figure 2: The Mekong Basin with the Lower Mekong Basin highlighted in red.

While there is evidence that the climate of the region is changing, on average becoming hotter and wetter, a wide range of potential future changes is projected to occur over the next 15 to 45 years:

- Temperatures are projected to increase across the basin and across seasons. The only real uncertainty is the magnitude of the increase and how quickly it occurs. By 2060 the average annual basin-wide increase could be as low as 0.3˚C or as high as 3.3˚C depending on the global emissions trajectory that is followed.
- Rainfall could increase or decrease with large variation in the magnitude of change and the location of impacts. Average basin-wide change in dry season rainfall is projected to vary between -23% to +23% by 2060 and wet season rainfall between -18% to +16%. Regional variations are likely to see much wetter average annual conditions in the north of the basin under a wetter overall scenario, and drier average annual conditions from the north, over the Khorat plateau and across the Tonle Sap region, in a drier overall scenario.
- Variations in hydrology will follow changes in precipitation and a similarly wide range of future impacts is possible. Overall basin water yield, annual river flow and level, wet season duration, peak flow and level, and dry season minimum flow and level, could all either increase or decrease depending on the emissions trajectory and the climate change model which turns out to be most accurate. The range in possible outcomes is enormous with annual river flow changing by between -59% and +27%, and dry-season minimum one-day flow changing by between -65% and +35% at Chiang Saen by 2060 under climate change only scenarios. Basin development will interact with climate change, in some cases exacerbating the change and in some cases mitigating it.

Projected changes are potentially very significant and many people and communities are vulnerable to potentially wide-ranging impacts:

- Agricultural yields are likely to be affected with the negative impacts outweighing the positive. Potential declines in rice yields are of particular concern. Planned increases in irrigation, changes in agricultural practice and technological improvements are likely to be required to offset these impacts.
- Yields from fisheries and aquaculture are also vulnerable but impacts could be either positive or negative. While aquaculture is often considered more vulnerable due to rising sea-levels, salinity intrusion and the impacts of increased temperatures, floods, and droughts on smaller ponds and reservoirs, basin-wide impacts on capture fisheries in flooded habitats are projected to be the more significant.
- Hydropower production in both the mainstream and tributaries is at risk due to increased drought frequency although changes could be positive or negative depending on the scenario.
- Navigation may be affected by lower dry season flows making some parts of the upper Mekong impassable at certain times of year. Roads and water supply infrastructure are at risk from more intense rainfall, increased flooding and landslides, while significant expenditure may be required to protect coastal infrastructure from rising sea levels and storm surges.
- Overall, food security has improved significantly in recent decades, the health of the population is better, poverty levels have fallen dramatically, the population is more urbanised and fertility rates have fallen. However, many households and communities along the Mekong corridor remain vulnerable to shocks, particularly droughts and floods which can have a material impact on their livelihoods. Future climate change is likely to exacerbate the losses from extreme events with greater numbers of people likely to be affected by larger flooding events in future.

Future climate change scenarios

Examining projected future change requires consideration of future climatic scenarios. While an infinite number of scenarios are possible only a small number can be realistically considered and these should encompass the range of plausible future climate projections. The regional results of the CCAI's basin-wide impact assessments, unless otherwise stated, have generally been derived from a small number of well performing Global Circulation Models (GCMs) selected from the SimCLIM database of CMIP5 models that together cover a wide range of changes in both magnitude and patterns of projected temperature and rainfall. The downscaling of global models was undertaken within SimCLIM using pattern scaling and bilinear interpolation.

In order to provide a wide range of climate change projections three emissions scenarios were selected from the four Resource Concentration Pathways developed for IPCC fifth assessment report. Combining the three emissions scenarios with the three model scenarios, results in nine climate scenarios covering the range of plausible climate change in the Lower Mekong Basin to 2030 and 2060 (Figure 3).

No.	Type of scenarios		Emission scenarios	GCM	Climate sensitivity
	Level of change	Pattern of change			
Low climate change scenarios					
1	Low	Wetter overall	RCP2.6	GFDL-CM3	Low
2		Drier overall		GISS-E2-R-CC	
3		Increased seasonal variability		IPSL-CM5A-MR	
Medium climate change scenarios					
4	Medium	Wetter overall	RCP4.5	GFDL-CM3	Medium
5		Drier overall		GISS-E2-R-CC	
6		Increased seasonal variability		IPSL-CM5A-MR	
High climate change scenarios					
7	High	Wetter overall	RCP8.5	GFDL-CM3	High
8		Drier overall		GISS-E2-R-CC	
9		Increased seasonal variability		IPSL-CM5A-MR	

Figure 3: Climate change scenarios used for basin-wide impact assessments.

Two basin-wide development scenarios developed for the MRC Basin Development Plan 2 were also applied: No. 4 (foreseeable future 20-year plan) and No. 8 (long-term development) to align with the 2030 and 2060 timeframes. Sea-level rise projections were found not to vary significantly between GCM and so a single model ('wetter overall'), coupled with low, medium and high emissions scenarios was selected for assessment of impacts and vulnerability in the Mekong Delta region (Table 1).

Table 1: Selected sea-level rise (metres) projection scenarios.

	Emissions scenario		
Period	Low emissions (RCP2.6)	Medium emissions (RCP4.5)	High emissions (RCP8.5)
2030 (2021-2040)	0.13	0.15	0.16
2060 (2051-2070)	0.30	0.33	0.40

Basin-wide assessment of projected future climate change

Key message

The Lower Mekong Basin is projected to warm significantly by mid-century across all seasons and under all scenarios and models. Annual increases range from 0.4°C to 3.3°C by 2060. Precipitation is projected to either increase or decrease depending on the model selected. Average basin-wide change in dry season rainfall is projected to vary between -23% to +23% by 2060 and wet season rainfall between -18% to +16%. Regional variations are likely to see much wetter average annual conditions in the north of the basin under the wetter overall scenario, and drier average annual conditions from the north, over the Khorat plateau and across the Tonle Sap region in the drier overall scenario.

Regional projections of changes in temperature and rainfall are largely consistent with global projections. That is, increasing temperatures and either increasing or decreasing rainfall depending on regional factors at range of scales. The rate of projected increase in temperatures is, however, much greater at the regional level than at the global level, with the upper range of increases from 3°C to 4°C by 2060, similar to global projections for 2090. The Lower Mekong Basin is projected to warm at a greater rate than the average global increase under all scenarios examined.

As expected, greater increases in mean annual temperature occur with higher resource concentration pathways. The average mean annual temperature across the LMB by 2060 is 25.5°C under RCP2.6, 26.5°C-26.6°C under RCP 4.5 and 27.9°C-28.1°C under RCP 8.5. Mean annual temperatures are generally higher in 2060 than in 2030 except for RCP2.6.

The direction of change in precipitation is determined by the choice of model, with both the overall wetter and increased seasonal variability models projecting a wetter LMB on average, while the drier overall model projects a drier LMB on average. Again, the magnitude of change is affected by the resource concentration pathway – the higher the RCP the greater the change. A similar result was demonstrated for Available Water Index (AWI). Average potential evapotranspiration (PET) across the Basin increases under all scenarios and all models.

Changes in Temperature

Increases in monthly temperatures are highly consistent across the year and across climate models with variations strongly linked to emissions scenarios (Table 2); the higher the emissions scenario, the greater the magnitude of projected temperature changes. The direction of change is of increasing average temperature across both wet and dry seasons in all models and scenarios.

The spatial variation in temperature increases generally shows greater increases in the north of the basin than the south with some higher temperatures extending across much of the Khorat plateau under both the wetter and drier overall scenarios. Maximum increases in mean annual temperature are typically constrained to northern and western parts of the LMB, while the Delta region exhibits the smallest increases (Figure 4). The drier overall model highlights a particularly strong warming trend in the Mun/Chi River Basin, with a relatively strong west to east temperature gradient. The smallest increases are anticipated in the east of the basin. The wetter overall and increased seasonal variability models are instead oriented from north to south, with the smallest increases in the south.

Table 2: Summary of projected basin-wide changes in (a) annual; (b) dry season; and (c) wet season basin-wide temperatures to 2030 and 2060 under three RCPs (2.6; 4.5; 8.5) and three model scenarios (drier overall, wetter overall, increased seasonal variability).

Annual	Low emission (RCP2.6)		Medium emission (RCP4.5)		High emission (RCP8.5)	
	2030	2060	2030	2060	2030	2060
Drier overall	0.5	0.4	0.9	1.6	1.5	3.3
Increased seasonal variability	0.5	0.4	0.9	1.5	1.5	3.1
Wetter overall	0.5	0.4	0.8	1.5	1.4	3.1

Dry season	Low emission (RCP2.6)		Medium emission (RCP4.5)		High emission (RCP8.5)	
	2030	2060	2030	2060	2030	2060
Drier overall	0.5	0.4	0.9	1.6	1.5	3.3
Increased seasonal variability	0.5	0.3	0.8	1.4	1.3	2.8
Wetter overall	0.5	0.4	0.8	1.5	1.4	3.1

Wet season	Low emission (RCP2.6)		Medium emission (RCP4.5)		High emission (RCP8.5)	
	2030	2060	2030	2060	2030	2060
Drier overall	0.5	0.4	0.9	1.6	1.5	3.3
Increased seasonal variability	0.5	0.4	0.9	1.6	1.6	3.4
Wetter overall	0.5	0.4	0.8	1.5	1.4	3.0

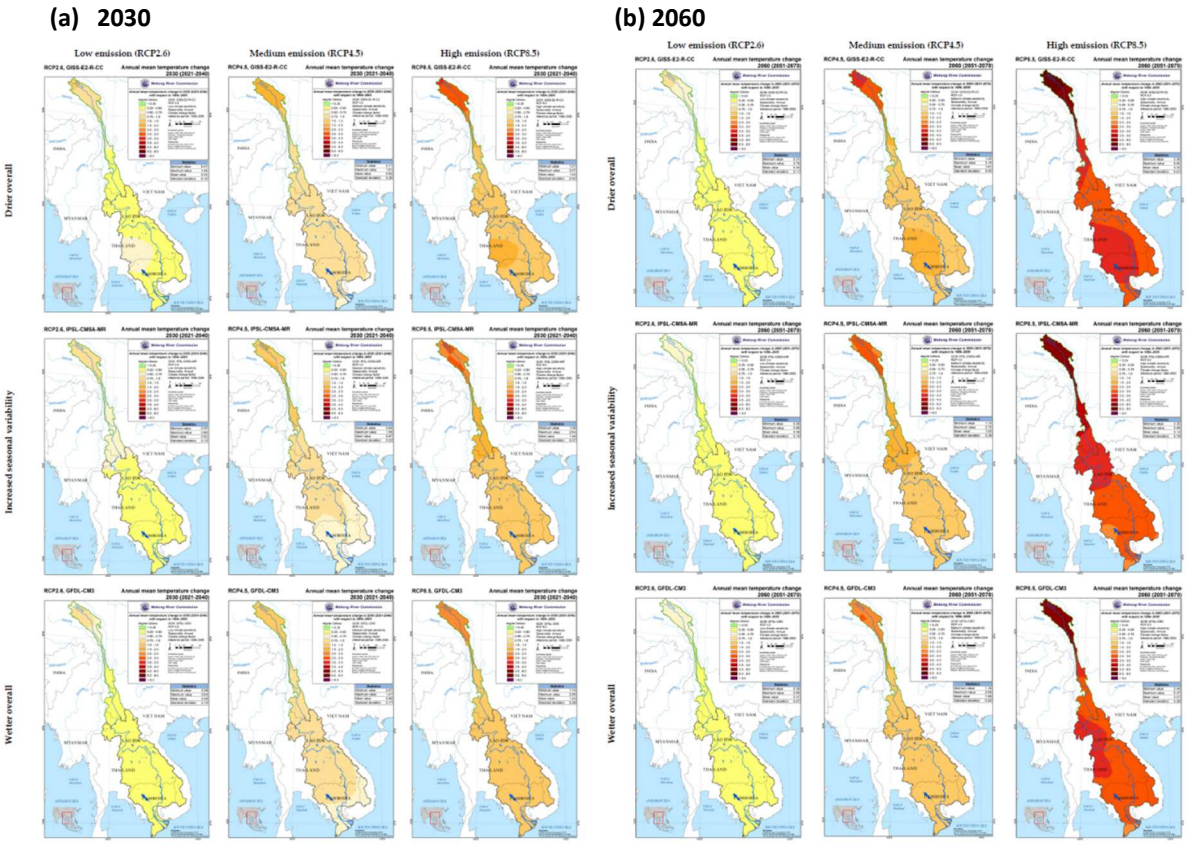


Figure 4: Spatial variations in annual average mean temperature changes projected to (a) 2030 and (b) 2060 under three emissions scenarios (RCP2.5; RCP4.5; RCP8.5) and three model scenarios (wetter overall, drier overall, increased seasonal variability).

Averaged across the entire LMB, maximum temperature increases are identical in magnitude to mean increases. Broader areas of warming are, however, evident in all scenarios particularly in central and northern areas. Minimum temperature increases are smaller in magnitude than average and maximum temperature increases, although only by 0.1°C to 0.3°C.

Changes in rainfall

Projected changes in monthly rainfall are highly inconsistent across the year and across scenarios but with the magnitude of change strongly linked to the choice of emissions scenario (Table 3); other than for dry season changes in the drier overall model, the higher the emissions scenario the greater the magnitude of projected rainfall change whether that change involves a reduction or an increase in rainfall.

Table 3: Summary of projected changes in annual, dry season and wet season basin-wide rainfall to 2030 and 2060 under three RCPs (2.6; 4.5; 8.5) and three model scenarios (drier overall, wetter overall, increased seasonal variability).

Annual	Low emission (RCP2.6)		Medium emission (RCP4.5)		High emission (RCP8.5)	
	2030	2060	2030	2060	2030	2060
Drier overall	-2%	-2%	-4%	-8%	-7%	-16%
Increased seasonal variability	2%	2%	3%	5%	5%	10%
Wetter overall	3%	2%	5%	8%	8%	17%

Dry season	Low emission (RCP2.6)		Medium emission (RCP4.5)		High emission (RCP8.5)	
	2030	2060	2030	2060	2030	2060
Drier overall	0%	0%	-1%	-1%	-1%	-1%
Increased seasonal variability	-4%	-3%	-7%	-11%	-11%	-23%
Wetter overall	3%	3%	6%	11%	11%	23%

Wet season	Low emission (RCP2.6)		Medium emission (RCP4.5)		High emission (RCP8.5)	
	2030	2060	2030	2060	2030	2060
Drier overall	-3%	-2%	-5%	-9%	-8%	-18%
Increased seasonal variability	3%	2%	5%	8%	8%	15%
Wetter overall	3%	2%	5%	8%	8%	16%

The variations in projected rainfall change tend to be greatest during the peaks of the dry season (March: -60% to +71% by 2060) and wet season (October: -33% to +92% by 2060). The greatest reductions in projected rainfall tend to occur during the January to March/April period, associated with the drier overall and increased seasonal variability scenarios, while the greatest increases in projected rainfall tend to occur in the September to December period for the increased seasonal variability scenario, and in March and August to November for the wetter overall scenario. There is a difference in the magnitude and pattern of projected change in rainfall across the three scenarios. In summary:

- the drier overall scenario tends to show reductions in rainfall;
- the increased seasonal variability scenario tends to show reductions in rainfall during the period January to June and increases in rainfall during the period July to December;
- the wetter overall scenario tends to show increases in rainfall; and
- the magnitude of change increases from the low emission through to high emission scenarios.

Projected changes to annual precipitation show considerable spatial variability between model simulations (Figure 5). The drier overall model shows a greater reduction in the northern LMB over northern Lao PDR and over the central LMB in Thailand and Cambodia. Some areas on the periphery of the LMB under the drier overall model become wetter, for example in the headwaters of the 3S sub-basin at the intersection of Cambodia, Lao PDR and Viet Nam. The increased seasonal variability model projects a wetter north and central LMB over Lao PDR and Thailand and a drier southern zone in Cambodia and Viet Nam, while the wetter overall model produces a west to east rainfall gradient with higher rainfall projected in the west, particularly under the high emissions scenario.

In models where a drying trend is observed, the largest changes are typically constrained to inland areas, particularly in the Central Plateau and Highlands. Wet season changes show similar spatial patterns of change to annual changes, whilst dry season changes are very different. Across all models, changes to wet and dry season precipitation are typically smallest in the Delta region.

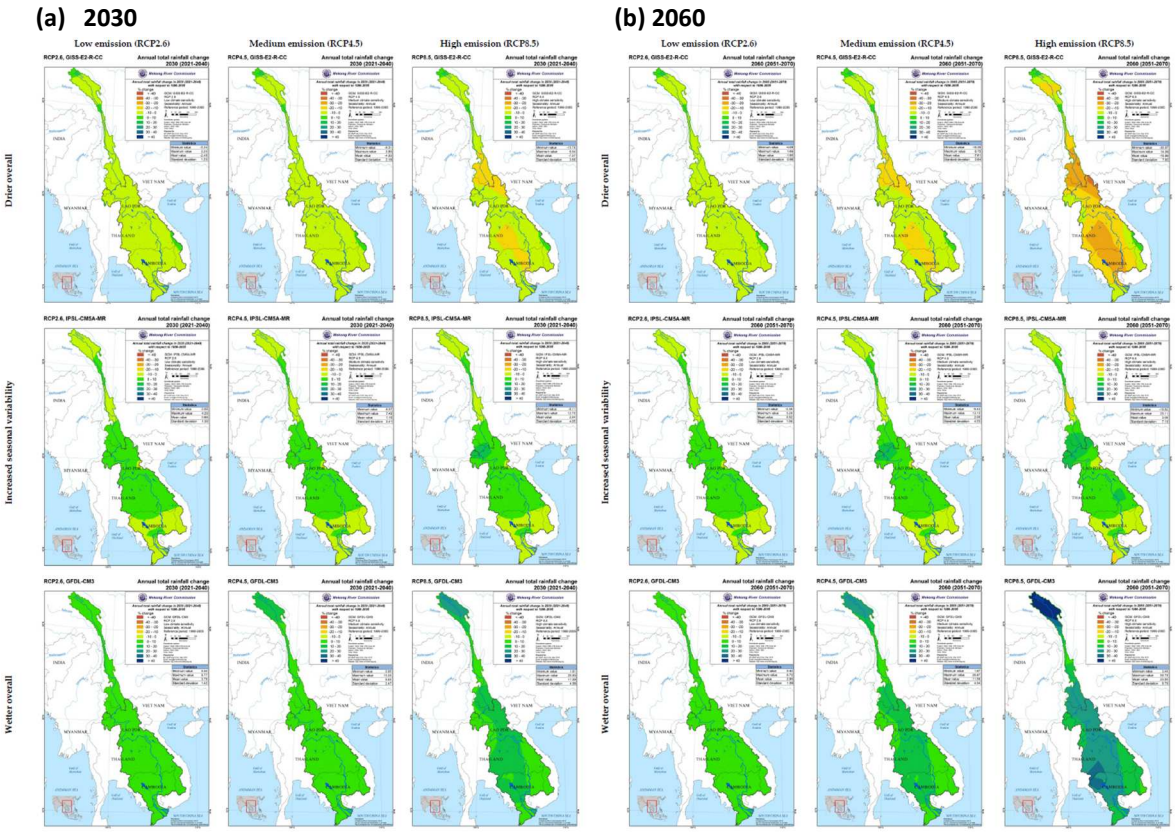


Figure 5: Spatial variations in annual average mean rainfall changes projected to (a) 2030 and (b) 2060 under three emissions scenarios (RCP2.5; RCP4.5; RCP8.5) and three model scenarios (wetter overall, drier overall, increased seasonal variability).

Relevant Assessment and Supporting Reports

MRC, 2015a. *Climate Change Atlas of the Lower Mekong Basin.* Mekong River Commission, Vientiane, Lao PDR

MRC, 2017a. *Projected Climate Change and impact on bioclimatic condition and terrestrial ecosystems in the Lower Mekong Basin*. Mekong River Commission, Vientiane, Lao PDR

MRC, 2017b. *Climate Change impacts on hydrology of the Lower Mekong Basin – Volume 1: Water level flow and salinity*. Technical Report. Mekong River Commission. Vientiane, Lao PDR

Basin-wide assessment of climate change impacts on hydrology

Key message

A wide range of potential future impacts on water resources from climate change are plausible. River flows and water levels in the wet and dry seasons may increase or decrease dramatically, depending on the future scenario. Changes in river flow, water level, wet season duration and peaks, and dry season minimums may have profound impacts on water-dependent biodiversity and livelihoods. Upper Mekong Basin snowmelt is projected to decrease substantially across all scenarios, particularly in the wet season. Dry season salinity intrusion is mostly projected to increase. The greatest increases to 2030 tend to be for the increased seasonal variability model and to 2060 for the drier overall model.

Assessment approach

The assessment of climate change impacts on hydrology and water resources was undertaken using the MRC Decision Support Framework/Toolbox based on observed hydro-meteorological data, the SWAT hydrological model, IQQM water resources simulation model and the ISIS hydrodynamic model, combined to simulate various hydrological parameters across the Mekong Basin. The assessment included with and without development scenarios.

Climate change impacts on hydrology

The projected impact of climate change on hydrology and water resources varies over a wide range. Impacts are potentially very substantial but are shown to be dependent on both climate model and emissions scenario. For those impacts that also consider basin development, this becomes an important factor in determining the magnitude of predicted impacts. Table 4 illustrates the variability in projected impacts at two hydrological monitoring stations, Chiang Saen and Kratie for both climate change only and climate and development scenarios. These results show that generally the greater impacts are due to climate change and that development is projected to either mitigate or exacerbate some of these impacts depending on the scenario. For example, drought season minimum one-day flows and levels may be reduced by up to -65% and -0.64m respectively at Chiang Saen due to climate change only, but by up to only -21% and -0.21m respectively when development is also considered. However, under other scenarios the projected change is greater when development scenarios are included.

Table 4: The range in selected hydrological impacts due to (a) climate change and (b) climate change and development scenarios projected to 2060 at Chiang Saen and Kratie monitoring stations.

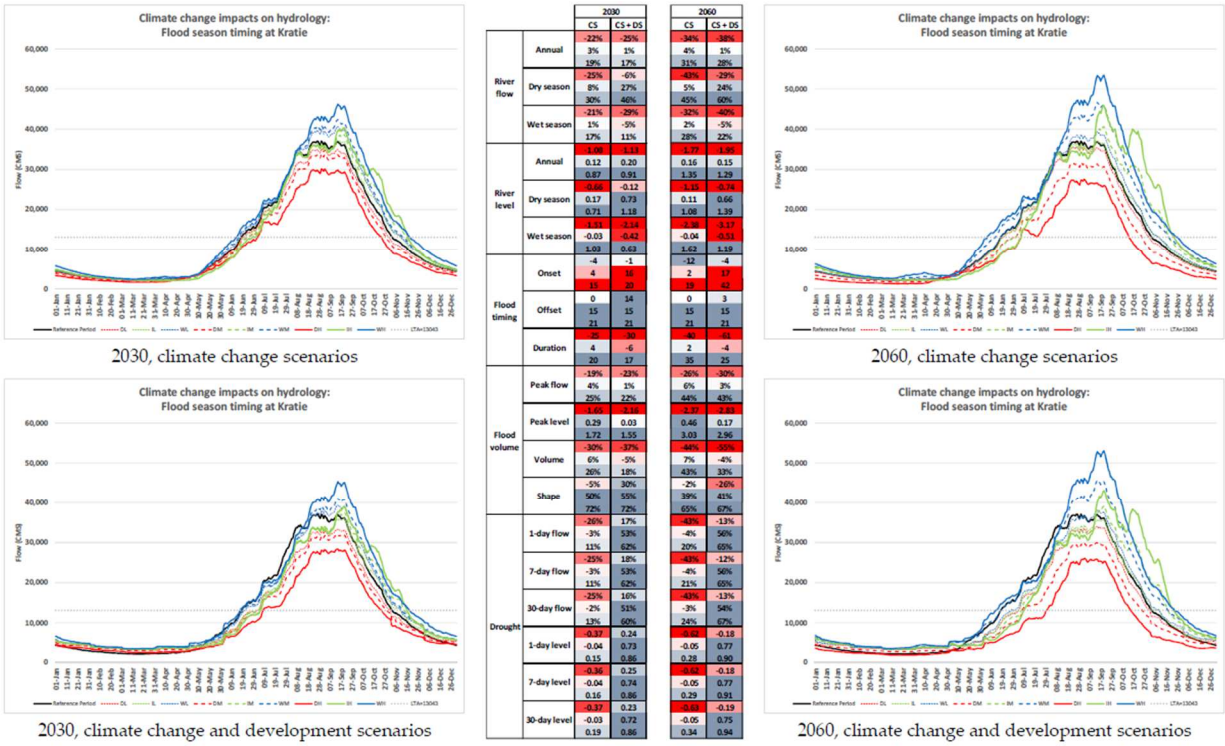
(a)

	Climate change scenarios			
	Min.		Max.	
	Chiang Saen	Kratie	Chiang Saen	Kratie
Annual river flow	-59%	-34%	27%	31%
Annual river level	-1.59	-1.77	0.63	1.35
Flood season duration	#N/A	-40	38	35
Flood season peak flow	-63%	-26%	64%	44%
Flood season peak level	-3.65	-2.37	2.80	3.03
Drought season minimum 1-day flow	-65%	-43%	35%	20%
Drought season minimum 1-day level	-0.64	-0.62	0.34	0.28

(b)

	Climate change and development scenarios			
	Min.		Max.	
	Chiang Saen	Kratie	Chiang Saen	Kratie
Annual river flow	-59%	-38%	27%	28%
Annual river level	-1.58	-1.95	0.67	1.29
Flood season duration	#N/A	-61	28	25
Flood season peak flow	-77%	-30%	31%	43%
Flood season peak level	-4.62	-2.83	1.31	2.96
Drought season minimum 1-day flow	-21%	-13%	79%	65%
Drought season minimum 1-day level	-0.21	-0.18	0.75	0.90

This variability is also illustrated across the year where the change in wet season flow in particular could be very large even by 2030 (Figure 6).



		2030		2060	
		CS	CS + DS	CS	CS + DS
River flow	Annual	-22%	-25%	-34%	-38%
		3%	1%	4%	1%
		19%	17%	31%	28%
	Dry season	-25%	-6%	-43%	-29%
		8%	27%	5%	24%
		30%	46%	45%	60%
	Wet season	-21%	-29%	-32%	-40%
		1%	-5%	2%	-5%
		17%	11%	28%	22%
River level	Annual	1.08	1.13	1.77	1.95
		0.12	0.20	0.16	0.15
		0.87	0.91	1.35	1.29
	Dry season	-0.66	-0.12	1.15	-0.74
		0.17	0.73	0.11	0.66
		0.71	1.18	1.08	1.39
	Wet season	1.13	-2.14	2.84	-3.17
		-0.03	-0.42	-0.04	-0.51
		1.03	0.63	1.62	1.19
Flood timing	Onset	-4	-1	-12	-4
		4	16	2	17
		15	20	19	42
	Offset	0	14	0	3
		15	15	15	15
		21	21	21	21
	Duration	5	30	40	41
		4	-6	2	-4
		20	17	35	25
Flood volume	Peak flow	-19%	-23%	-26%	-30%
		4%	1%	6%	3%
		25%	22%	44%	43%
	Peak level	-1.65	-2.16	-2.77	-2.83
		0.29	0.03	0.46	0.17
		1.72	1.55	3.03	2.96
	Volume	-30%	-37%	-44%	-50%
		6%	-5%	7%	-4%
		26%	18%	43%	33%
	Shape	-5%	30%	-2%	-26%
		50%	55%	39%	41%
		72%	72%	65%	67%
Drought	1-day flow	-26%	17%	-43%	-13%
		-3%	53%	-4%	56%
		11%	62%	20%	65%
	7-day flow	-25%	18%	-43%	-12%
		-3%	53%	-4%	56%
		11%	62%	21%	65%
	30-day flow	-25%	16%	-43%	-13%
		-2%	51%	-3%	54%
		13%	60%	24%	67%
	1-day level	-0.37	0.24	-0.62	-0.18
		-0.04	0.73	-0.05	0.77
		0.15	0.86	0.28	0.90
	7-day level	-0.36	0.25	-0.62	-0.18
		-0.04	0.74	-0.05	0.77
		0.16	0.86	0.29	0.91
	30-day level	-0.37	0.23	-0.63	-0.19
		-0.03	0.72	-0.05	0.75
		0.19	0.86	0.34	0.94

Figure 6: Summary of projected hydrological impacts at Kratie monitoring station under three model scenarios (wetter, drier, increased seasonal variability) and three emissions scenarios (RCP2.6, RCP4.5, RCP8.5) with and without development impacts to 2030 and 2060.

Projected changes in Upper Mekong Basin snowmelt generally lead to increased flow during the dry season under all models and scenarios but substantially less in the wet season and across the year. Across all scenarios and models the annual reduction in snowmelt is projected to be -5.7% to -57.5% by 2060. The range in projected change in monthly snowmelt is -21.0 mm to +4.7 mm by 2060. The greatest reductions in projected snowmelt occur during the early wet season, associated with the high emissions scenarios; and the greatest increases tend to occur in the late dry season, associated with the wetter overall and high and medium emissions scenarios.

For both 2030 and 2060 no consistent patterns relating the predicted change in salinity to model or emission scenario were identified, although it is notable that the wetter overall high emission scenario is associated with the lowest increases / greatest reductions in predicted salinity impacts. The greatest increases in projected salinity impacts to 2030 tend to be for the increased seasonal variability model to 2030 and the drier overall model to 2060.

Relevant Assessment and Supporting Reports

MRC, 2017b. *Climate Change impacts on hydrology of the Lower Mekong Basin – Volume 1: Water level flow and salinity*. Technical Report. Mekong River Commission. Vientiane, Lao PDR.

Basin-wide assessment of climate change impacts on floods

Key message

Climate change may cause an increase or decrease in flooded area across the Lower Mekong Basin, depending on whether the projected future climate is wetter or drier. If wetter, the area affected by floods could be much larger than at present across all Lower Mekong Basin countries, with a large increase in the population affected, especially in Viet Nam. This will exacerbate the economic losses to households and communities from extreme events, particularly as many households and communities along the Mekong corridor remain vulnerable to the impact of floods on their livelihoods.

Assessment approach

JBA Consulting undertook basin-wide probabilistic flood modelling using a combination of techniques built on the MRC's hydrodynamic models for the mainstream, and two dimensional and direct rainfall-runoff cell based modelling and analysis of the tributaries. One of the key outputs of this assessment is a database of 80 flood depth maps, which can inform further damage assessments and quantitative risk analysis.

Climate change impacts on floods

The projected impact of climate change on floods depends in large part on the model applied. Under both the wetter overall model and the increased seasonal variability model the flooded area is projected to increase for floods of all return intervals. Under the drier overall model the flooded area is projected to decrease for all but the very largest of floods (1 in 500 and 1 in 1000 years). The biggest proportional changes are projected to occur for the smaller floods with return intervals of 1 in 2 years and 1 in 5 years (Table 5). Under the highest emissions scenario for the wetter overall model, the change projected to 2060 is an increase in flooded area of 38 per cent for a 1 in 2 year flood. For the same flood return interval the flooded area is projected to increase 27 per cent under the medium emissions scenario.

Table 5: Percentage change in flooded area for ten different return interval events under a medium emissions scenario (RCP4.5) and the wetter overall (GFDL), drier overall (GISS) and increased seasonal variability (IPSL) models for 2030 and 2060 and including the high emissions (RCP8.5) scenario for 2060.

	ISIS model	% Change	2030		% Change	2060		
Event	Flood Area (Ha)	GFDL 45	GISS 45	IPSL 45	GFDL 45	GISS 45	IPSL 45	GFDL 85
Q2	4,816,132	10.46	-5.37	5.80	27.30	-2.59	23.15	38.06
Q5	5,584,220	7.03	-3.83	4.58	20.21	-3.05	17.84	28.55
Q10	5,838,216	6.42	-2.78	4.79	18.50	-1.95	17.61	26.95
Q20	6,028,768	5.67	-1.77	4.79	17.22	-1.33	16.92	25.64
Q50	6,226,212	4.70	-1.18	5.12	15.75	-1.29	16.61	24.70
Q75	6,286,532	4.76	-1.74	5.24	15.33	-0.97	16.78	24.51
Q100	6,324,636	4.81	-0.83	5.35	15.33	-0.84	16.90	24.55
Q200	6,402,104	5.01	-0.09	5.49	14.95	-0.43	17.41	24.47
Q500	6,486,780	5.02	0.81	5.67	14.65	0.35	17.95	24.31
Q1000	6,549,372	4.97	1.07	5.89	14.29	0.72	18.16	24.48

The increase in flooded area using a composite model is projected to be highest in proportional terms in Viet Nam (at 24% and 31% in 2030 and 2060, respectively) but highest in area terms in Cambodia with an increase of more than 5 million hectares in both 2030 and 2060 (Table 6). The

smallest increases in area are projected to occur in Lao PDR, but even there the increase is 9 per cent by 2030 and 18 per cent by 2060.

Table 6: Increase in flooded area in each LMB country using a composite of all models under medium (RCP4.5) and high emissions (RCP8.5) scenarios to 2060.

Area Flooded (Ha)	Base Q100	2060 Med	2060 Extreme	Increase Area	Increase Area
Cambodia	5,009,360	5,383,096	5,667,144	7%	13%
Lao	3,105,288	3,382,004	3,654,076	9%	18%
Thai	3,439,312	3,686,108	4,012,840	7%	17%
Viet Nam	3,112,212	3,845,956	4,074,148	24%	31%
Total	14,666,200	16,297,200	17,408,200	11%	19%

Vulnerabilities to climate change impacts on floods

The increase in flooding projected under these scenarios will affect more and more people. Under a medium emissions scenario by 2060 an extra 5.26 million people are expected to be affected by flooding compared to the baseline period. Under the high emissions scenario an extra 7.03 million people will be affected with the largest increase in Viet Nam (Table 7).

Table 7: Increase in population affected in each LMB country using a composite of all models under medium (RCP4.5) and high emissions (RCP8.5) scenarios to 2060.

Population Affected(millio	Base Q100	2060 Med	2060 Extreme	RCP 4.5 Increase (million)	2060 RCP8.5 Increase (m)
Cambodia	6.102	6.884	7.529	0.78	1.43
Lao	1.797	2.432	2.485	0.63	0.69
Thai	5.790	6.404	6.951	0.61	1.16
Viet Nam	13.334	16.565	17.086	3.23	3.75
Total	27.023	32.285	34.052	5.26	7.03

Almost 60 per cent of households surveyed along the Mekong mainstream for SIMVA 2014 identified crop farming as the main occupation of household members. Even excluding cropping and livestock, other water resource dependent activities play an important role in peoples' livelihoods, on a par with wage earners in permanent employment. Tonle Sap Lake in Cambodia and Songkhram in Thailand, both of which are characterized by extensive floodplains and wetlands, were identified as areas where water resource dependence is very important.

Coping strategies for the impacts of flooding, which were identified in the SIMVA studies, vary across the Lower Mekong Basin. Some of the strategies identified were borrowing money and receiving assistance from government. The most desperate coping strategy of selling productive assets was a strategy for around 10 per cent of the sample households, mainly in Cambodia.

Relevant Assessment and Supporting Reports

JBA, 2017. *Enhancement of basin-wide flood analysis and additional simulations under climate change to provide datasets for impact assessment and MASAP preparation (Stage 1)*. Report prepared for the Mekong River Commission. JBA Consulting.

MRC, 2015b. *Social Impact Monitoring and Vulnerability Assessment 2014: Shocks and Trends*. Mekong River Commission, Vientiane, Lao PDR.

Basin-wide assessment of climate change impacts on drought

Key message

Climate change may cause an increase or decrease in drought frequency and duration across the Lower Mekong Basin, depending on whether the projected future climate is wetter or drier and on the interaction with local conditions. Even under the same future scenario some areas are projected to experience more frequent and longer droughts while some areas experience less frequent and shorter droughts. Households and communities throughout the Lower Mekong Basin are vulnerable to the impact of droughts on their livelihoods.

Assessment approach

The assessment of climate change impacts on drought examined the projected change in seven indices of drought, consisting of two meteorological indices (percent normal precipitation and rainfall deciles), three hydrological or water supply indices (streamflow percent exceedance, a streamflow deficit index, and a hydrological flow health index) and two agricultural indices (a soil moisture deficit index and an evapotranspiration deficit index). The indices were calculated using rainfall records and the Soil and Water Assessment Tool (SWAT) database and model.

Climate change impacts on droughts

The projected impact of climate change on the frequency and duration of droughts varies considerably depending on location within the LMB. For example, the average percentage change in average annual drought frequency based on a Soil Moisture Deficit Index (SDMI) decreases in some areas and increases in others (Figure 7), with the upper Mekong Basin being particularly badly affected even by 2030. Large areas of the central LMB in Thailand and Cambodia are projected to have a reduction in drought frequency using a composite model, although this will depend on the future scenario.

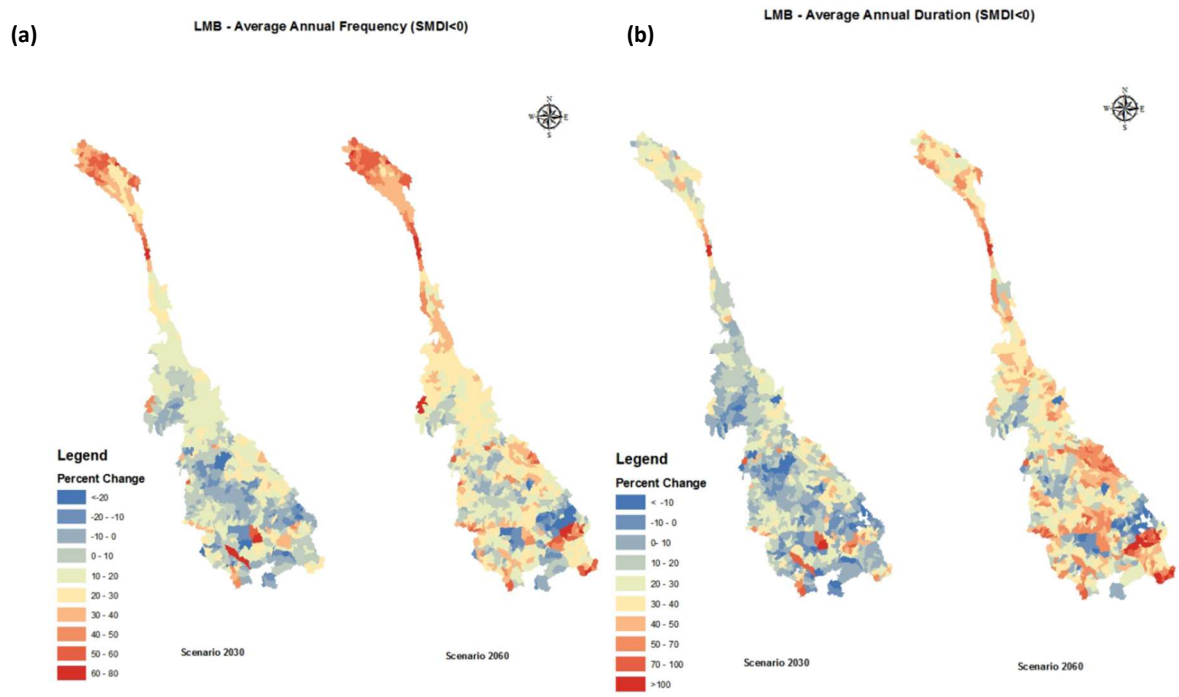


Figure 7: Average percentage change in average annual drought (a) frequency and (b) duration based on SDMI<0 across all climate models and emissions scenarios to 2030 and 2060.

Similarly, drought duration based on the SDMI is projected to decline across large areas of the basin in 2030, although this reverses in many areas, especially along the eastern periphery and in the south-east by 2060 (Figure 7). The range of other drought indices demonstrates similar geographic variability in projected climate change impacts. For example, the meteorological index of rainfall deciles less than the threshold of 5 shows greater projected change over northern Lao PDR and Thailand and Cambodia to 2030 and then central Lao PDR to 2060 (Figure 8).

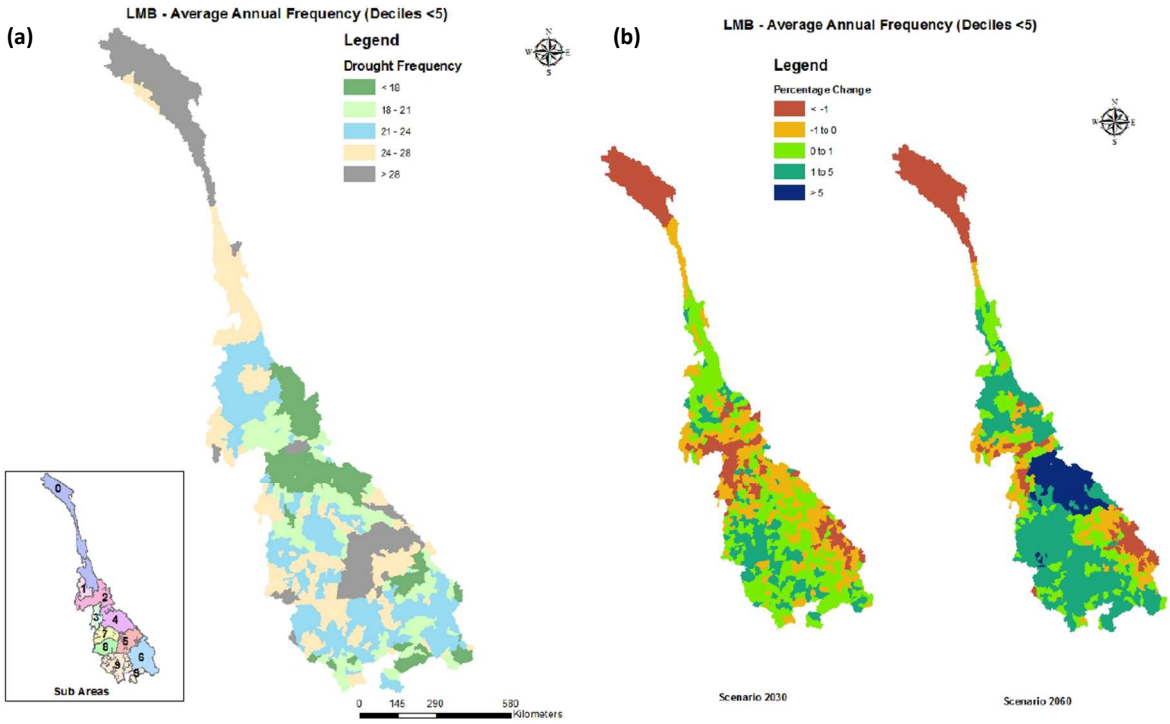


Figure 8: Average annual drought frequency for (a) weeks during the baseline period and (b) percentage change to 2030 and 2060, based on rainfall deciles<5 across all climate models and emissions scenarios to 2030 and 2060.

Vulnerabilities to climate change impacts on floods

As with vulnerabilities associated with flood, the high proportion of households and communities dependent on agriculture and water resources means a high degree of vulnerability to an increase in frequency and duration of droughts. Coping strategies for impacts of drought as identified in the SIMVA studies were very similar to the coping strategies identified for floods with variations across the Lower Mekong Basin. Borrowing money and receiving assistance from government were two of the strategies identified. Adaptation to changing weather was found to be very limited in scale. Only five per cent of the sample households had changed the season for growing rice; another 15 per cent had changed to planting rice later, and seven per cent of the households to planting earlier. Only two per cent of households surveyed had changed crops due to drought, and one per cent had changed crops due to flooding.

Relevant Assessment and Supporting Reports

MRC, 2015b. *Social Impact Monitoring and Vulnerability Assessment 2014: Shocks and Trends*. Mekong River Commission, Vientiane, Lao PDR.

MRC, 2017c. *Lower Mekong Basin Drought Indices Analysis*. Mekong River Commission, Vientiane, Lao PDR.

Basin-wide assessment of climate change impacts on ecosystems and biodiversity

Key message

Climate change impacts on ecosystems and biodiversity are projected to be very substantial under a range of future scenarios, with consequences for species survival and the provision of ecosystem services. Projected impacts vary geographically with different ecoregions more or less impacted under different models. By 2060 many ecoregions will face completely novel bioclimatic conditions. LMB species are highly vulnerable to the effects of climate change with large numbers of fish particularly at risk due to their sensitivity to hydrological cues. Changes in some ecosystem services such as water yield, sediment and nutrient retention may be positive or negative depending on whether the region faces a wetter or drier future.

Assessment approach

The assessment of climate change impacts on ecosystems and biodiversity was undertaken in three parts, examining: (i) changes in bioclimatic conditions; (ii) species vulnerability; and (iii) changes in some ecosystem services. Bioclimatic conditions were assessed using a statistically derived environmental stratification across the 14 ecoregions. Species vulnerability was evaluated using the ICUN biological trait based approach to assessing sensitivity, adaptive capacity and exposure across six species groups (amphibians, birds, fish, mammals, reptiles and plants). Four ecosystem services (water yield, sediment retention, nutrient retention and carbon storage) were evaluated using the InVEST suite of models.

Climate change impacts on ecosystems and biodiversity

Substantial changes in bioclimatic conditions are projected across the LMB's ecoregions (Figure 9). Excluding Northern Viet Nam Lowland Rain Forests given its small size, the proportion of each ecoregion shifting to a different bioclimatic zone by 2030 ranges from 2.3-24% for RCP2.6 and 8.9-60% for RCP8.5 under the wetter overall model; 3.9-21% for RCP2.6 and 19.4-63.2% for RCP8.5 under the drier overall model; and from 2.4-22.4% for RCP2.6 and 20.9-87.8% for the increased seasonal variability model. By 2060, up to 100% of some ecoregions may experience completely novel bioclimatic conditions.

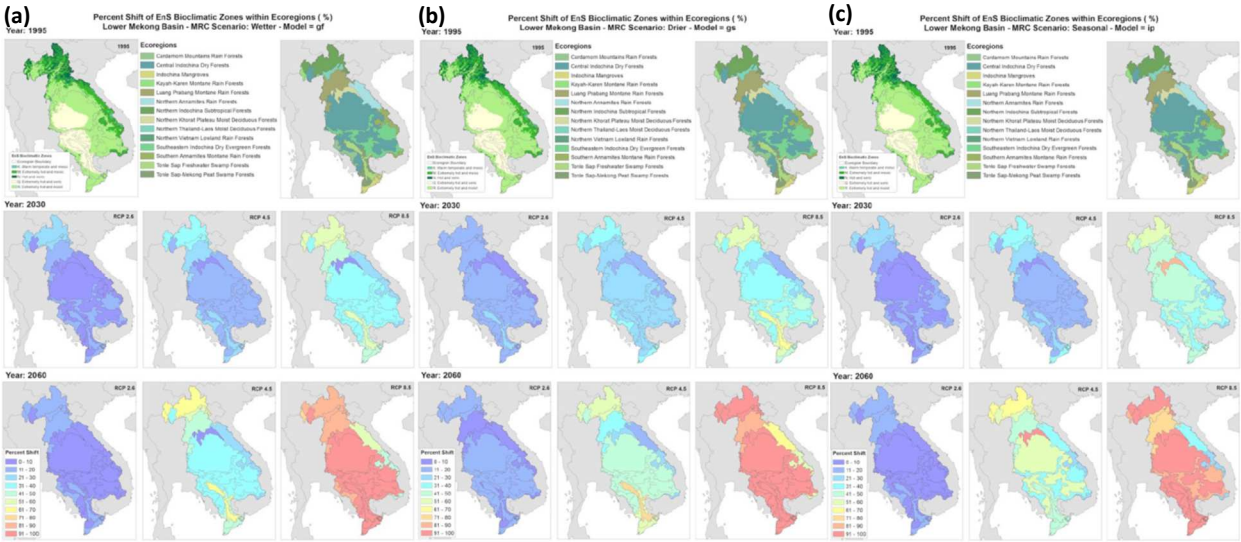


Figure 9: Proportion of each ecoregion shifting to a different bioclimatic zone under baseline conditions and as projected for 2030 and 2060 across the three emissions scenarios (RCP 2.6; 4.5; 8.5) by (a) the wetter scenario model; (b) the drier scenario model; and (c) the increased seasonal variability model.

If global emissions follow the lower trajectory the most significant climate change impacts on ecoregions are likely to be felt in the near future and then remain relatively stable, while if emissions follow the highest scenario then very substantial impacts will be felt in the near term and will continue

to worsen over time. Overall the proportional shifts are greater in the wetter and drier overall scenarios, but are still very large for the increased seasonal variability scenario.

Regional variations mean that the climate change impacts on species are likely to be different in different areas (Figure 10). Under a moderate climate scenario with optimistic assumptions, hotspots across multiple species groups include Tonle Sap and surrounding provinces, which was highlighted as containing notable numbers of climate change vulnerable birds, reptiles and plants, and the main channel of the Mekong River which contains large numbers of vulnerable freshwater fish. Also along the Mekong River, as highlighted on several maps, are large numbers of vulnerable plants, reptiles (especially at the Delta) and a few mammals (from Kratie province to the Lao PDR border).

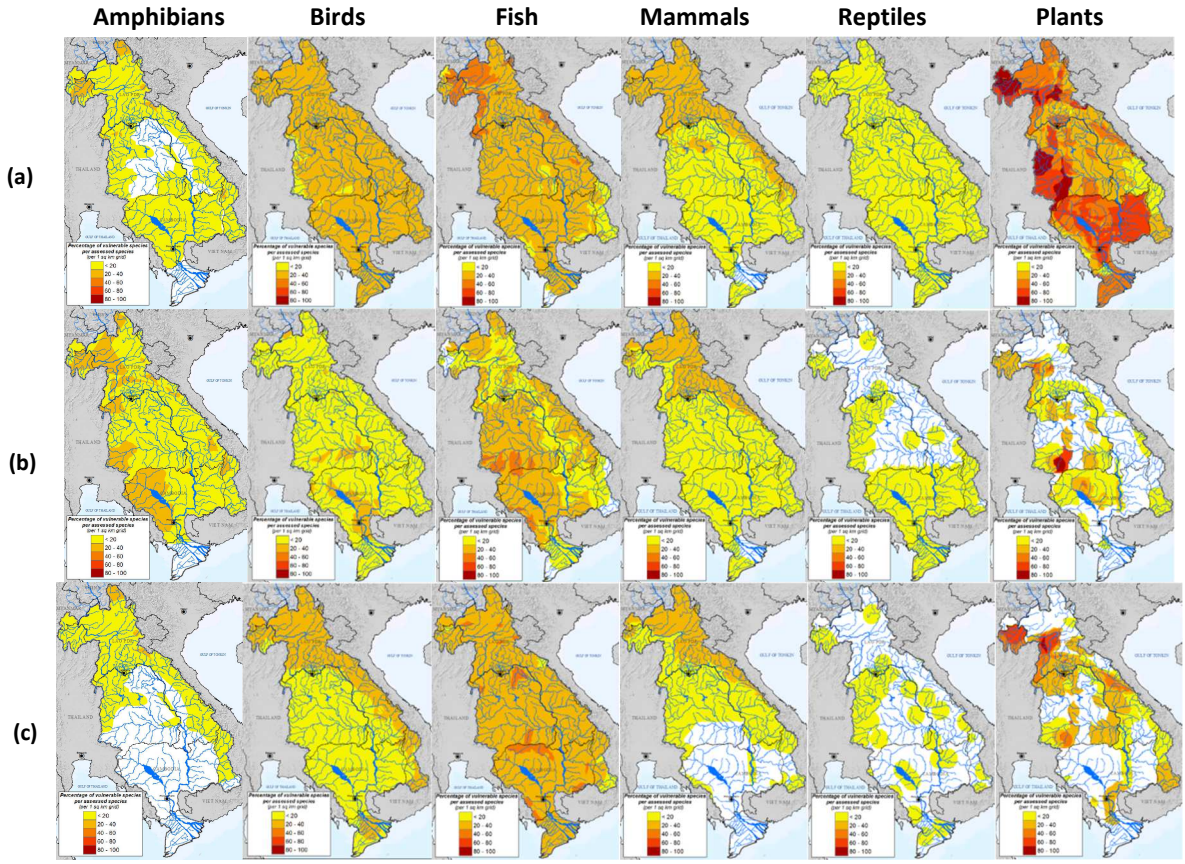


Figure 10: Percentage of species per grid cell vulnerable to climate change across the LMB for (a) wetter overall; (b) drier overall; and (c) increased seasonal variability models for RCP4.5 to 2060 with optimistic assumptions.

Under a moderate scenario to 2060 soil losses are projected to increase by 16.9% under a wetter overall model, 15.8% under an increased seasonal variability model, and 0.7% under a drier overall model. Exported nutrient (nitrogen and phosphorous) changes are generally less than one per cent under all scenarios and models, while changes in basin-wide water yield varies from -10% to +14%.

Relevant Assessment and Supporting Reports

MRC, 2017a. *Projected Climate Change and impact on bioclimatic condition and terrestrial ecosystems in the Lower Mekong Basin*. Mekong River Commission, Vientiane, Lao PDR.

MRC, 2017d. *Basin-wide climate change vulnerability assessment of Lower Mekong Basin species*. Mekong River Commission, Vientiane, Lao PDR.

MRC, 2017e. *Basin-wide impacts of climate change on ecosystem services*. Mekong River Commission, Vientiane, Lao PDR.

Basin-wide assessment of climate change impacts on food security

Key message

Climate change impacts on food security have been considered by assessing the potential impacts on cropping and fisheries yields. The projected impacts of climate change on crop yields are expected to be negative for both rice and maize with greater impacts on rice. Projected impacts on fisheries could be positive or negative depending on the scenario, although with those dependent on flood zone habitats likely to experience greater changes than those dependent on rice paddy habitats. Only minor impacts on aquaculture productivity were projected due many provinces being unaffected by salinity intrusion.

Assessment approach

The basin-wide assessment of climate change impacts on food security focused on projected changes to crop and fisheries yields. Crop modelling was undertaken using the AquaCrop model developed by FAO with modelling zones being the 15 Basin Development Plan sub-areas and five bioclimatic zones. Projected changes in fisheries yield was assessed by modelling changes to fish habitat, specifically flood area habitat and rice paddy habitat. Aquaculture impacts were assessed by considering the effects of salinity intrusion in the Delta and a calculation of potential productivity per usable area of land.

Climate change impacts on crop yields and fisheries production

Increases in the frequency of extreme events such as floods and droughts as well as temperature and rainfall changes will have an impact on agricultural production. Drought can reduce yields or lead to the total loss of crops, especially rain-fed rice. Floods can destroy planted areas with lowland areas and especially the delta area where the impacts might be exacerbated by rising sea-levels, more at risk.

MRC modelled the potential impacts of climate change on both rice and maize yields and projected that averaged over all scenarios, including irrigated and rain-fed production systems, impacts on yields are expected to be negative with larger impacts on rice than maize (Table 8). Data limitations, however, mean these results should be treated with caution.

Table 8: Projected climate change impacts on rice yield across LMB countries in 2030 and 2060.

Crop type	Country	Baseline	2030		2060	
		Crop yield (ton/ha)	Crop yield (ton/ha)	% of change	Crop yield (ton/ha)	% of change
Rice	Cambodia	2.92	2.88	-1.45	2.83	-3.22
	Lao PDR	4.21	4.07	-3.51	3.99	-5.76
	Thailand	2.37	2.12	-11.42	2.06	-14.95
	Viet Nam	5.00	4.96	-0.97	4.92	-1.67
Maize	Cambodia	4.72	4.69	-0.79	4.67	-1.16
	Lao PDR	5.62	5.55	-1.33	5.54	-1.61
	Thailand	2.40	2.46	2.65	2.43	1.22
	Viet Nam	4.30	4.295	-0.13	4.295	-0.13

For rice production the most significant impacts are projected to occur up to 2030 with smaller decreases in yield between 2030 and 2060. For maize, the small decline in yield to 2030 is largely projected to continue to 2060. The most significant impacts on rice yield are projected to be in Thailand and the most significant impacts on Maize in Lao PDR.

Depending on the scenario selected, the change in area of the flood zone fish habitat varied from -5922 km^2 (-13%) to +6293 km^2 (+13.7%) by 2060 with no development, while changes in the area of rice paddy habitat varied from -3597 km^2 (-2.7%) to +3043 km^2 (+2.3%). As yield per area was determined for each habitat type the change in yield varied in a similar way.

Total fish yields from the flood zone during the baseline period were estimated at 458,000-917,000 tons annually, and fish yields from rice paddies were estimated at 672,000-1,345,000 tons. This provided a total wild fish yield of 1,206,000 to 2,488,000 tons per year (including production in reservoirs, assumed to be constant for all scenarios), which is consistent with earlier MRC estimates. Given the shifts in habitat availability the magnitude of changes in fish yields are expected to be greater for the flood zone than in the rice paddies. Considering scenarios with no development alone, yields in the flood zone are expected to change by -60,000 to +125,000 tons $yr-^{-1}$ (-13 to +9%), compared to changes of -18,000 to +30,000 tons yr^{-1} (-3 to +2%) in yields from rice paddies.

Cumulative changes in total fish yields as a result of shifts in both habitat types lead to a net change of -155,000 tons yr^{-1} (-6% from baseline) to +97,000 tons yr^{-1} (+4%) for all future scenarios. For scenarios with no future development, very small changes (-31,000 to +12,000 tons yr^{-1}) were estimated in the short term (2030) for medium emissions scenarios for all three models, and only minor changes (±2% from baseline) for high emissions scenarios. The magnitude of change doubled to 2060, for which expected changes range from -89,000 to +89,000 tons yr^{-1} (-13% to + 14% of total baseline yield). When development scenarios are considered, it appears that there are likely to be much more detrimental conditions in the short term, with more than a three-fold increase in changes (-118,000 to +65,000 tons yr^{-1}) when compared to the scenarios with no development.

Over most scenarios there are projected to be minor losses (1 to 6%) in delta-wide aquaculture production compared to baseline conditions. The only exceptions to this are the two scenarios of medium-term horizon with high climate sensitivity and development (wetter overall and RCP8.5 and drier overall and RCP 8.5 for 2060), which show an increase in the total Delta production by 10-11 per cent. Delta-wide changes to aquaculture, however, are not expected to be evenly distributed among provinces. On the one hand, losses in Ca Mau (an average of 59,148 tons yr^{-1} for scenarios with no development, or 59% of baseline production) alone could be up to ten times higher than at the next most affected province, Soc Trang (average loss of 5,852 tons yr^{-1}). On the other hand, Ben Tre is expected to see an increase in production by 6,831-94,416 tons yr^{-1} in all but one scenario (medium term horizon of a drier climate with high sensitivity). Furthermore, since no changes in acute salinity were estimated for Dong Thap, An Giang, Can Tho, and Vinh Long, where 23%, 20%, 12%, and 9% of the current Delta's aquaculture production take place, respectively, a majority of the delta-based aquaculture could be unaffected by the future salinity intrusion.

Relevant Assessment and Supporting Reports

MRC, 2015c. Fisheries habitat and yield in the Lower Mekong Basin. MRC Technical Paper No. 47. Mekong River Commission, Phnom Penh, Cambodia.

MRC, 2016. *Assessment of the impact of climate change on fisheries resources under different climate change conditions and scenarios in the Lower Mekong Basin*. Mekong River Commission, Vientiane, Lao PDR [DRAFT REPORT].

MRC, 2017f. *Basin-wide assessment of climate change impacts on food security and adaptation options in the Lower Mekong Basin*. Mekong River Commission, Vientiane, Lao PDR [DRAFT REPORT].

Basin-wide assessment of climate change impacts on hydropower

Key message

Climate change impacts on hydropower production depend on the direction of future changes in hydrology, particularly river flow at different times of year. These impacts could be positive or negative both on the Mekong mainstream and in the tributaries with the drier overall model and the higher emissions scenarios having the biggest deleterious impacts on power production. The range in potential future impacts is considerable.

Assessment approach

The assessment of climate change impacts on hydropower was undertaken using SWAT and IQQM models on both tributaries and the mainstream with each dam separately simulated under climate change and future development scenarios.

Climate change impacts on hydropower

The projected climate change impact on hydropower production depends significantly on whether the future is wetter or drier (Figures 11 and 12). Under the wetter overall model all countries are projected to have an increase in energy production due to climate change with Cambodia having the largest increase to 2030 and Viet Nam the largest increase to 2060, under a medium emissions scenario (RCP4.5). Under the drier overall model, all countries except Viet Nam are projected to have lower energy production due to climate change than they otherwise would, both to 2030 and to 2060.

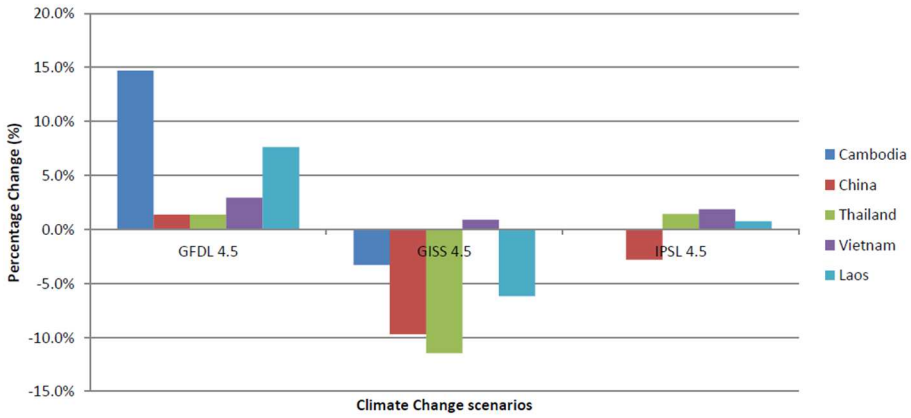


Figure 11: Percentage change in energy production under 2030 proposed dams under the RCP4.5 scenario for the wetter overall (GFDL), drier overall (GISS) and increased seasonal variability (IPSL) models.

The largest reductions in power production due to climate change are projected to occur with the high emissions scenario (RCP8.5) under the drier overall model and this is worse in China and Thailand than elsewhere (-40%; Table 9), although Lao PDR may also be badly affected (-30%). The increased seasonal variability model also generally projects a reduction in power production under all emissions scenarios and for all countries although the impact is not as pronounced as for the drier overall model.

Overall the impact of climate change could be negative or positive and is likely to affect power production in both the tributaries and the mainstream (Table 10). The range in potential future impacts is considerable. For example, in Thailand tributaries the change in minimum power

production under the high emissions scenario to 2060 could be between -100 per cent under the drier overall scenario and +80 per cent under the increased seasonal variability model.

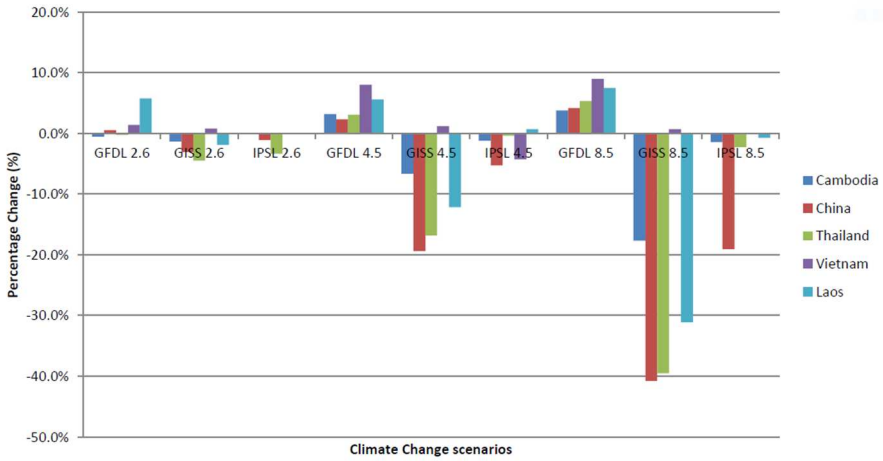


Figure 12: Percentage change in energy production under 2060 proposed dams under each emissions scenario for the wetter overall (GFDL), drier overall (GISS) and increased seasonal variability (IPSL) models.

Table 9: Average change in power production with 2060 proposed dams compared to the 2007 climate baseline for each emissions scenario and the wetter overall (GFDL), drier overall (GISS) and increased seasonal variability (IPSL) models.

	Wetter RCP2.6	Drier RCP2.6	Seasonal RCP2.6	Wetter RCP4.5	Drier RCP4.5	Seasonal RCP4.5	Wetter RCP8.5	Drier RCP8.5	Seasonal RCP8.5
Cambodia	-0.5%	-1.3%	-0.1%	3.2%	-6.7%	-1.2%	3.8%	-17.7%	-1.5%
China	0.5%	-3.0%	-1.1%	2.3%	-19.4%	-5.3%	4.2%	-40.8%	-19.1%
Thailand	-0.2%	-4.5%	-3.3%	3.1%	-16.8%	-0.4%	5.3%	-39.5%	-2.2%
Vietnam	1.4%	0.8%	0.0%	8.0%	1.2%	-4.2%	9.0%	0.7%	-0.1%
Laos	5.8%	-1.9%	0.0%	5.6%	-12.1%	0.7%	7.5%	-31.1%	-0.7%

Table 10: Percentage change in minimum daily power production with 2060 proposed mainstream and tributary dams compared to the 2007 climate baseline for each emissions scenario and the wetter overall (GFDL), drier overall (GISS) and increased seasonal variability (IPSL) models.

	GFDL 2.6	GISS 2.6	IPSL 2.6	GFDL 4.5	GISS 4.5	IPSL 4.5	GFDL 8.5	GISS 8.5	IPSL 8.5
Cambodia (Main)	-5.66%	-3.45%	2.80%	8.82%	-27.71%	-1.15%	14.58%	-58.70%	-6.60%
Cambodia (Trib)	7.21%	4.32%	-0.35%	54.27%	0.53%	-49.26%	54.89%	-3.49%	-2.94%
China (Main)	1.30%	-30.50%	-0.76%	7.28%	-51.89%	-3.61%	28.94%	-60.54%	-32.01%
Thailand -(Trib)	0.58%	-0.16%	11.48%	29.93%	-88.98%	44.45%	58.94%	-100.00%	79.81%
Vietnam (Trib)	26.81%	17.76%	-2.45%	105.30%	4.24%	-98.77%	102.97%	4.74%	-0.46%
Laos (Main)	-1.02%	-2.35%	0.88%	7.12%	-39.13%	-0.84%	21.70%	-66.01%	-38.08%
Laos (Trib)	4.10%	-5.70%	-0.22%	17.63%	-25.72%	6.87%	23.85%	-46.10%	12.42%

Relevant Assessment and Supporting Reports

MRC, 2017g. *Change in hydropower production under climate change*. Presentation to regional consultation workshop on basin-wide assessments of climate change impacts on hydrology, flood behaviour, drought behaviour and hydropower in the Lower Mekong Basin on 30-31 March 2017. Mekong River Commission, Vientiane, Lao PDR.

Basin-wide assessment of climate change impacts on socio-economic conditions and vulnerability

Key message [Preliminary]

Projected climate change impacts on socio-economic conditions are potentially very significant and many people and communities are vulnerable to wide-ranging impacts. There are broad economic and structural changes occurring across Lower Mekong Basin countries which will help to mitigate the impacts of climate change (e.g. economic growth, urbanisation, reducing poverty and improving health and infrastructure). However, many people are still very reliant on natural systems for their livelihoods and food security, which makes them more vulnerable to impacts on these systems. The capacity to adapt and remain resilient in the face of climate change will depend on a range of factors including the diversification of livelihoods, and the assets and resources available to households to cope with shocks.

Assessment approach

The assessment of climate change impacts on socio-economic conditions and vulnerability applies a standard two-step approach: (i) the determination of impact, being a function of the level of exposure to climate change induced threats and the sensitivity of the object of the assessment to this exposure; and (ii) the determination of vulnerability, being a function of impact and adaptive capacity. The analysis is focused on the livelihood impacts of changes in sector productivity for: (i) agriculture (rice and maize production); (ii) fisheries (capture fisheries and aquaculture); (iii) hydropower; and (iv) ecosystem goods and services, using a baseline drawn from data on population density, economic growth and development, poverty rates, agriculture production, and fish consumption and dependency. Results are being considered across five livelihood zones (forested uplands, intensively farmed uplands, lowland plains and plateaus, floodplain, and delta).

Climate change impacts on socio-economic conditions and vulnerability [Preliminary results]

The projected climate change impact on socioeconomic conditions and vulnerability have so far been considered in relation to drought (Figure 13) and production of aquaculture, rice and maize (Figures 14 and 15). Based on these preliminary results, vulnerability to drought is expected to be fairly widespread by 2030, but becoming more severe by 2060 particularly in Lao PDR and parts of northern and eastern Cambodia.

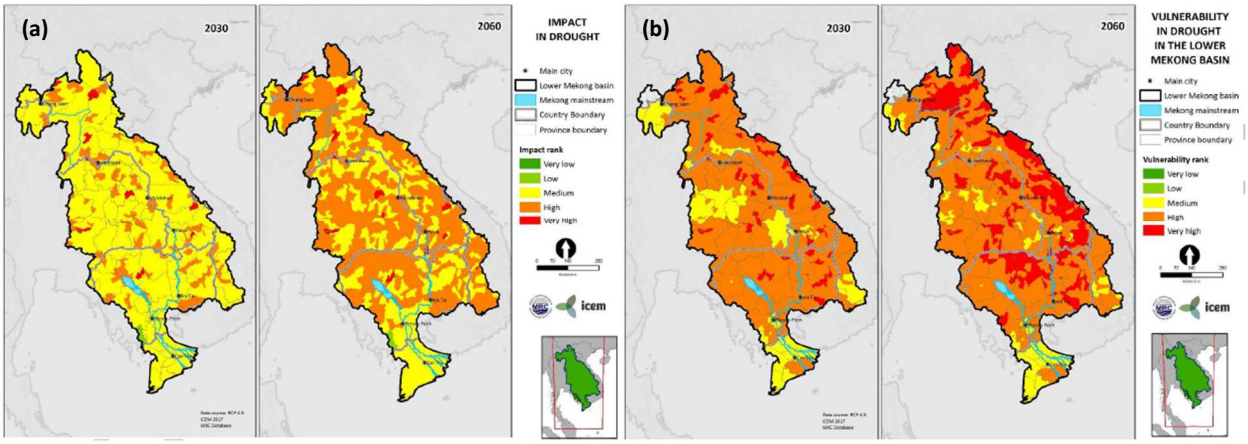


Figure 13: (a) impact ranking for drought; and (b) vulnerability ranking for drought, to 2030 and 2060.

Vulnerability to the impacts of climate change on aquaculture production is the same under development and no development scenarios and appears to be worse in 2030 than in 2060 in some

Delta provinces. All places assessed show at least medium vulnerability to climate change impacts on aquaculture.

Vulnerability to climate change impacts on rice and maize production varies in different parts of the LMB. Areas with the highest vulnerability for rice are primarily in northern Lao PDR as well as across Cambodia and some southern parts of Thailand and Lao PDR. The Delta region remains relatively less vulnerable, even to 2060. Areas with the highest vulnerability to impacts on maize production are mostly in the central LMB, particularly north-east Thailand and central Lao PDR. However, almost the entire basin other than the Delta is assessed as having at least a high vulnerability ranking.

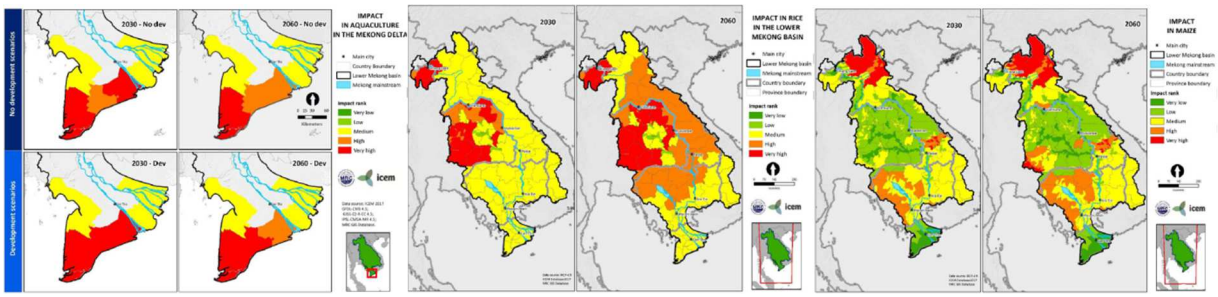


Figure 14: Impact ranking for (a) aquaculture production; (b) rice production; and (c) maize production to 2030 and 2060.

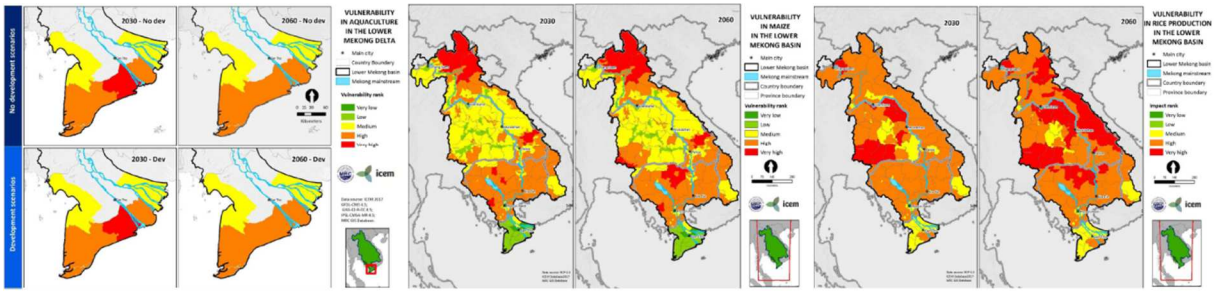


Figure 15: Vulnerability ranking for (a) aquaculture production; (b) rice production; and (c) maize production to 2030 and 2060.

Relevant Assessment and Supporting Reports

MRC, 2015b. *Social Impact Monitoring and Vulnerability Assessment 2014: Shocks and Trends*. Mekong River Commission, Vientiane, Lao PDR.

MRC, 2017h. *Socio-economic vulnerabilities of communities to climate change in the LMB*. Mekong River Commission, Vientiane, Lao PDR. [DRAFT REPORT]

Conclusions

Projected future climate changes and the resulting impacts on water resources and water related sectors are in some scenarios extreme. The implications for socio-economic systems may be profound with vulnerable communities being those most dependent on natural resources for their livelihoods.

There are broad economic and structural changes occurring across Lower Mekong Basin countries which will help to mitigate the impacts of climate change (e.g. economic growth, urbanisation, reducing poverty and improving health and infrastructure). However, many people are still very reliant on natural systems for their livelihoods and food security, which makes them more vulnerable to climate change impacts. The capacity to adapt and remain resilient in the face of climate change will depend on a range of factors including how diversified livelihoods are and the assets and resources available to households to cope with shocks.

Through their National Communications to the United Nations Framework Convention on Climate Change, all Member Countries have identified potential barriers to effective adaptation including:

1. a lack of human resources capacity
2. regional scenarios and information on climate change impacts being inadequate
3. data and information gaps
4. a lack of financial resources and the mechanisms for financing action on climate change
5. insufficient technology transfer and required investment
6. a lack of awareness both within government at different levels, and across the community on potential climate change impacts and adaptation options

Despite this capacity deficit, there are many examples of adaptation being enacted across the region and recognition there is a need to do much more. Access to international finance and regional cooperation and knowledge sharing will play an important role in ensuring this occurs.

The wide-range of projected impacts across water and water-related sectors on the basis of equally plausible climate scenarios, with potentially different impacts in different parts of the Basin, means that it is essential to identify and implement adaptation policies that:

- have broad socio-economic benefits and rationale, essentially supporting good practice and sustainable development pathways and ensuring resilience to shocks whether they be due to climate change or other causes (e.g. global market volatility, natural disasters – whether or not they become more frequent);
- are flexible and scalable – the direction and magnitude of change cannot be known with certainty. All we know is that significant change is very likely to occur. It is important that communities can deal with change regardless of how it manifests itself and can rapidly scale-up the response as change becomes more evident and severe;
- support improved governance and strengthened institutions that allow for participatory approaches and enhanced decision-making capacity for individuals and communities – a one-size-fits-all approach is unlikely to succeed given the variation in potential impacts across the LMB and so awareness and access to information is critical for household and business decisions;
- support a diversification of income sources and livelihoods wherever possible, so that people have options at times when they really need them; and
- provide for information (including monitoring and early-warning) and capacity building, which is essential to enabling good decisions at all levels of government and community.