CLIMATE CHANGE BASELINE ASSESSMENT

MRC SEA of hydropower on the mainstream

Key strategic issues

- What changes are foreseen in climate and hydrological variability and extremes?
- What implications will those changes have for natural and social systems in the basin?
- What implications will those changes and their effects have for development sectors in the basin including hydropower?
- What are the linked risks and opportunities for mainstream hydropower development (for example, in terms of energy generation, operations, GHG emissions and carbon financing)

Key climate changes influencing ecosystems, livelihoods and development

through changes in:

- Temperature
- Rainfall
- Water volume, runoff and flow
- Sea level
- Tidal fluctuations
- Occurrence of extreme events and conditions – storms, floods and drought

BDP indicators

- Climate change influences all assessment indicators identified in the BDP for:
  1. Economic development objectives
  2. Environmental protection objectives
  3. Social development objectives
  4. Equitable development objectives

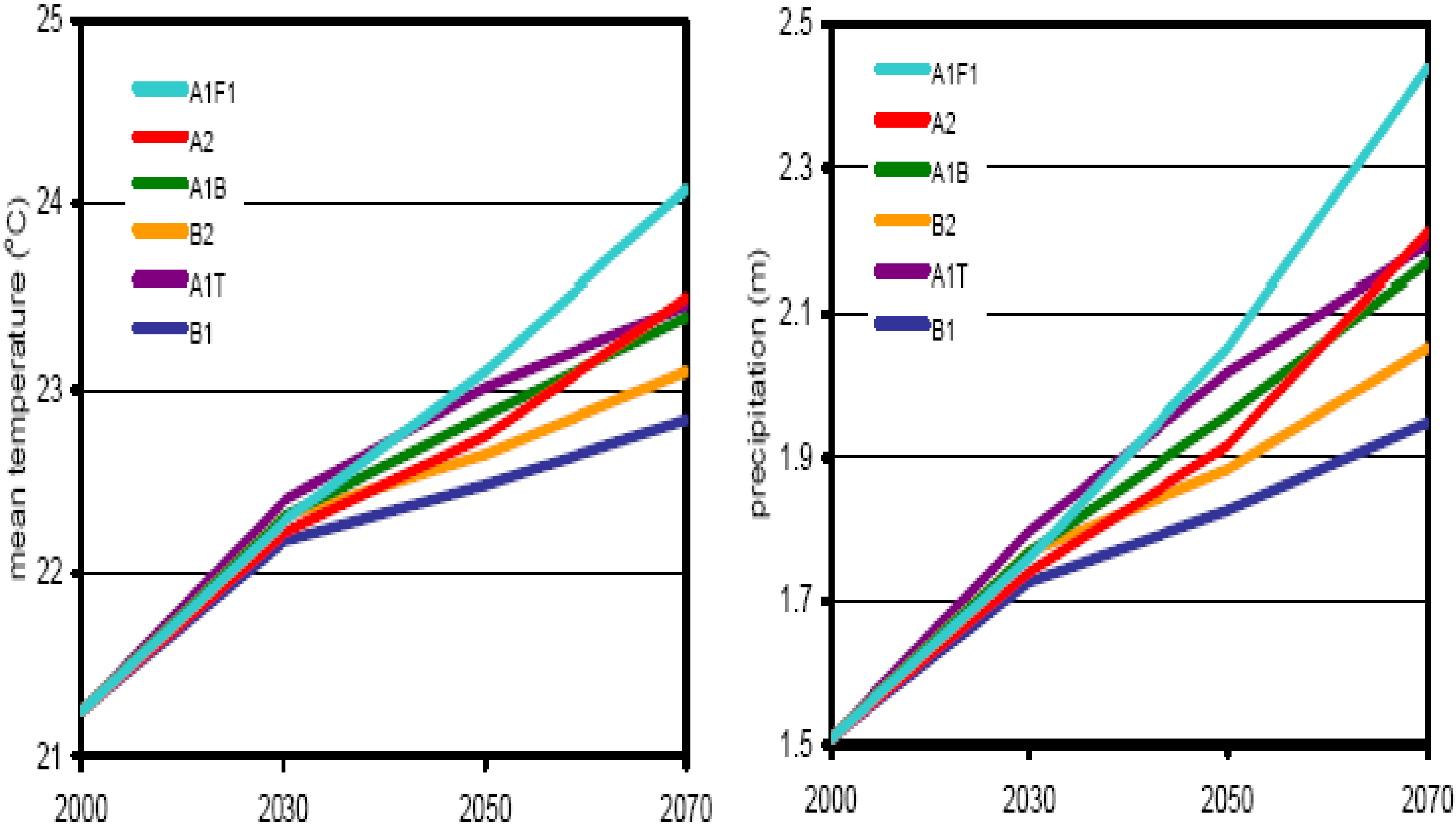
Two key considerations when assessing climate change effects

- The global development scenarios (they vary in terms of impacts on green house gas emissions)
- The climate models used in applying the IPCC scenarios to the Mekong region

Important because:

- Different scenarios result in differing scale of change
- Different models can lead to differing estimates for the range and pace of changes within one scenario

Projected mean temperature and mean annual rainfall for the Mekong Basin for different IPCC scenarios at 2030, 2050 and 2070

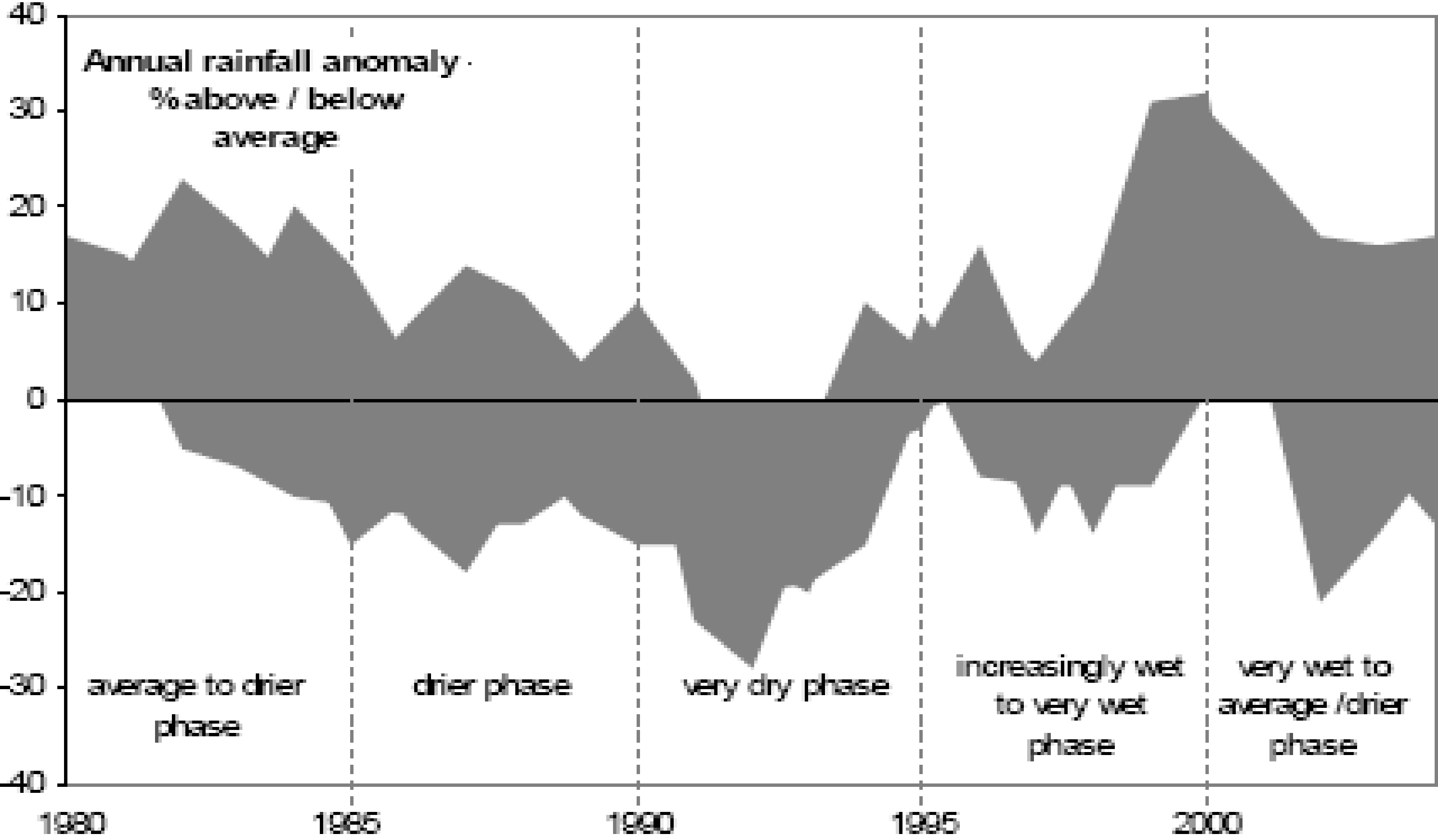


Taking one scenario (A1B) and the mean results from 11 models

Changes in the basin vary:

- From catchment to catchment
- From North to South
- From season to season
- From year to year

Deviations of regional rainfall above and below average over the 25 years between 1980 and 2004



Climate change in the basin – annual average (2030 for A1B)

Indicator	Historical record 1951-2000	2030	Increase
Temperature	21.2°C	22.0°C	**3.7%** or 0.8°C
Runoff	~512,000 mcm	~619,000 mcm	**21%** or ~107,000 mcm
Rainfall	1.509 m	1.712 m	**13.5%** or 0.2m
Flow	13600 m3s-1, the mean annual discharge at Kratie from 1924-2006	16592 m3/s	**22%**
Flooding (incidence of extreme wet events at Kratie – zone 5)	▪Annual probability 5% ▪Duration 5.1 months	▪76% ▪Duration 5.7 months	▪**71%** increased probability ▪**12%** increase in duration ▪Increase of 3,800km^2 area of flooding in delta

Temperature and rainfall (2030 A1B)

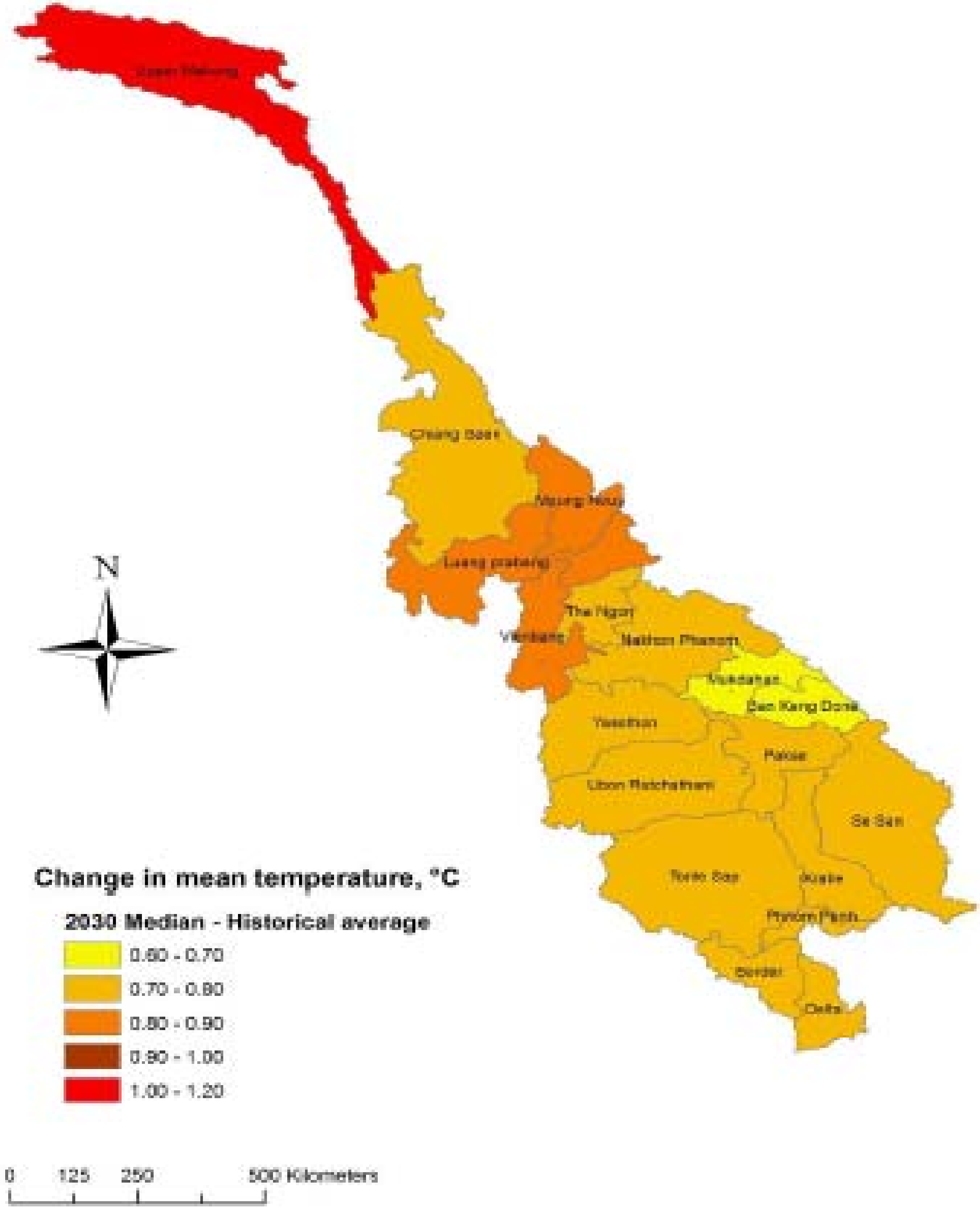
Temperature

- Increase in mean basin temperature by 0.8°C.
- Greater increased in northern zones of the basin – Increase by close to 1.4°C in the Upper Mekong Basin

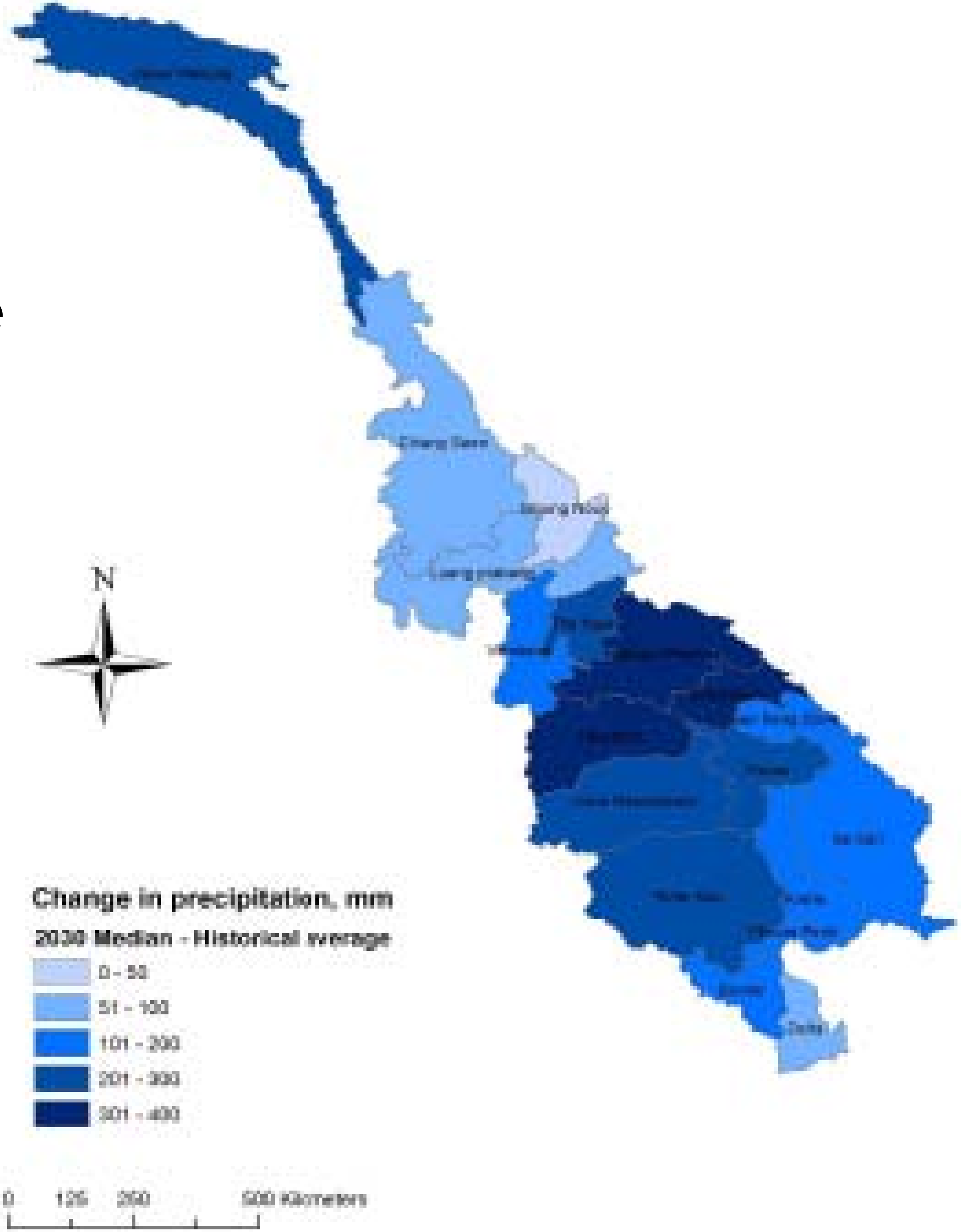
Rainfall

- Annual rainfall to increase by 13.5% (0.2m) mainly due to increases in wet season (May to Oct)
- Dry season rainfall will
  - increase in northern zones (1 and 2)
  - decrease in southern zones (3 to 6 – ie from Vientiane to the Delta)
- Overall disparity between wet and dry seasons to increase especially in zones 3 to 6

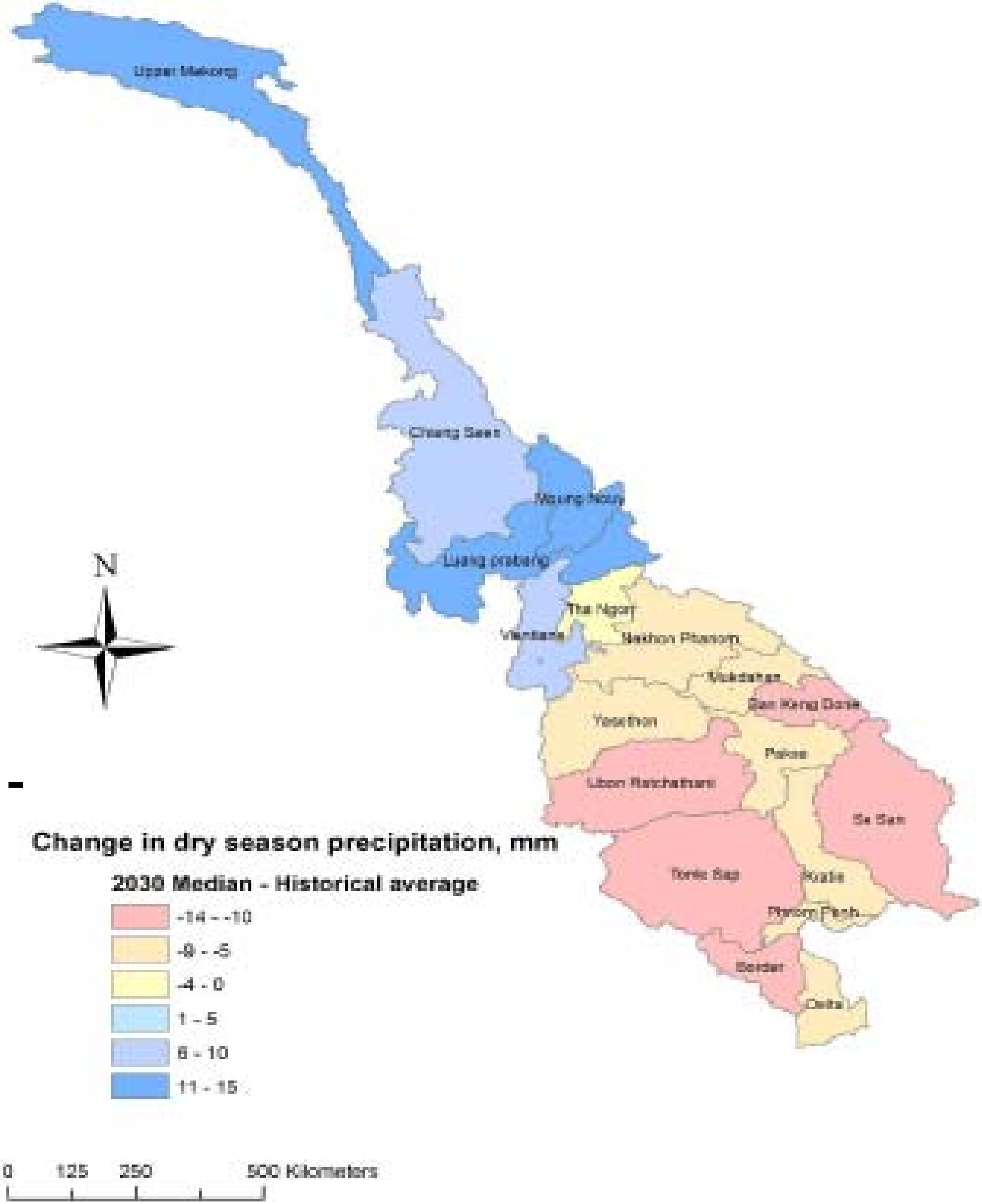
Projected change in mean temperature at 2030 compared with historical (1951-2000) mean temperatures



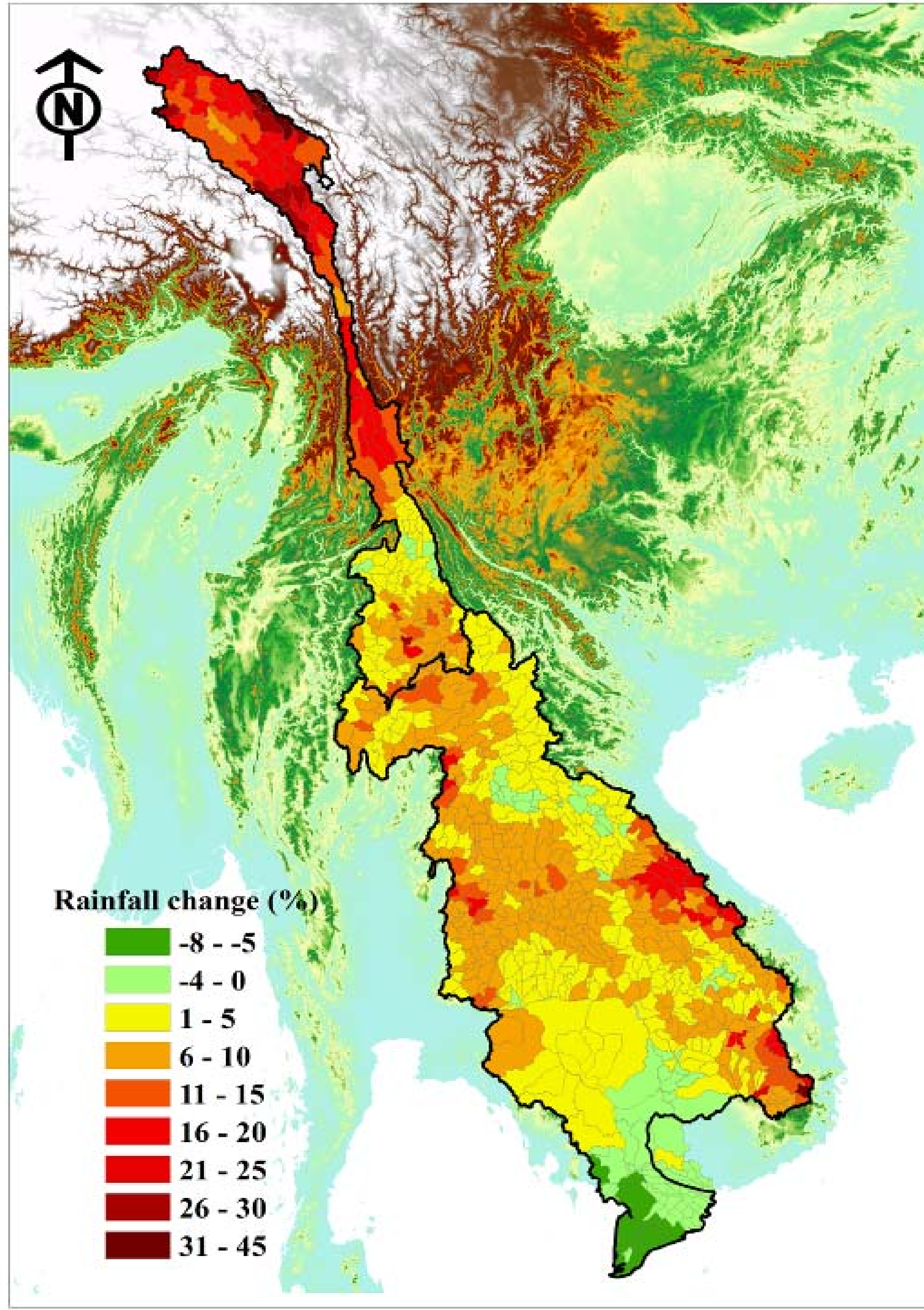
Projected change in mean annual precipitation at 2030 compared with historical (1951-2000) mean precipitation



Projected change in precipitation during the dry season (November to April) at 2030 compared with historical (1951-2000) mean precipitation



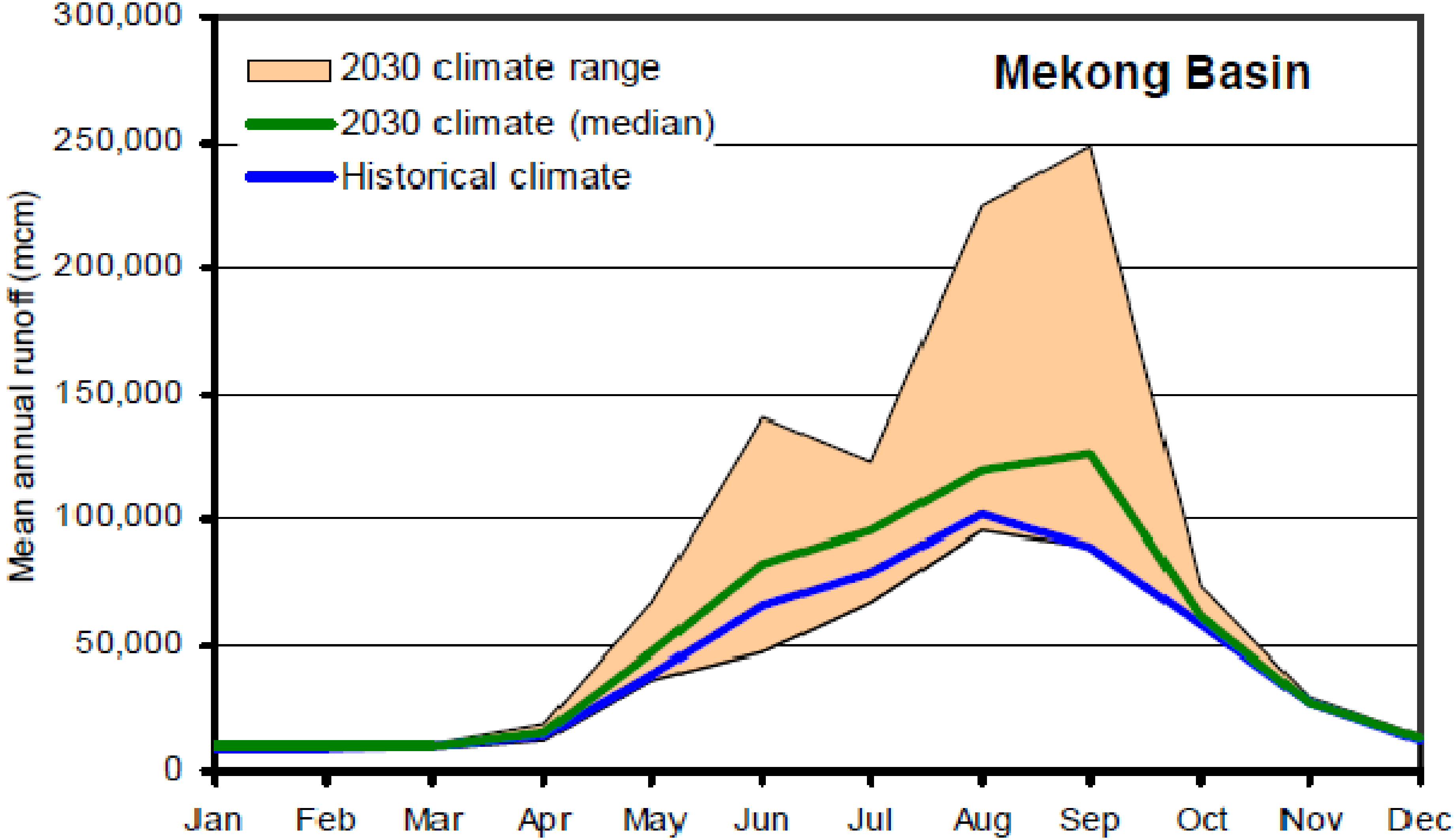
Change in mean annual precipitation (%) during 2010–2050 compared to 1985–2000 for scenario A2



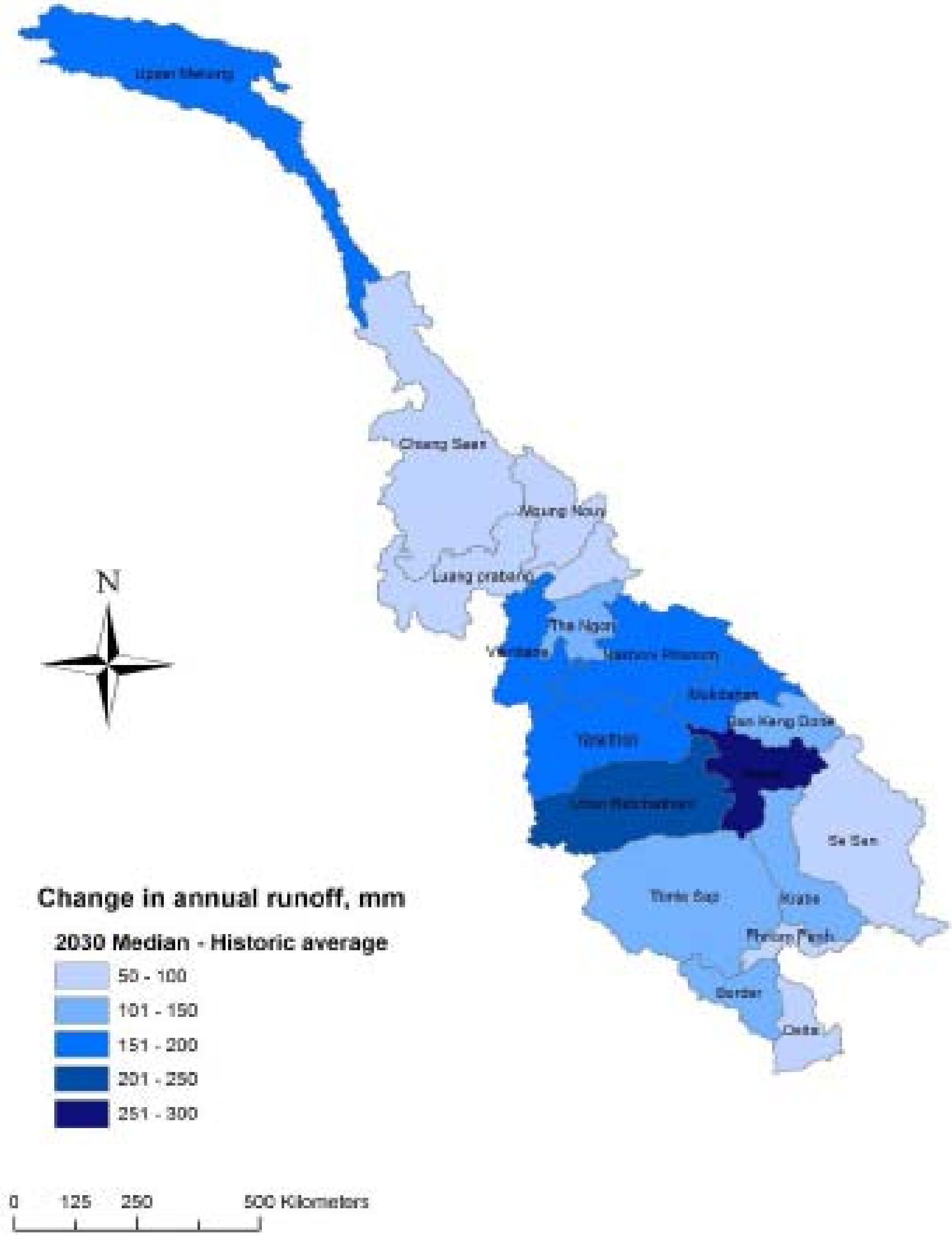
Runoff

- Total annual runoff from the basin to increase by 21% mainly during the wet season
- Annual discharge at Kratie will increase by 22% with increases in all months but mainly wet season

Historical (1951-2000)and future (2030) monthly runoff



Change in mean annual runoff at 2030 compared with historical (1951-2000) mean annual runoff for catchments of the Mekong Basin

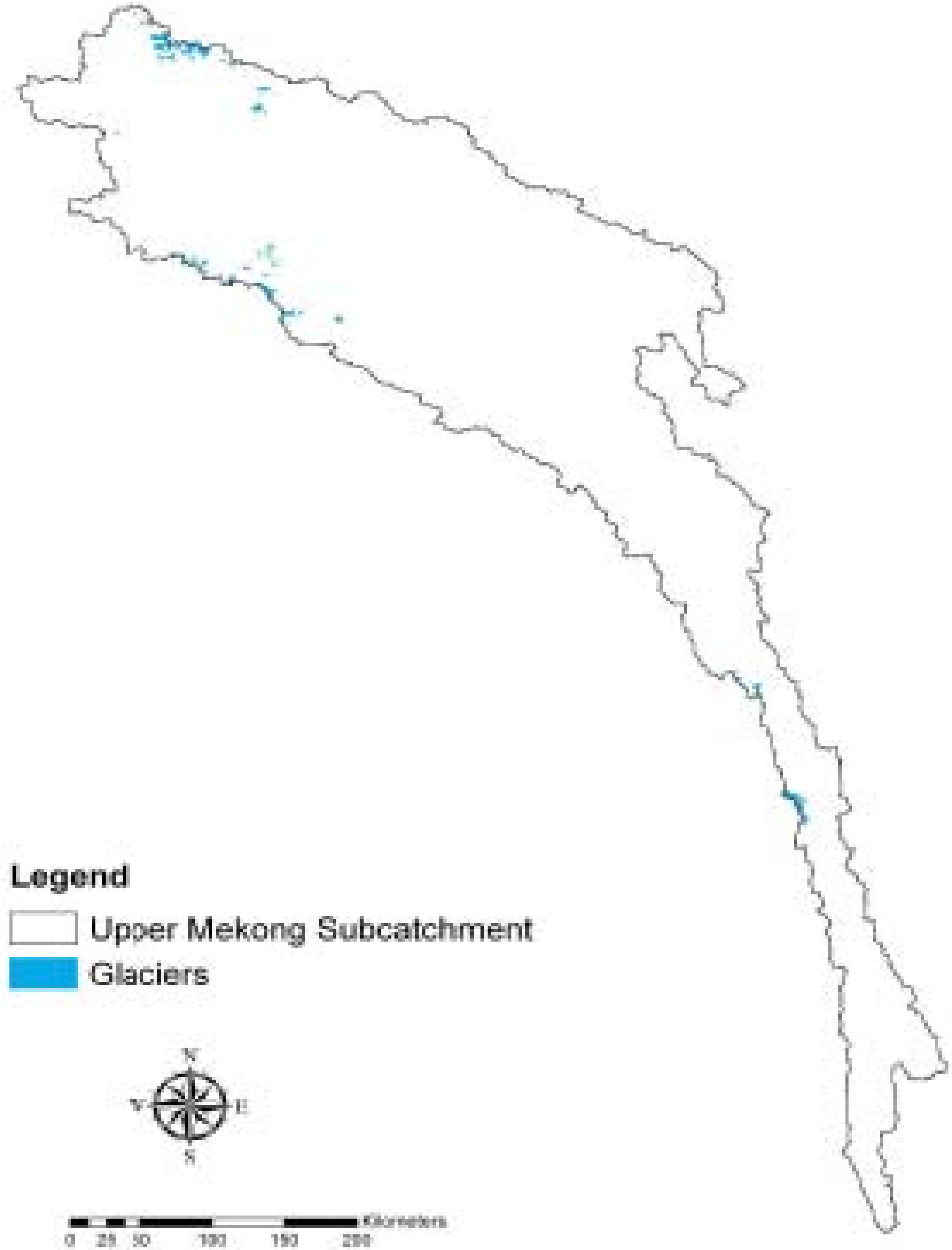


Melting of glaciers

Indicator	Historical record 1951-2000	2030	Increase
Contribution of glacial and snow melt to discharge to LMB	1% of mean annual discharge from Chiang Sean due to glaciers - 118 mcm/year 8% from snow melt snow ~6,700 mcm	142 and ~7,700 mcm	20% increase from glacial/snow melt

- Discharge from will be increase but impact on flow and water availability small
- glacial melt contributes only 0.1% to annual discharge to LMB (historically) – that will remain at a similar level in 2030

Upper Mekong glaciers



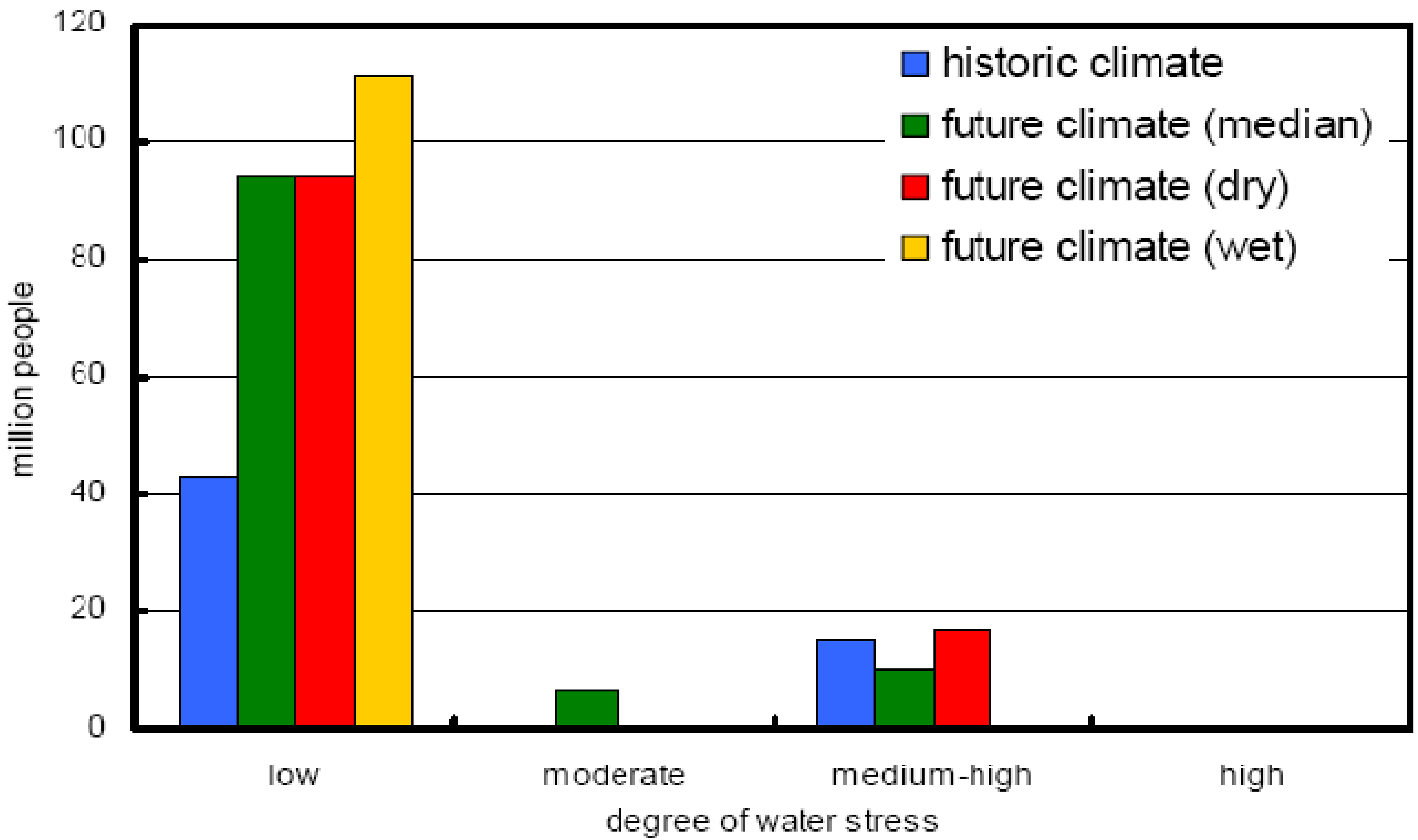
Flooding

- Flooding will increase throughout the basin – with downstream zones affected most.
- For example at Kratie (zone 5) the annual probability of extreme wet flood events will increase from 5% (historic conditions) to 76%. It will increase to 96% in the wet season
- Duration of flooding to increase in this zone and its onset will come earlier – Tonle Sap max and min area and levels to increase annually
- Area - Annual average flooding in delta to increase by 3,800km^2
- Impact greatest on the mainstream Mekong due to cumulative contribution from tributaries

Drought

- Despite rainfall increases, Northern Thailand and the Tonle Sap catchment (zone 5) are still susceptible to high water stress in the dry season
- There will be more dry spells
- And greater extremes between wet and dry seasons in southern and eastern areas

People experiencing water stress in the Mekong basin under historic climate and 2030 climate projections



Some effects on hydropower

By 2030:

- Increased rainfall, runoff and flow throughout basin would increase potential capacity of tributaries for hydropower
- Increase in extreme wet events an important consideration
- Some catchments will experience very high increases in runoff and water volume – possibly beyond the capacity of existing tributary schemes.
- Dam design and retrofitting would need to take into account changing conditions of rainfall and runoff and of extreme events

Effects on fisheries

By 2030:

- River nutrient load likely to increase with increased area, frequency and duration of flooding
- Fish habitats and populations might expand in some areas due to expanded water area and flooding
- Food might increase with expanded organic and sediment load
- In other areas – eg flooded forest – habitat substantially reduced due to increase in lake size (no room for ecosystem shift). Seasonal habitat in channels might reduce

Effects on fisheries

- Small increases (1–2°C) in temperature may have sub-lethal effects on tropical fish physiology, particularly reproduction.
- Salinity changes in the delta may also drive changes in species distribution
- The extended flooding may also affect aquaculture – particularly when located in the coastal areas of the delta.

Effects on agriculture

Indicator	Historical record 2000 (million tonnes)	2030 (million tonnes)	Increase
Agricultural productivity in the basin	42.9.	44.5	3.6%.
Paddy or equivalent food demand	17	33	94% due to population growth
Food production above demand	25	11	minus 56%

Effects on agriculture

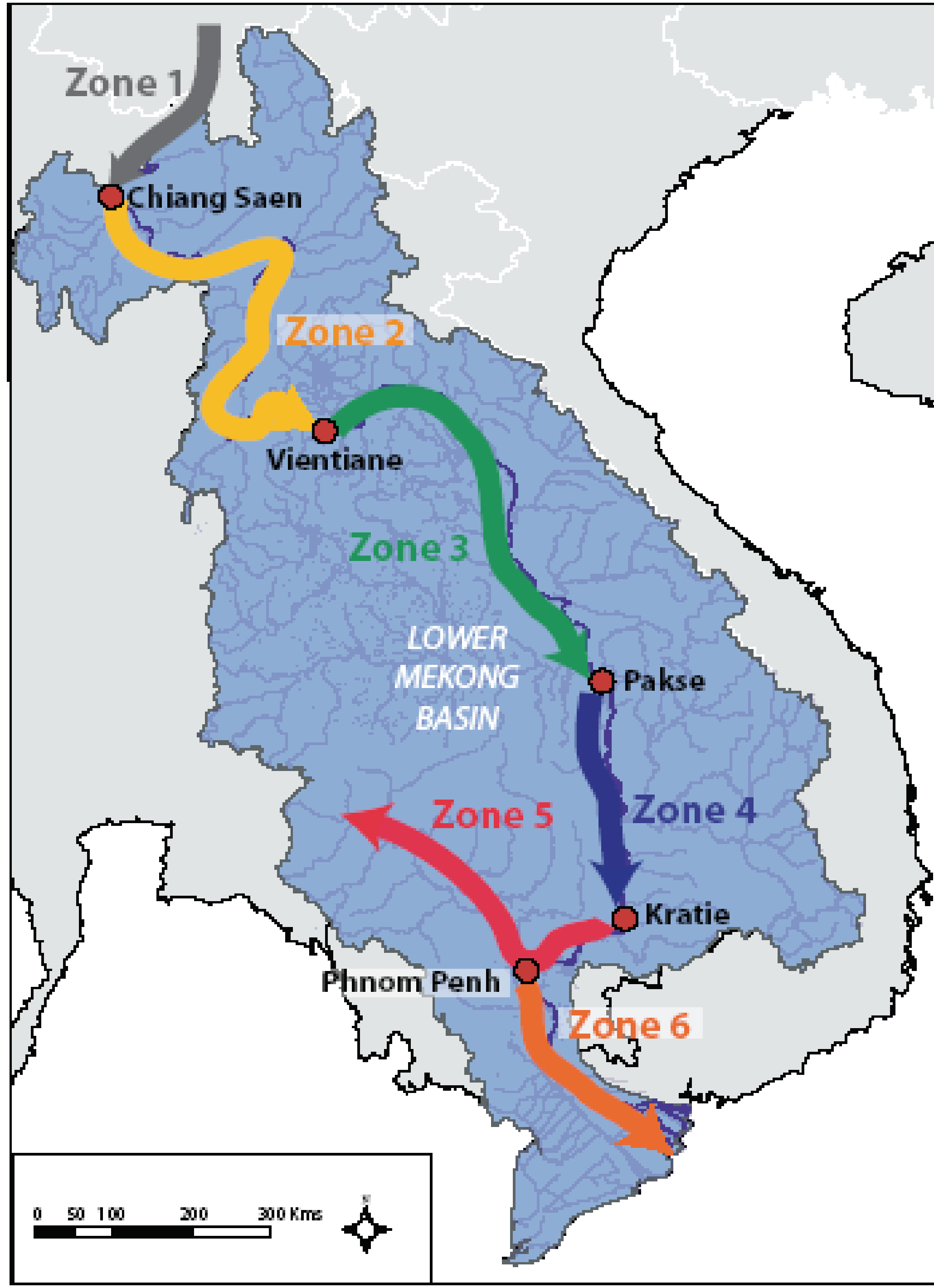
By 2030:

- Increase in the number of sub catchments deficit in production (Phnom Penh, Border and Delta catchments in the south of the basin)
- Increase in wet season rainfall would increase productivity of rain fed rice,
- Water availability generally will increase for all uses
- Decrease in dry season rainfall in some areas would lead to a fall in irrigated rice production
- More dry spells could affect crop productivity in some catchments

Effects on agriculture

- Increased floodplain deposition (also water logging?)
- In delta aquaculture and agriculture highly sensitive to salinity
- Soil erosion will increase due to increased runoff
- Increased erosion of river banks and channels

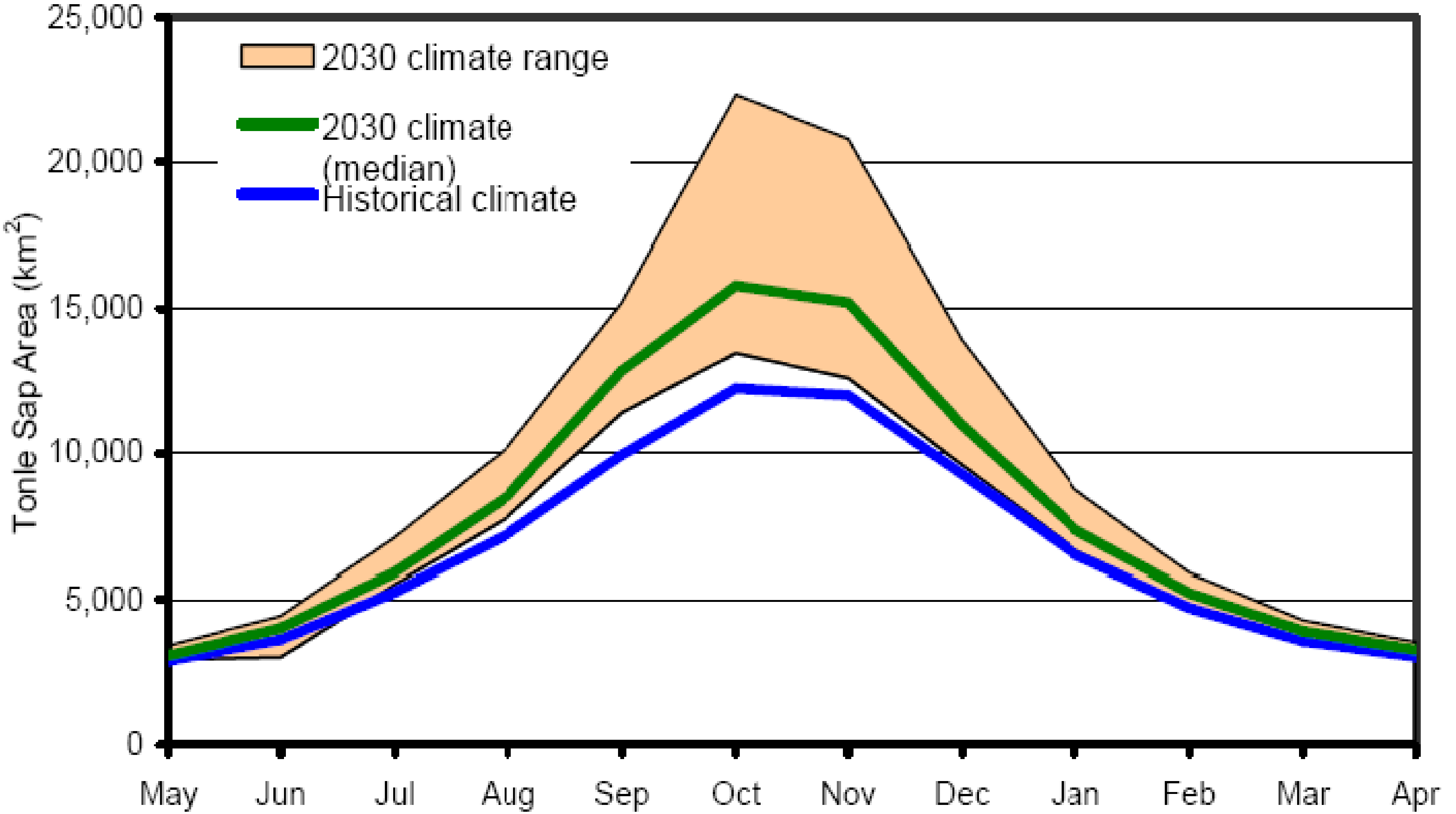
Climate effects by mainstream ecological zones



Zone 5 – Kratie to Phnom Penh and the Tonle Sap - Floodplains and the Great Lake

- Temperature and annual precipitation increased;
- Dry season precipitation decreased;
- Annual runoff increased;
- Dry season runoff decreased;
- Dry season water stress increased and remains high;
- High probability of increased flooding
- Seasonal fluctuation in Tonle Sap Lake area and levels increased;
- Minimum area of Tonle Sap Lake increased,
- Maximum area of the lake during the wet season is projected to increase from 15,000 km^2 by an average of 3,600km^2 – ie to 18,600km^2
- Increase maximum levels by an average of ~2.3 m each year.
- Flooding starts earlier in the wet season and longer duration

Historical (1951-2000) and future (2030) seasonal fluctuation in area of Tonle Sap Lake



Zone 6 – Phnom Penh to the sea – Mekong delta, tidal zone

- Temperature and annual precipitation increased;
- Dry season precipitation decreased;
- Annual runoff increased;
- Dry season runoff decreased;
- Increased flooding incidence and area with combined seaward and upstream pressure – in addition to local rainfall
- Historically delta subject to saline intrusion during dry season when discharge is low
- Increases in min monthly discharge at Kratie should act to reduce saline intrusion
- Increases in sea level rise, storms and tidal extremes will increase saline intrusion into freshwater aquifers threatening water used for irrigation and drinking purposes

Delta

- Agricultural productivity decreased - Risk to rice production, both through changed rainfall patterns (mainly reduced) and increased intrusions of saline water
- Increase in frequency of extreme flood events with a negative impact on rice productivity
- These adverse impacts could affect all three cropping seasons; main rain fed crop, winter–spring crop and summer–autumn crop
- Food scarcity due to population increase

Green house gas emissions

- Greenhouse gas emissions are increasing in the LMB along with economic development
- Per capita emissions are low compared with other parts of the world.
- Total emissions from the four LMB countries are:
  - 1.5% of total world emissions
  - 35% of emissions from the ASEAN countries
- Cambodia has the lowest per capita emissions
- Thailand has the highest and is close to the world average.
- Greenhouse gas emissions relative to GDP are highest for Lao PDR.
- Emissions intensity decreased for all four LMB countries from 2000 to 2005.

Greenhouse gas (GHG) emissions absolute, per capita and relative to GDP

Country	GHG emissions (tonnes CO2 eqv)	GHG emissions/capita (t CO2 eqv/person)	GHG emission intensity (t CO2 eqv./million year 2000 international US$)
Cambodia	22.7	1.6	1131.6
Lao PDR	17.4	3.1	1691.1
Thailand	351.3	5.6	788.7
Vietnam	176.9	2.1	993.2
China	7219.2	5.5	1353.6
USA	6963.8	23.5	561.7
World	37766.8	5.8	672.3

Baseline issues still to resolve if feasible

- Effects on the Yunnan dams and their effect on moderating changes
- Effects on tributary dams and their effect on moderating changes
- Initial modeling of BDP scenarios by MRC deals with A2 and B2 – results in the pipeline

Conclusions

By 2030 the LMB would experience significant:

- changes in climate and changes in the hydrology regime with far reaching natural systems effects.
- The mainstream Mekong would be directly and indirectly affected by those changes
- Major adjustments to local livelihoods and key development sectors would be required.
- Existing hydropower projects would require auditing and possibly retrofitting
- Yunnan dams would require review and possibly design modifications
- Catchments experiencing high rainfall and runoff would have increased hydropower capacity