Mekong Adaptation and Resilience to Climate Change (Mekong ARCC)

Climate Change Impact and Adaptation Study

Interim Report

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TABLE OF CONTENTS

INTRODUCTION **3**

APPROACH **3**

RESULTS STATUS **4**

PROGRESS **5**

PHASE 1: INCEPTION **5**

Activities 5

Outputs 5

PHASE 2: BASELINE **5**

Activities and results 5

Outputs and events 6

PHASE 3: FUTURE CLIMATE CONDITIONS AND THREATS **8**

Activities 8

Outputs 10

PHASE 4: VULNERABILITY ASSESSMENT **10**

Activities 10

Outputs and events 12

PHASE 5: ADAPTATION OPTIONS **12**

Activities 12

Outputs and events 13

PROMOTION AND COMMUNICATIONS **13**

Presentations for donors and national and regional forums 13

NEXT STEPS **14**

PHASE 3: FUTURE CLIMATE CONDITIONS AND THREATS **14**

PHASE 4: VULNERABILITY ASSESSMENT **14**

PHASE 5: ADAPTATION OPTIONS **14**

PHASE 6: REPORTING **14**

REVISED SCHEDULING **15**

ANNEXES **16**

ANNEX A: STUDY PAPER ON THE DETAILED BIOPHYSICAL CHARACTERISTICS OF THE ECOZONES **17**

ANNEX B: KEY THEME SPECIES/SYSTEMS **18**

ANNEX C: CLIMATE BASELINE AND CLIMATE PROJECTIONS FOR THE WHOLE LMB **21**

ANNEX D: CLIMATE CHANGE THREAT HOTSPOTS **24**

ANNEX E: EXAMPLE PRIORITY PROVINCE CLIMATE CHANGE THREAT MAPS **27**

ANNEX F: PRIORITY PROVINCE THREAT PACKAGE EXAMPLE **33**

ANNEX G: HYDROLOGICAL ANALYSIS OF THE IMPACTS OF CLIMATE PROJECTIONS FOR EIGHT MAINSTREAM MEKONG STATIONS **34**

ANNEX H: NATURAL SYSTEMS GROUP SECTOR SPECIFIC CLIMATE CHANGE THREAT ANALYSIS **35**

ANNEX I: CAM ASSESSMENT MATRIX SUPPORT TOOLS **36**

ANNEX J: BASIN-WIDE LAND USE SUITABILITY FOR CASSAVA, COFFEE ROBUSTA, MAIZE, RAIN FED RICE, RUBBER AND SOYA 38
ANNEX K: BASIN-WIDE CROP YIELD MODELLING FOR RAIN FED RICE 45
ANNEX L: PRIORITY PROVINCE CROP YIELDS FOR RAIN FED RICE AND MAIZE 47
ANNEX M: ADAPTATION PLANNING METHODOLOGY 48

INTRODUCTION

The Mekong ARCC project is a five- year program (2011-2016) funded by the USAID Regional Development Mission for Asia (RDMA) in Bangkok and implemented by DAI in partnership with the International Centre for Environmental Management (ICEM) and World Resources Institute (WRI). The project focuses on identifying the environmental, economic and social effects of climate change in the Lower Mekong Basin (LMB), and on assisting highly exposed and vulnerable rural populations in ecologically sensitive areas increase their ability to adapt to climate change impacts on water resources, agricultural and aquatic systems, livestock, ecosystems, and livelihood options.

Mekong ARCC is comprised of five major technical tasks in addition to overarching program management. These are:

1. Regional Platform Partner and Knowledge Centre;
2. Climate Change Impact and Adaptation Study;
3. Ecosystem and Community-based Adaptation Initiatives;
4. Valuing Ecosystem Services in Economic Planning for the Lower Mekong River Basin; and
5. Scaling-Up Successful Approaches.

This document outlines the interim progress for Climate Change Impact and Adaptation Study (Task 2) of the project as of November 2012.

Task 2 is led by ICEM and the study team is made up of 21 international and regional specialists. The aim of Task 2 is to undertake a climate change impact and adaptation study on the water resources, food security, livelihoods and biodiversity of the Lower Mekong Basin (LMB).

The objectives of the study are to:

- identify vulnerabilities of rural poor and their environment to CC vis-à-vis water resources, food security, livelihoods and biodiversity (terrestrial and aquatic flora and fauna);
- provide a scientific evidence base for the selection of case study sites;
- identify adaptation strategies to inform development of community and ecosystem-based adaptation initiatives; and
- inform policy makers, development specialists and the global climate science community on the impacts of climate change on the water resources, food security, livelihoods and biodiversity of the LMB.

APPROACH

Task 2 lays the foundation for the whole Mekong ARCC project by providing the scientific evidence base for identifying highly vulnerable and valuable agricultural and natural systems assets in the LMB, defining adaptation options and priorities, and guiding the selection of focal areas for enhancing existing adaptation and demonstrating and testing new adaptation strategies. The study focuses on five themes:

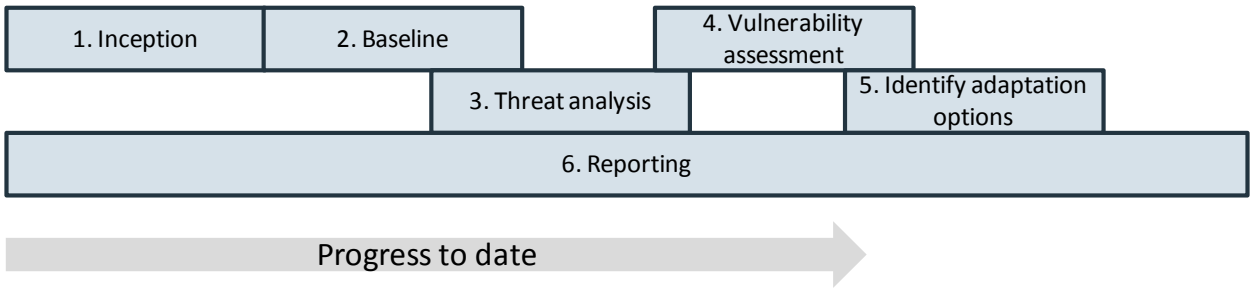
- Agriculture
- Capture fisheries and aquaculture
- Livestock
- Natural systems

- Socio-economics

As outlined in the Task 2 Workplan, approved on 26th March 2012, the study is split into six phases:

- **Phase 1 Inception:** During the inception phase the study team finalized the study methodology and team members.
- **Phase 2 Baseline:** During the baseline phase the study team developed a zoning system for the basin and described the key species and ecological systems for each theme in each zone.
- **Phase 3 Future climate conditions and threats:** The study team undertook climate modeling to describe projected changes in climatic and hydrological conditions in the LMB.
- **Phase 4 Vulnerability assessments**: The study team is assessing the vulnerability of each theme's key species/systems in provinces of the basin projected to be exposed to extreme climate changes
- **Phase 5 Adaptation options**: The study team is developing options for integrated adaptation at priority areas that link agriculture, livestock, and fisheries with ecosystem services and biodiversity.
- **Phase 6 Reporting**: The study team is preparing a set of reports to disseminate the findings back into the wider Mekong ARCC project and to other stakeholders in the region.

Figure 1. Study phases and progress to date



RESULTS STATUS

Please note that this is in Interim Report and therefore the results presented in this document are not final and should not be taken as such.

PROGRESS

PHASE 1: INCEPTION

ACTIVITIES

During the inception phase ICEM fielded the study team and defined the study methodology. A detailed work plan was developed outlining the approach for conducting the basin-level study including methodology; climate models and agro-ecological zoning methods to be used; identifying crops, animal husbandry systems, and ecosystems to be examined; and data sources and constraints.

During the Inception Phase a TOR for each of the 21 team members was developed and incorporated into individual contracts to ensure quality performance and availability of the entire team for the full project period.

OUTPUTS

The following outputs were prepared as part of the Inception Phase:

- Task 2 Work plan approved on 26th March 2012; and
- Contracts for the 21 study team members were prepared and signed.

PHASE 2: BASELINE

ACTIVITIES AND RESULTS

Ecozones

The Task 2 study team started by identifying the unit of spatial analysis for the basin. This common spatial framework is essential to the integration of the different study components in the climate change vulnerability and adaptation assessments. The challenge in identifying the study's spatial unit was to create zones with distinctive characteristics that take into account existing climate, ecosystems and agricultural potential. The ecosystems needed to reflect the original assemblages of plants and animals as the landscape and ecological context for rapidly evolving and expanding agricultural development. The Task 2 team decided not to adopt the conventional agricultural regions which are based on agricultural potential and do not adequately reflect natural system linkages. They concluded it was more appropriate to view agriculture in terms of farming ecosystems and analyses them as part of wider ecological zones.

The study team identified ecozones for the basin as the basic framework of analysis. During the first team meeting in May 2012, the Task 2 team reviewed the options and methods for defining basin wide ecozones founded on strong information and consultation. The WWF Mekong Basin eco zones developed over several years during the late 1990's to early 2000's including regional consultations were selected as the most useful basis for the study. They take in detailed data on:

- Elevation;
- Historic land cover using WWF's terrestrial biomes; and
- Floodplain wetlands.

The study team considered that refinements were needed to the WWF ecozones to reflect in more detail their agricultural potential and existing conditions. It was decided that the following changes would be made to develop a set of zones that are more appropriate for the analysis to be undertaken under this project:

- Area previously classified as Mangrove/delta to be split into three areas – delta mangroves and coastal wetlands, delta freshwater wetlands, delta acidic swamp forest
- Area previously classified as High elevation broadleaf forest to be split into two areas – the Annamites area to the east of the LMB and the North Indochina area in the north of the LMB
- Join areas classified as Tonle Sap swamp forest and Lower floodplain, wetland (Kratie to delta) into one ecozone titled Tonle Sap swamp forest and lower floodplain (Kratie to Delta).

The final set of ecozones in order of increasing elevation is (Figure 1):

- Delta mangroves and coastal wetlands
- Delta freshwater wetlands
- Delta acidic swamp forest
- Tonle Sap swamp forest and lower floodplain (Kratie to Delta)
- Lower floodplain, wetland, lake (Pakse to Kratie)
- Low-elevation dry broadleaf forest
- Mid floodplain, wetland, lake (Vientiane to Pakse)
- Mid elevation dry broadleaf forest
- Low-mid elevation moist broadleaf forest
- Upper floodplain wetland, lake (Chiang Saen to Vientiane)
- High elevation moist broadleaf forest – North Indochina
- High elevation moist broadleaf forest - Annamites

Theme baselines

Each theme group has prepared a theme baseline at the ecozone level and priority province level. The baseline assessments involved research using review of scientific, socio-economic and development literature, existing databases, consultation with other experts and team expert judgment. Theme baselines include the following information:

- Identification of key species/systems;
- Species/systems descriptions;
- Species/systems database including climate tolerances;
- Impacts of past extreme events;
- Linkages between sectors;
- Ecozone profiles of theme key species/systems; and
- Priority province profiles of key species/systems.

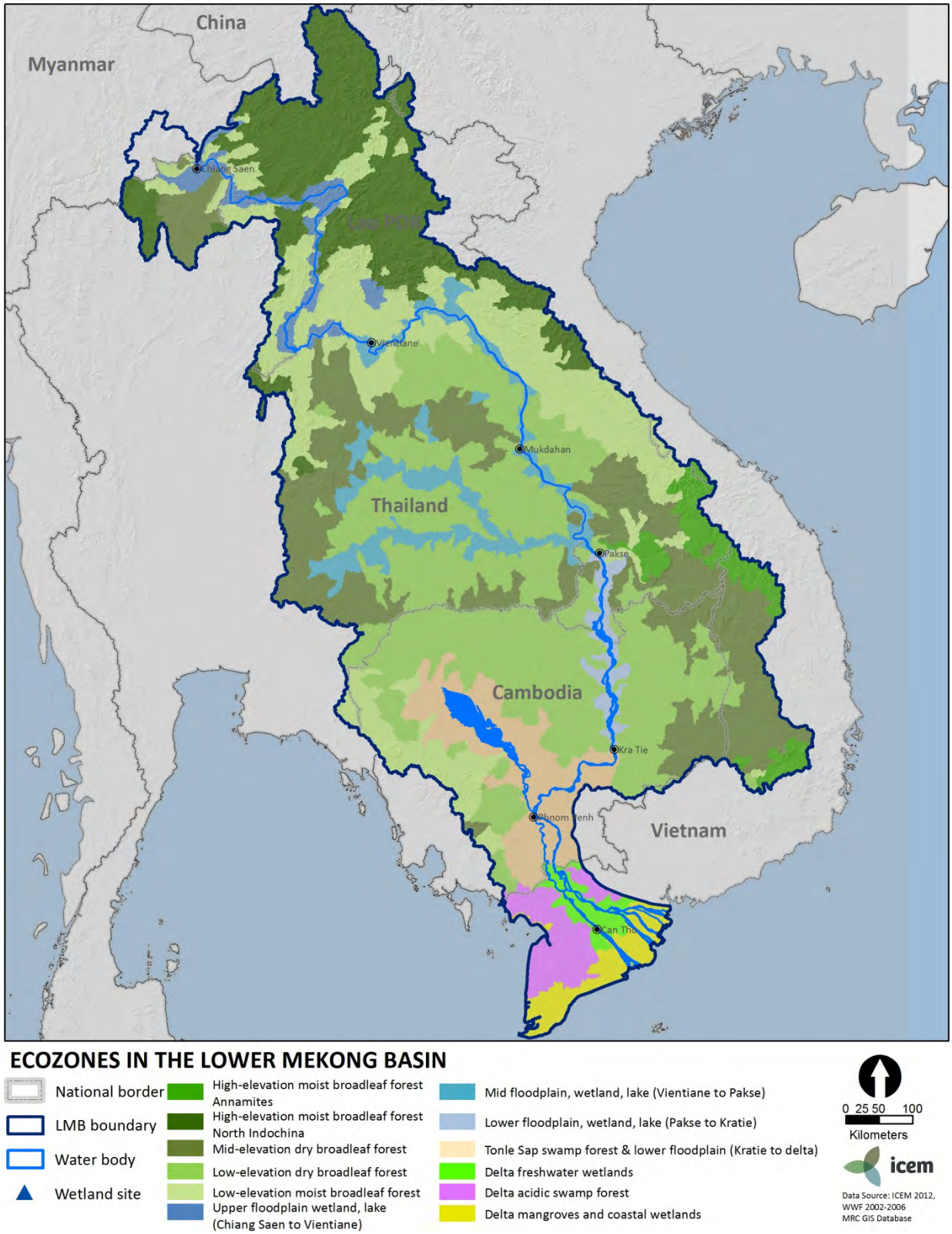
OUTPUTS AND EVENTS

The following outputs and events were prepared and held as part of the Baseline Phase:

- Team baseline working session held from 7-11th May 2012 in Vientiane, Lao PDR;
- Study paper on the detailed biophysical characteristics of the ecozones (see Annex A);

- Identification of key species/systems for each theme (see the list in Annex B); and
- Draft baseline sections of the final reports for each theme.

Figure 2.Ecozones

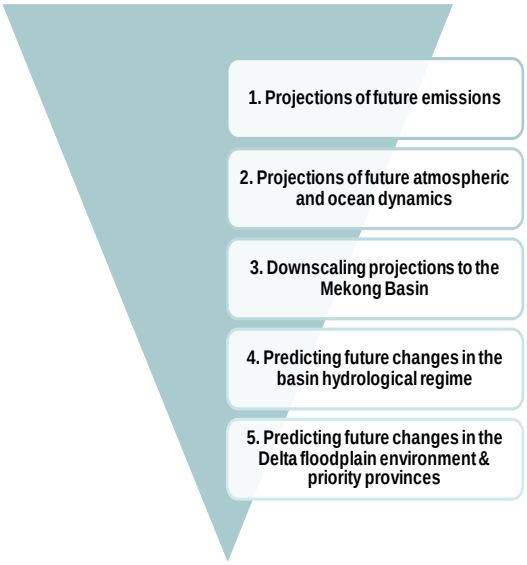


PHASE 3: FUTURE CLIMATE CONDITIONS AND THREATS

ACTIVITIES

The purpose of Phase 3 was to develop an original and comprehensive set of projections for the likely climate change trends over a 25-year period centered around 2050 (2045 – 2069) using the best and most up to date technologies, modeling and methods. Six Global Circulation Models (GCMs) were statistically downscaled for the Mekong Basin to quantify the future temperature and rainfall conditions. The results were then used to model the implications for the Mekong's hydrological regime and provide a quantified description of the climate change threats for the LMB (Figure 3).

Figure 3. Climate downscaling



ARCC vulnerability projections centered on 2050 (2045-2069) because 2050 allows the identification of CC trends with confidence. Those projections show the ranges and directions of the changes in temperature and precipitation, and help set adaptation responses.

The study team modeled a number of additional important parameters including soil water availability, peak runoff, erosion potential, and the occurrence of droughts and storm events.

From the extensive list of modeled parameters climate threat packages were developed for each of the 11 priority provinces. The packages were designed to inform the theme groups of the projected change in climate for each of the provinces. The theme groups' interpretation of each of these changes in climate feeds into the exposure assessment phase of the CAM methodology (see Figure 4 for more detail). The threat packages contain:

- One page summary of the key climate threats (only for the primary priority provinces)
- Maps of current and projected maximum temperature and precipitation
- Graphical analysis of maximum temperature, precipitation, droughts, storms and water availability.

The theme groups were then able to request additional threat analysis if required. For example the natural systems group needed more information on days of rainfall and total annual rainfall for analysis of the vulnerability of cardamom.

The study team developed a separate flood model for the Mekong delta to assess impacts of sea level rise, storm surge and increased Mekong mainstream flows. This modeling work is in progress with results feeding into the vulnerability assessments.

An important component of the study is the identification of climate change hotspots. The hotspot approach is helping to integrate and orient study findings and will provide a scientific basis for the selection of focal areas for the community adaptation initiatives that will be undertaken in Mekong ARCC Task 3. The team took a threat analysis approach to identifying hotspots. The method involved identifying

areas projected to experience the greatest increases in climate threats or opportunities. Seasonal (wet and dry season) change in daily maximum temperature and daily precipitation were chosen as the focus threats because they are the entry points of climate change to the basin climate regime. For example, an area that is projected to experience a large wet season or dry season change in temperature or precipitation will be identified as a highly threatened area. The hotspot approach did not take into account the potential impacts of the threat or potential adaptation options. The threat analysis led to the definition of ecozone, catchment, provincial and protected area hot spots throughout the basin.

To identify the priority provinces for vulnerability assessments and adaptation planning, additional criteria were defined:

- Provinces with high increase in projected climate change threat
- Representation of all ecozones
- Representation of the delta area
- Representation of each of the thematic sectors (fisheries, agriculture, livestock, natural systems and socio-economics)
- Representation of all four countries

The study team also applied a land use suitability model – LUSET – to evaluate the suitability of each land unit for a single crop based on climatological characteristics such as rainfall, drought and temperature. The suitability for baseline and projected climate change conditions is expressed along a scale of 0-100. Due to time constraints the number of crops that land suitability modeling could be completed for was limited to seven. The following criteria were used to identify the seven crops:

- Importance for subsistence
- Strategic economic importance in national economies
- Information available for modeling
- Prevalence in the basin
- The suite of crops will cover a diversity of ecozone areas

Land use suitability modeling was undertaken at the basin level for seven crops:

- Coffee robusta - economically important[1]
- Rubber - economically important[1]
- Soya - economically important [1]
- Cassava – economically important[1] and important for subsistence
- Rain fed rice – economically important[1] and important for subsistence
- Maize - important for subsistence

Crop yield modeling using the physiological FAO AquaCrop model has been fully integrated into the LUSET land suitability model. Due to the computing time required for the crop yield modeling, analysis was restricted to two crops. Aquacrop is better suited to modeling annual rather than perennial crops. Rain fed rice and maize were identified as annual crops that are economically important and important for

[1] FAO (2011) Food and agricultural commodities production. Available at http://faostat.fao.org/site/339/default.aspx. Accessed on 9 March 2012.

subsistence in the basin. Projected change in annual yield (t/ha) for the priority provinces was modeled for each of the two crops.

OUTPUTS

The following outputs have been prepared as part of this study phase:

- Climate baseline (1980-2004) and climate projections (1945 – 1980) for 5x5km grid of the whole LMB (map representation the basin wide climate data is shown in Annex C);
- Climate change hotspot ecozones, provinces and catchments have been identified (see Annex D for the full list of hotspot areas);
- Priority provinces were identified as the areas where the team would undertake vulnerability and adaptation planning assessments (the full list of priority provinces appears as Annex D);
- 42 priority province and ecozone maps showing the projected changes in temperature and precipitation (an example appears as Annex E), the full set of maps will be included in the threat packages submitted on 6th December 2012;
- Climate change threat packages for the 11 priority provinces each included up to 25 graphs of key parameters (an example appears as Annex F), the full set of threat packages will be submitted on the 6th December 2012;
- Hydrological analysis of the impacts of climate projections for eight mainstream Mekong stations (appears as Annex G); and
- Sector specific climate change threat analysis as requested by each of the theme groups (extra analysis requested by the natural systems group appears in Annex H).

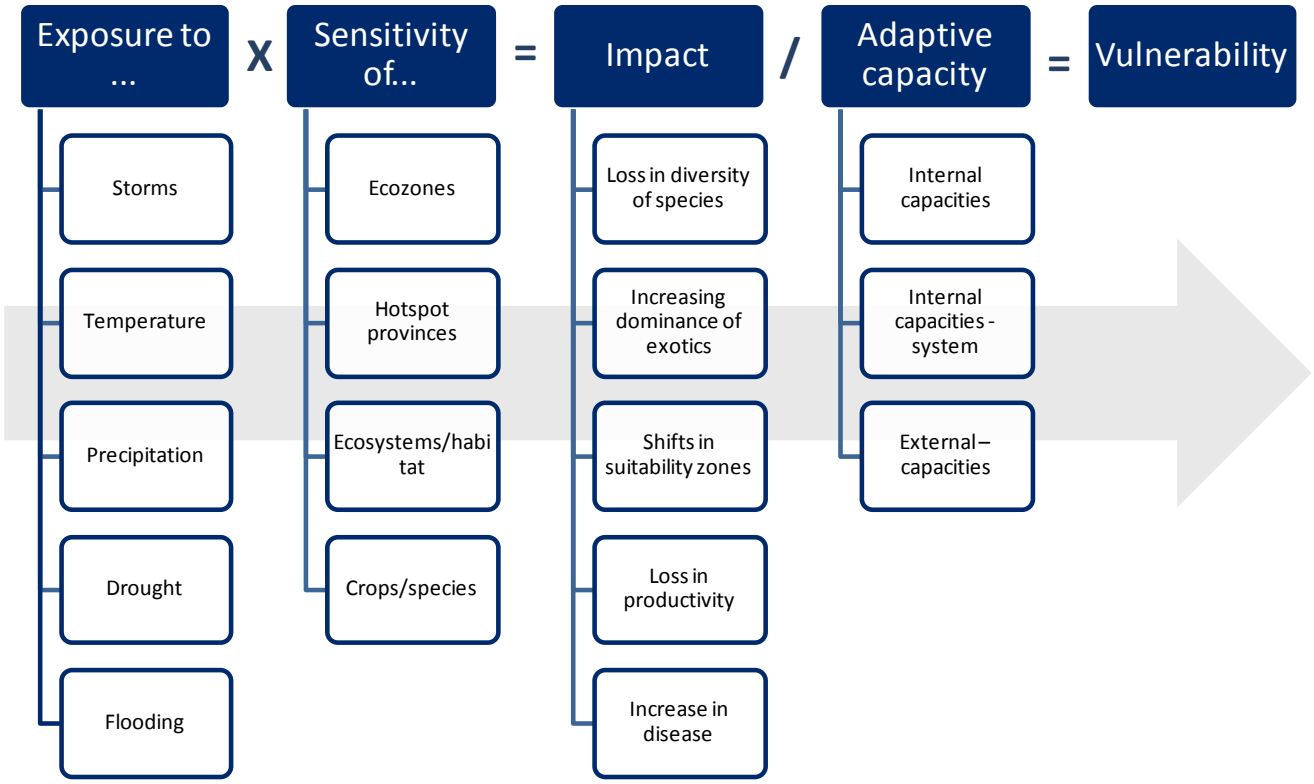
PHASE 4: VULNERABILITY ASSESSMENT

ACTIVITIES

The team has used the ICEM Climate Change Vulnerability Assessment and Adaptation Planning(CAM) methodology, baseline species/systems information and the threat analysis results to undertake vulnerability assessments for the key systems/species identified in their theme baselines. The natural systems group used two methods – (i) the CAM to assess the vulnerability of clusters of protected areas linked to the priority provinces (e.g. the Mondul Kiri PA cluster covering 70% of the province) and (ii) a separate species based vulnerability assessment developed by ICEM specifically for wild species. Vulnerability assessments have been undertaken for key species/systems for each of the priority provinces in which they are found.

The CAM method outlines four important factors in assessing vulnerability; exposure, sensitivity, impact and adaptive capacity (Figure 4).**Exposure** is the degree of climate stress on a particular asset; it is influenced by long-term changes in climate conditions, and by changes in climate variability, including the magnitude and frequency of extreme events. **Sensitivity** is the degree to which a system will be affected by, or responsive to climate change exposure. The potential **impact** (or level of risk) is a function of the level of **exposure** to climate change induced threats, and the **sensitivity** of the target assets or system to that exposure. **Adaptive capacity** is understood in terms of the ability to prepare for a future threat and in the process increase resilience and the ability to recover from the impact. These four factors were analyzed using the baseline and climate threat modeling results and matrix support tools developed by ICEM (the CAM method support tools appear as Annex I).

Figure 4. Vulnerability assessment section of the CAM process



Although the study is not yet finished there are some interesting results already appearing. These results, presented below, will be confirmed as the study completes and will be presented in full in the final study report.

Initial analysis of the impacts of climate change on protected areas has shown that there will be a transformation of ecosystems brought about by:

- Accelerating loss of populations and species (extreme temperatures, coupled with drying - a significant driver of biodiversity loss);
- New 'problem' species entering communities;
- Reorganization of plant and animal communities; and
- Geographic range shifts eastward and some perhaps upwards and range losses

Assessments of climate impacts of NTFPs in Mondul Kiri, Cambodia suggests that there will be a wide range of responses of NTFP species to climate change threats; and some species may be enhanced but others will be even more threatened.

Initial vulnerability assessments of livestock systems have shown that:

- Low-input house level systems that generally use ‘local’ breeds have greater internal resilience to climate changes but lower external resilience. These systems are typically slow to change because they lack knowledge of and access to supporting services;
- More commercial systems that raise higher performance exotics/crossbreds exhibit lower internal adaptive capacity but typically greater external capacity to adapt to climate changes; and
- Wild species in the LMB are an important genetic resource and will be threatened by climate change directly and indirectly through loss of habitat, hunting and the threat of infectious diseases.
-

Implementing the CAM methodology for wild fishers and aquaculture in Chiang Rai indicates:

- Upland and migratory fish are vulnerable to climate change threats;
- Black fish are more climate resilient than migratory fish and upland fish and may be expected to increase in the proportion of fish catches as temperatures increases;
- Aquaculture is more vulnerable to climate change than capture fisheries; and
- Intensive aquaculture appears to be more vulnerable to climate change than semi-intensive or extensive systems.

OUTPUTS AND EVENTS

The following outputs have been prepared as part of the vulnerability assessment phase:

- Team vulnerability assessment working session held from 24-28th September 2012 in Hanoi, Vietnam;
- A detailed and refined CAM methodology package with guidance on process and tools;
- A detailed and refined CAM species vulnerability assessment methodology package with guidance;
- Vulnerability assessments for key livestock systems, aquaculture and capture fisheries species, Protected Areas and agricultural crops;
- Species vulnerability assessment spreadsheets for key non-timber forest products (NTFPs);
- Basin-wide land use suitability maps for cassava, coffee robusta, maize, rain fed rice, rubber and soya (see in Annex J);
- Basin-wide crop yield maps for rain fed rice (see in Annex K); and
- Priority province crop yields for rain fed rice and maize (see in Annex L).

PHASE 5: ADAPTATION OPTIONS

ACTIVITIES

Currently The Task 2 team is developing options for integrated adaptation interventions that link agriculture, livestock, and fisheries with ecosystem services and biodiversity. These options are being designed to inform the design of the community and ecosystem-based adaptation initiatives that are part of the wider Mekong ARCC project.

During 2-3rd of November 2012 the team met to clarify and refine the ICEM CAM adaptation planning methodology. By the end of the two days a clear methodology had been outlined and an initial application to a selection of the priority provinces had been completed.

OUTPUTS AND EVENTS

To date the following outputs and events have been prepared as part of the adaptation options phase:

- Team adaptation planning working session held during 29-30th October, 2-3rd November 2012 in Hanoi, Vietnam;
- Definition and refinement of the adaptation planning methodology (more detail is provided in Annex M); and
- Initial adaptation planning completed for Mondulkiri Province in Cambodia and Kien Giang Province in Vietnam for all themes.

PROMOTION AND COMMUNICATIONS

PRESENTATIONS FOR DONORS AND NATIONAL AND REGIONAL FORUMS

On the request of DAI and USAID the study team have presented and discussed the study methodology and results at a number of meetings and national and regional forums including:

- Initial Task 2 planning meeting with DAI representatives on 6-7th November 2011 in Bangkok;
- Presentations of the study methodology to USAID on 7th of November 20122 at the USAID Regional Development Mission for Asia office, Bangkok
- Presentation of the study and methodology to ADB Environment Operations Centre Representatives on 8th November 2011 at the Environment Operations Centre, Offices at Central World, Bangkok;
- Task 2 and 3 integration planning meeting with DAI representatives on 2-3rd April 2013at the Salana Boutique Hotel, Vientiane;
- Presentation on the study methodology and initial results at the 2nd Global Conference on Agriculture, Food Security and Climate Change co-organized by Vietnam, the Netherlands FAO and the World Bank at the Melia Hotel, Vietnam, September 2012.
- Presentation on the study at the Second FAO/World Bank Expert Meeting , Investing in Agriculture and Natural Resources Management in the context of Climate Change in East Asia and the Pacific, Bangkok, May 14-16, 2012;
- Mekong ARCC Task 2 Interim Results workshop, 31 October – 1 November 2012 at Sofitel Plaza, Hanoi;
- Meetings with MONRE IMHEN, MRC, FAO, WB and ADB teams; and
- Working with the ADB EOC and MRC to exchange and share data.

NEXT STEPS

Following the last two team working sessions in October and November, back to back with regional workshops, the team reviewed the status and progress in completing phases 2 to 4 assessment materials. Various gaps and additional tasks were identified for the team theme groups to finalize their work on those phases. Also, a detailed work plan and schedules were developed to complete remaining phases of adaptation assessment and reporting leading to the final regional workshop.

PHASE 3: FUTURE CLIMATE CONDITIONS AND THREATS

The study team will identify the expected scale of threats by 2030 and for a global average temperature increase of 2°C. This will be completed through the following process:

- Analysis of the full climate project time series (1980 – 2080) will be undertaken for a limited number of stations and parameters to assess the trend of climate change. From this trend the study team will identify the time slice for a 2°C global average temperature increase;
- The trends identified will be compared to global trends taken from existing IPCC results;
- An expert judgment/analysis approach using the identified trends will develop the likely progression of climate change in the LMB between now and 2050, focusing on the 2030 and 2°C time slices.

PHASE 4: VULNERABILITY ASSESSMENT

The study team will finalize the vulnerability assessments for the key species identified by each theme group in each of the five priority provinces and whichever of the six secondary priority provinces are relevant for the theme.

PHASE 5: ADAPTATION OPTIONS

The study team will continue to work through the adaptation planning methodology for the most vulnerable assets in each of the theme groups as identified in the vulnerability assessments.

PHASE 6: REPORTING

A number of important reports will be prepared as part of this project:

- A final report for each theme will include the following sections:
    - Baseline
    - Vulnerability assessment
    - Adaptation planning
- A synthesis report which summarizes the results of the different theme analyses into one volume.

In addition the study team will present the vulnerability and adaptation planning assessments at a regional Mekong ARCC Task 2 Final Results workshop. It is expected that this workshop will run over 1-2 days and will focus on succinct presentation of the assessment results and final recommendations for adaptation actions. The study team will provide significant support and have a major role as determined in consultation with USAID and DAI.

REVISED SCHEDULING

During the November team working session the theme groups identified the remaining tasks to finalize their assessments and developed detailed scheduling of possible deadlines given other commitments. It became clear that the existing deadlines are not feasible due to the amount of work involved in the completion of analyses; preparation of the theme baselines, vulnerability assessment and adaptation planning sections of each theme report; and drafting the theme sections of the synthesis report. It is essential to have the draft synthesis report available for the regional workshop. In addition the team believes it is important to have all the GIS products and other communications products ready for distribution to stakeholders before the final workshop.

The study team proposes the revised schedule for Task 2 outlined in Table 1 to ensure there is adequate time to complete preparatory technical and operational tasks leading up to the final regional workshop.

Table 1. Revised event and deliverable schedule

Activity	Due date
Synthesis report outline for comment(*Task 2team internal deadline*)	7 November 2012
Finalize theme baseline, VA and adaptation planning sections of each theme report (*Task 2team internal deadline*)	30 January 2013
Draft theme sections of synthesis report (*Task 2team internal deadline*)	28 February 2013
Distribute draft synthesis report	11 March 2013
Final regional workshop	21 March 2013
Final synthesis and theme reports	29 March 2013

ANNEXES

ANNEX A: STUDY PAPER ON THE DETAILED BIOPHYSICAL CHARACTERISTICS OF THE ECOZONES

ANNEX B: KEY THEME SPECIES/SYSTEMS

The key livestock systems identified in the baseline include:

- Smallholder cattle/buffalo
- Dairy/large commercial
- Small commercial pig
- Smallholder low input pig
- Small commercial chicken
- Scavenging chicken
- Field running layer duck

The livestock baseline also identified the following wild species for further analysis:

- *Russula sp* (Mushroom)
- *Ammomum spp*, False Cardamom (Grasses/herb)
- *Sesbania sesban*, Egyptian pea (Aquatic plant)
- *Dioscorea hispida*, Bitter yam (Climber)
- *Dendrobium lindleyi* (Orchid)
- *Calamus crispus* (Rattans)
- *Broussonetia papyrifera*, Paper mulberry (Shrubs)
- *Dipterocarpus alatus* (Trees)
- *Scaphium sp*, Malva nut (Trees)
- *Sonneratia sp*, Mangrove apple (Trees)
- *Apis dorsata*, Giant honeybee (Insects)
- Red Ants (Insects)
- Crickets (Insects)

The following Crop Wild Relatives (CWRs) were also chosen by the natural system's group:

- *O. granulate* (Wild rice)
- *O. nivara*(Wild rice)
- *O. officinalis*(Wild rice)
- *O. ridleyi* (Wild rice)
- O. *rufipogon* (Wild rice)
- O. sativa/prosativa, Floating rice (Wild rice)

The following Crop Wild Relatives (CWRs) were also chosen by the natural system's group:

- *O. granulate* (Wild rice)

- *O. nivara* (Wild rice)
- O. officinalis (Wild rice)
- *O. ridleyi* (Wild rice)
- O. *rufipogon* (Wild rice)
- O. sativa/prosativa, Floating rice (Wild rice)

The key protected areas located in the priority provinces include:

- Nong Bong Kai Non Hunting Area, Chiang Rai, Thailand
- Chu Prong, Gia Lai, Vietnam
- Cluster including Hin Namnu, Phou Hin Boun NPA and Nakai-Nam Theun in Khammoune, Lao PDR
- Cluster including Ha Tien, Hon Chong, U Minh Thuong and Phu Quoc in Kien Giang, Vietnam
- Cluster including Lomphat WS, Mondulkiri BGCA, Phnom Nam Lyr WS, Phnom Prich WS in Mondul Kiri, Cambodia

For each of the primary priority provinces three aquatic species have been selected representing upland fish (if relevant), migratory fish, black fish and estuarine fish (if relevant):

- Chiang Rai
    - *Tor tambroides* (U)
    - *Cyclocheilichthys enoplos* (M)
    - *Trichogaster pectoralis* (B)
- Mondulkiri
    - *Scaphiodonichthys acanthopterus* (U)
    - *Hypsibarbus malcolmi* **(**M)
    - *Mastocembalus armatus* (B)
- Kien Giang
    - *Macrobrachium rosenbergii* (M)
    - *Channa straitus* (B)
    - *Anadosa granosa* (E)
- Gia Lai
    - *Bangana behri* (U)
    - *Probarbus jullianii* (M)
    - *Hemibagrus nemurus* (B)
- Khammoune
    - *Channa lacius* (U)
    - *Puntioplites falcifer* (M)

- *Clarias batrachus* (B)

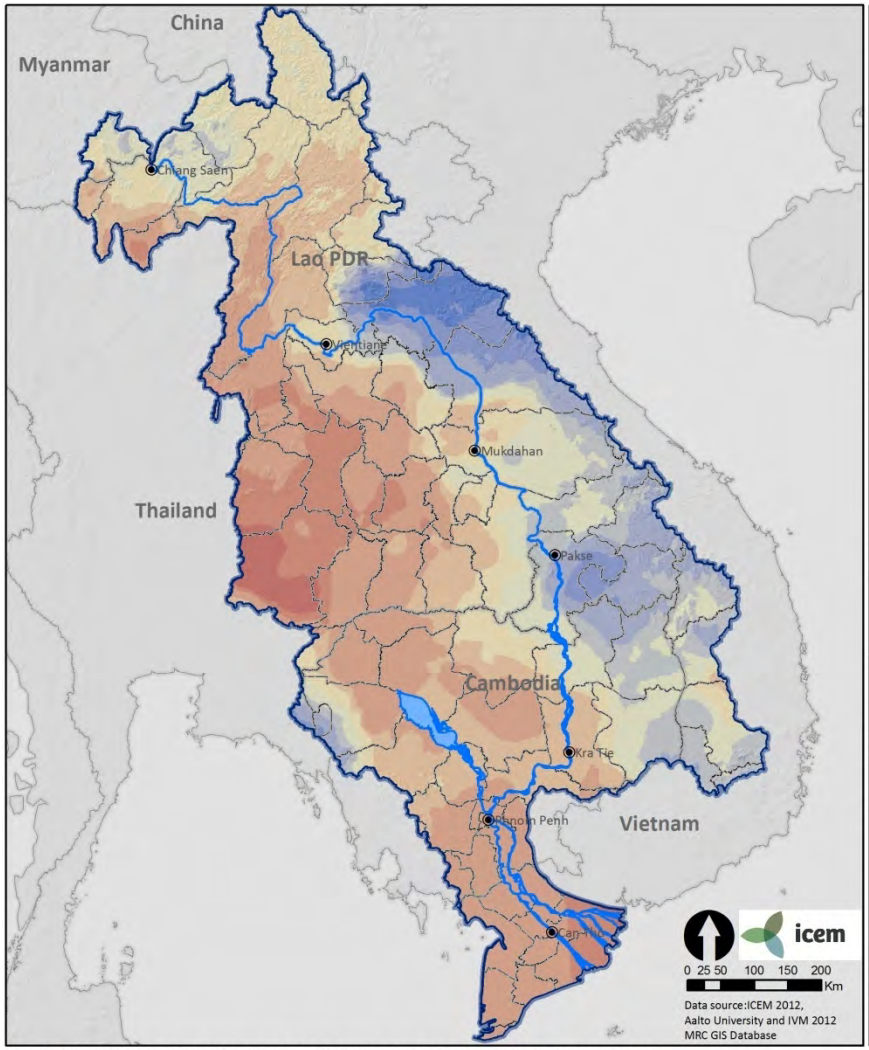
The key agricultural crops identified in the agricultural baseline include:

- Rice
- Cassava
- Maize
- Soya
- Sugarcane
- Coffee
- Rubber

The key livelihood zones included in the baseline include:

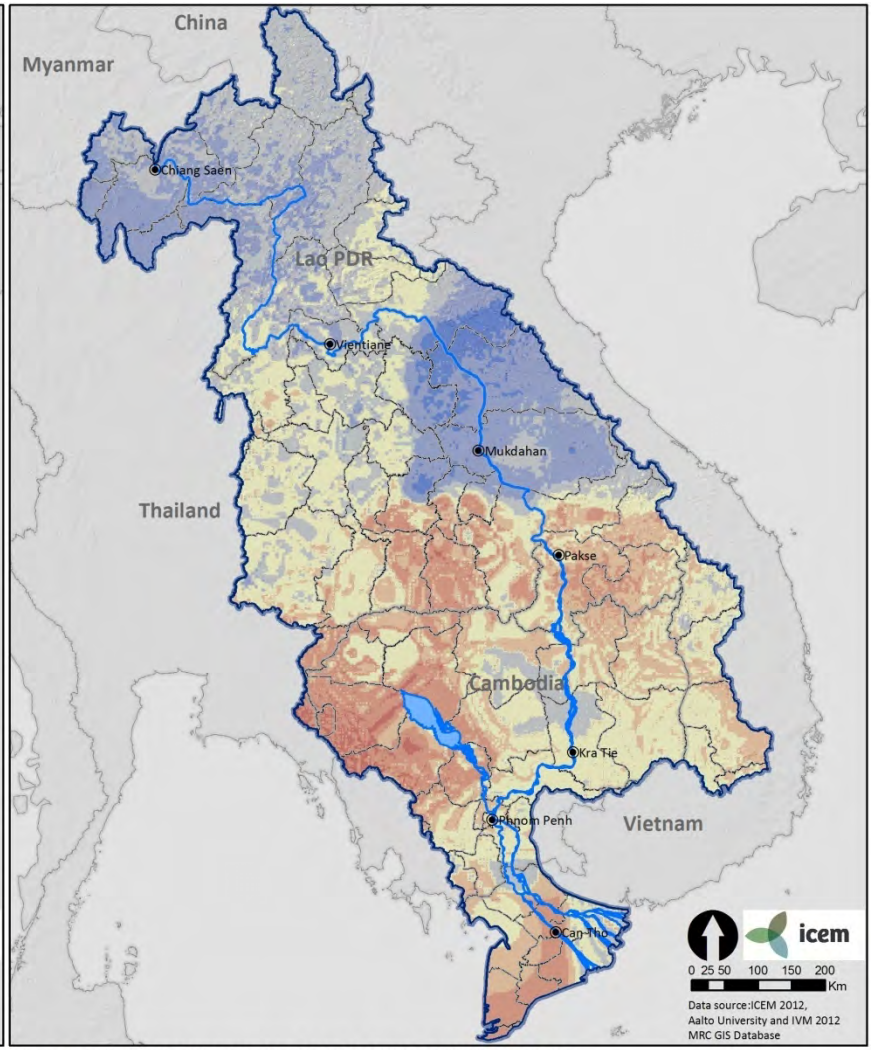
- Delta
- Floodplain
- Lowland plains and plateaus
- Intensively used uplands
- Forested uplands

ANNEX C: CLIMATE BASELINE AND CLIMATE PROJECTIONS FOR THE WHOLE LMB



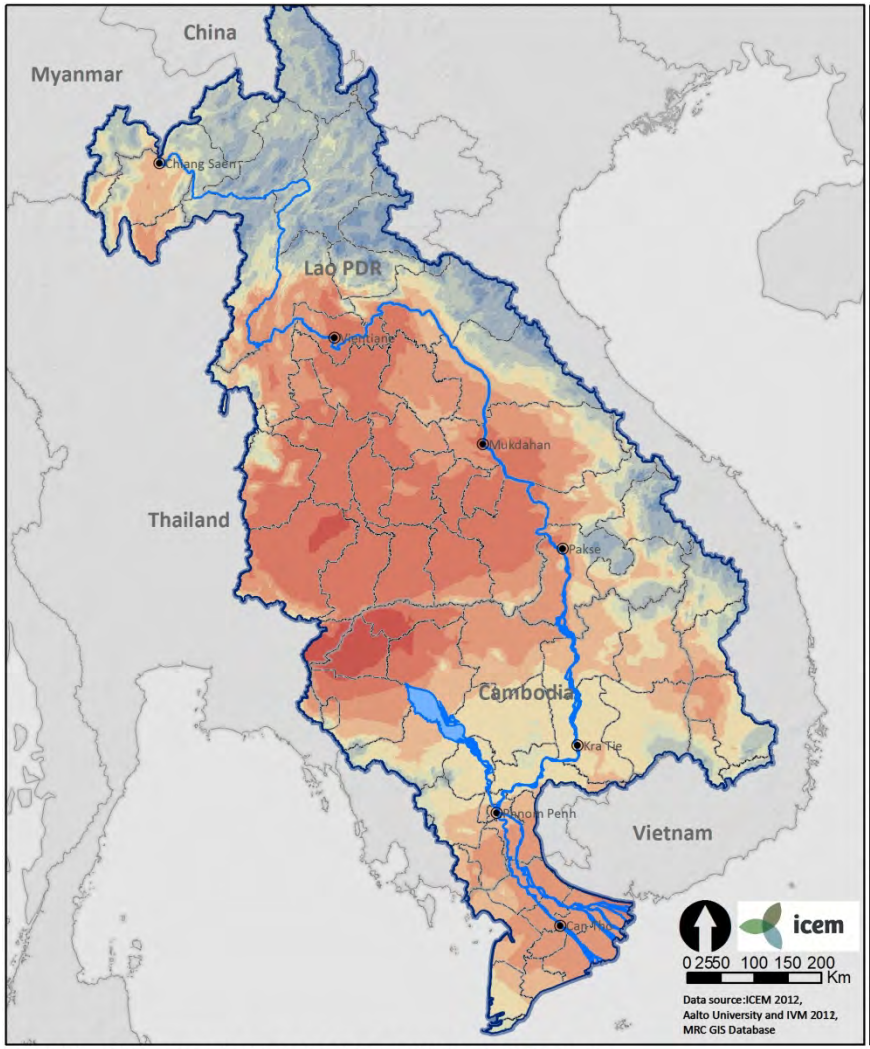
PRESENT AVERAGE ANNUAL PRECIPITATION, LOWER MEKONG BASIN

Lower Mekong basin	**Precipitation in 2050**	1,401 - 1,600	2,201 - 2,600
Mekong mainstream	829 - 1,000	1,601 - 1,800	2,601 - 3,000
National border	1,001 - 1,200	1,801 - 2,000	3,001 - 3,594
Province border	1,201 - 1,400	2,001 - 2,200	



% PRECIPITATION CHANGE IN 2050, LOWER MEKONG BASIN

Lower Mekong basin	**% Precipitation change**	6.1 - 8
Mekong mainstream	3.3 - 4	8.1 - 10
National border	4.1 - 5	10.1 - 14
Province border	5.1 - 6	14.1 - 18

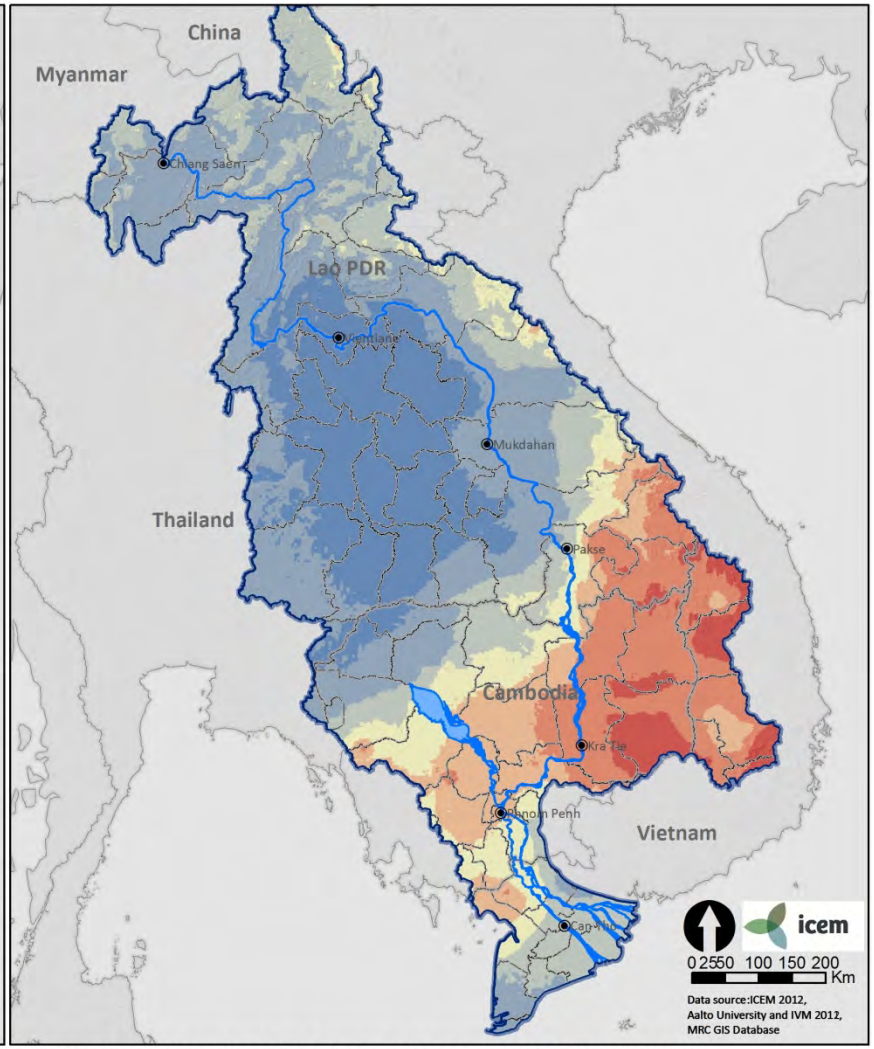


PRESENT AVERAGE MAX TEMPERATURE, LOWER MEKONG BASIN

- Lower Mekong basin
- Mekong mainstream
- National border
- Province border

Average Max Temperature

- 17.8 - 22
- 22.1 - 24
- 24.1 - 26
- 26.1 - 28
- 28.1 - 29
- 29.1 - 30
- 30.1 - 31
- 31.1 - 32
- 32.1 - 33
- 33.1 - 33.6



% AVERAGE MAX TEMPERATURE CHANGE (2050), LOWER MEKONG BASIN

- Lower Mekong basin
- Mekong mainstream
- National border
- Province border

(%)Temperature change

- 5 - 6
- 6.1 - 7
- 7.1 - 8
- 8.1 - 9
- 9.1 - 10
- 10.1 - 12
- 12.1 - 16.3

ANNEX D: CLIMATE CHANGE THREAT HOTSPOTS

MOST THREATENED

The most threatened areas were identified by classifying areas projected to experience the greatest increases in climate threats or opportunities. Seasonal (wet and dry season) change in daily maximum temperature and daily precipitation were chosen as the focus threats because they are the entry points of climate change to the basin climate regime.

Ecozones

The 12 ecozones ranked from most threatened to least threatened:

- High elevation moist broadleaf forest - Annamites
- Lower floodplain, wetland, lake (Pakse to Kratie)
- Mid floodplain, wetland, lake (VTE to Pakse)
- High-elevation moist broadleaf forest - North Indochina
- Low-elevation dry broadleaf forest
- Mid-elevation dry broadleaf forest
- Tonle Sap swamp forest and lower floodplain
- Low-mid elevation moist broadleaf forest
- Upper floodplain wetland, lake (CS to VTE)
- Delta mangroves and coastal wetlands
- Delta freshwater wetlands
- Delta acidic swamp forest

Catchments

The 15 most threatened catchments in the LMB:

- HoaagHua, Lao PDR
- Nam Hinboun, Lao PDR
- Nam Thon, Lao PDR
- Nam Mae Ing, Thailand
- Nam Kam, Thailand
- HuaiHo, Thailand
- HuaiThuai, Thailand
- Huai Bang Haak, Thailand
- Huai Bang Sai, Thailand
- Nam MangNgai, Lao PDR
- Huai Bang I, , Thailand
- Nam Khop, Lao PDR
- Se San, Cambodia and Vietnam

- Nam Mae Kok, Thailand
- HuaiMuk, Thailand

Provinces

.The 15 most threatened provinces in the LMB :

- Phayao, Thailand
- Nakhon Phanom, Thailand
- Chiang Mai, Thailand
- Gia Lai, Vietnam
- Mukdahan, Thailand
- Lam Dong, Vietnam
- Khammouan, Lao PDR
- Kon Tum, Vietnam
- Chiang Rai, Thailand
- Ratanak Kiri, Cambodia
- Mondul Kiri, Cambodia
- Attapu, Lao PDR
- Binh Phuoc, Vietnam
- Bokeo, Lao PDR
- Dak Lak, Vietnam

PRIORITY PROVINCES

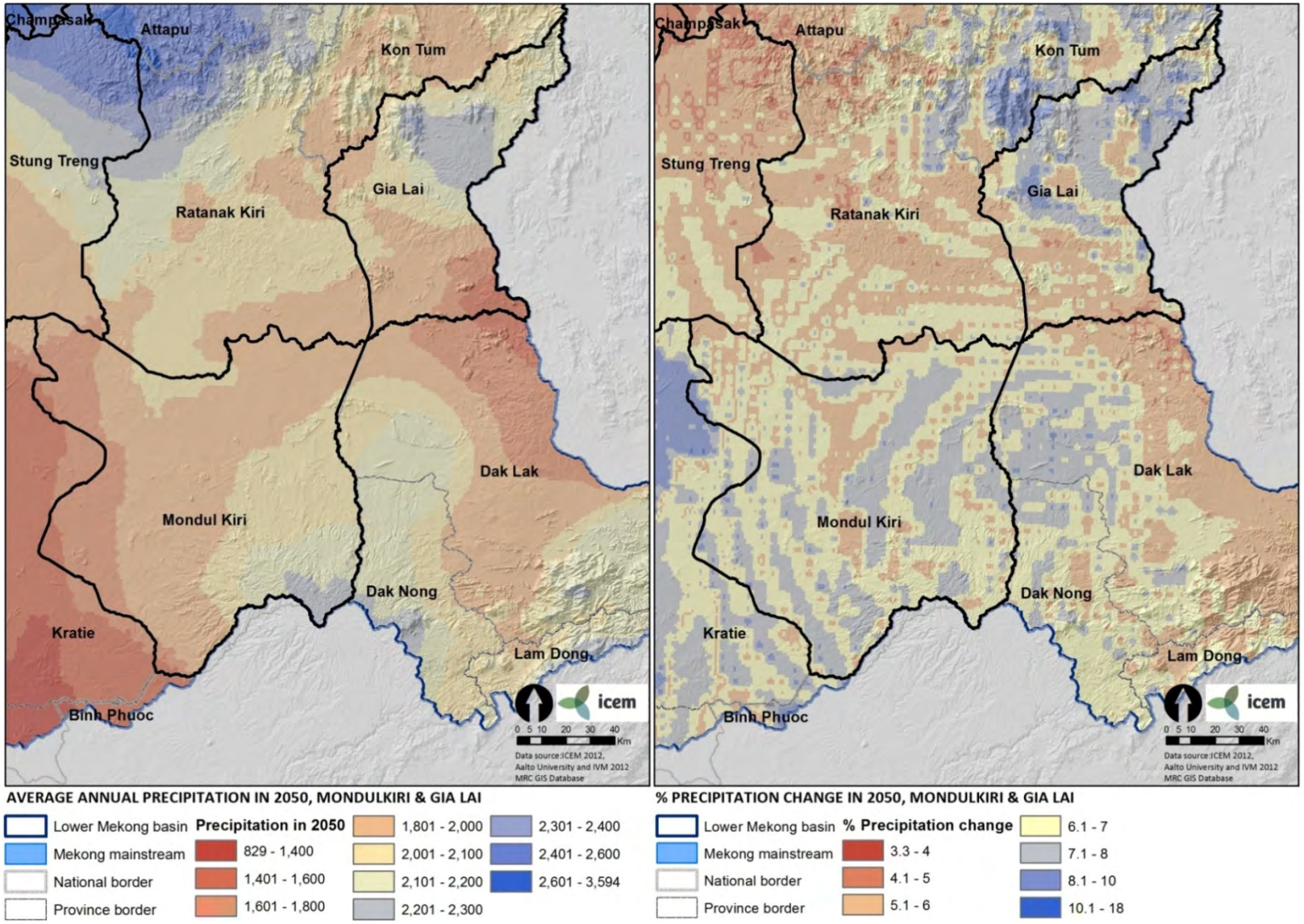
To identify the priority provinces on which to focus the vulnerability and adaptation planning assessments the team developed the following criteria:

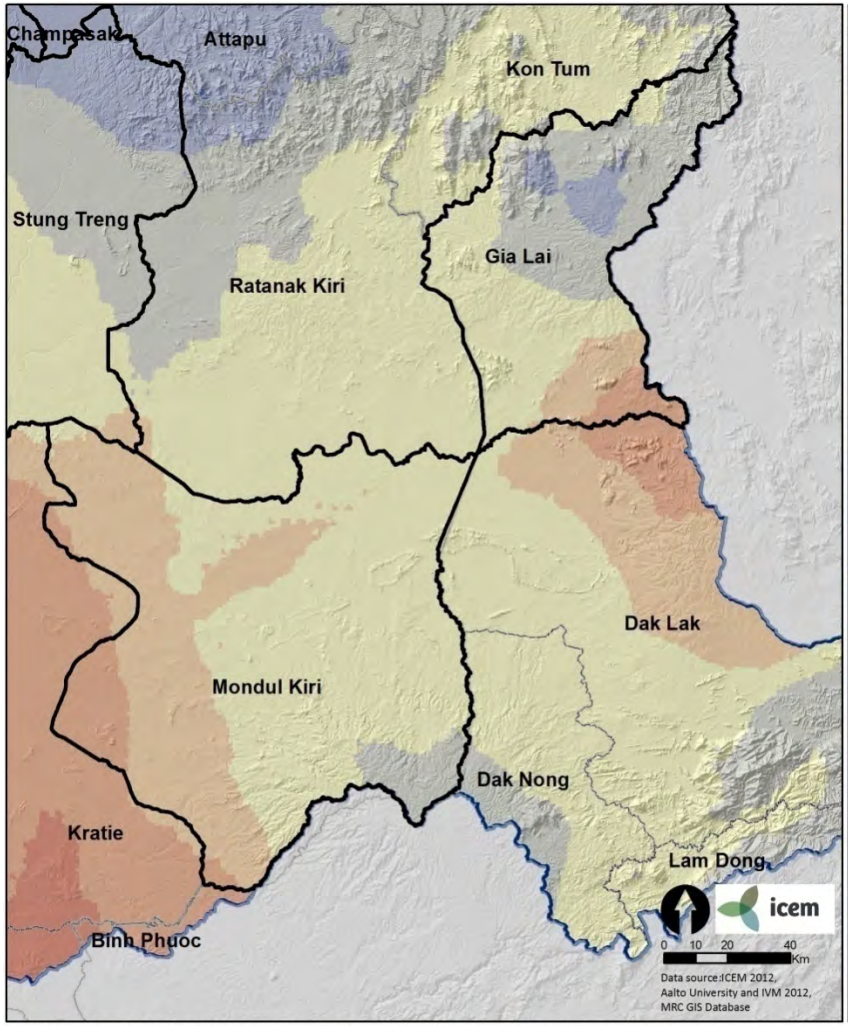
- Provinces with high increase in projected climate change threat
- Representation of all ecozones
- Representation of delta area
- Representation of thematic sectors (fisheries, agriculture, livestock, natural systems and socio-economics)
- Representation of all countries

The final list of priority provinces includes:

- **Primary priorities** (all theme groups will undertake vulnerability and adaptation assessments for these provinces)
    - Ken Giang
    - MondulKiri
    - Gia Lai
    - Chiang Rai
    - Khammouan
- **Secondary priorities** (theme groups will only undertake vulnerability and adaptation assessments in the provinces relevant to their theme)
    - Kampong Thom
    - SakonNakhon
    - Stung Treng
    - Champasak
    - Ben Tre
    - Xe Kong

ANNEX E: EXAMPLE PRIORITY PROVINCE CLIMATE CHANGE THREAT MAPS



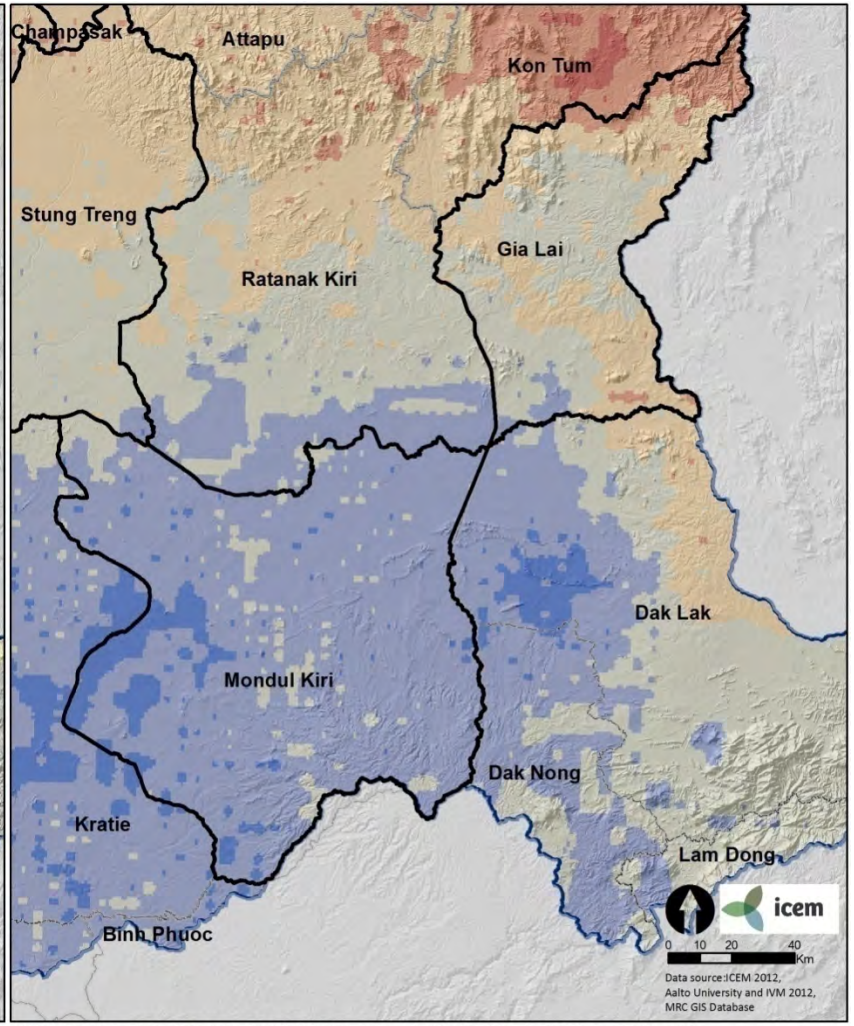


AVERAGE PRECIPITATION IN WET SEASON IN 2050, MONDULKIRI & GIA LAI

- Lower Mekong basin
- National border
- Province border
- Mekong mainstream

Precipitation Wet Season in 2050 (mm)

- 658 - 1,000
- 1,001 - 1,200
- 1,201 - 1,400
- 1,401 - 1,600
- 1,601 - 1,800
- 1,801 - 2,000
- 2,001 - 2,200
- 2,201 - 2,600
- 2,601 - 3,194

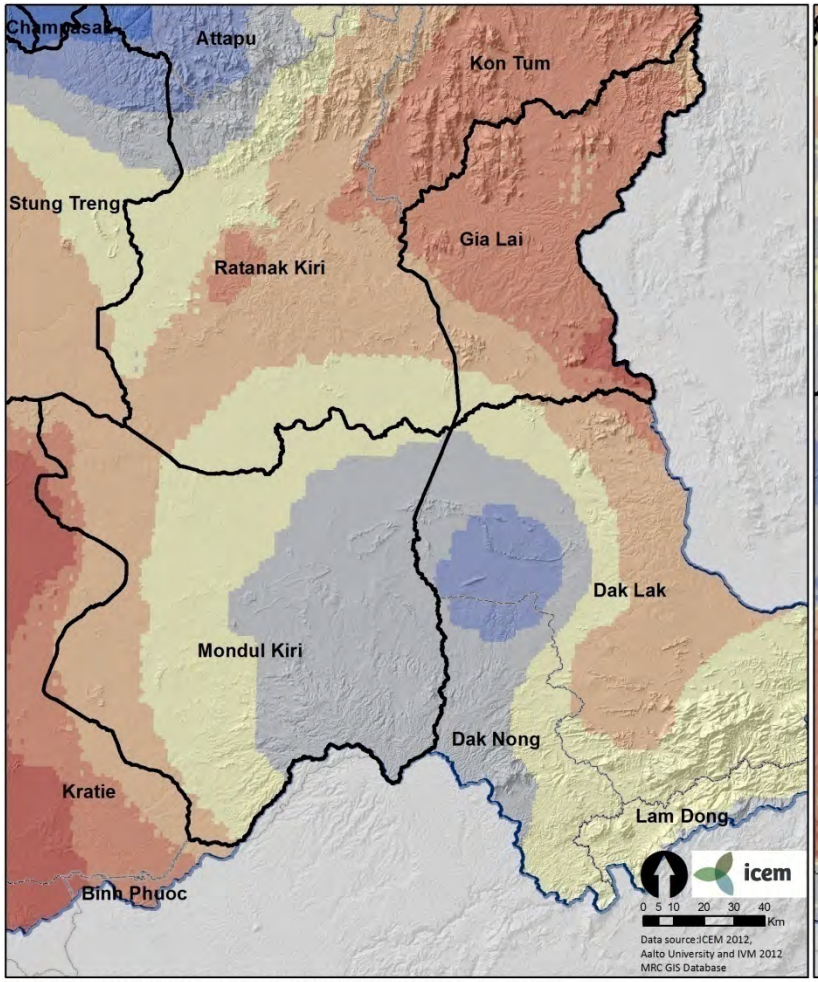


% PRECIPITATION CHANGE IN WET SEASON (2050), MONDULKIRI & GIA LAI

- Lower Mekong basin
- National border
- Province border
- Mekong mainstream

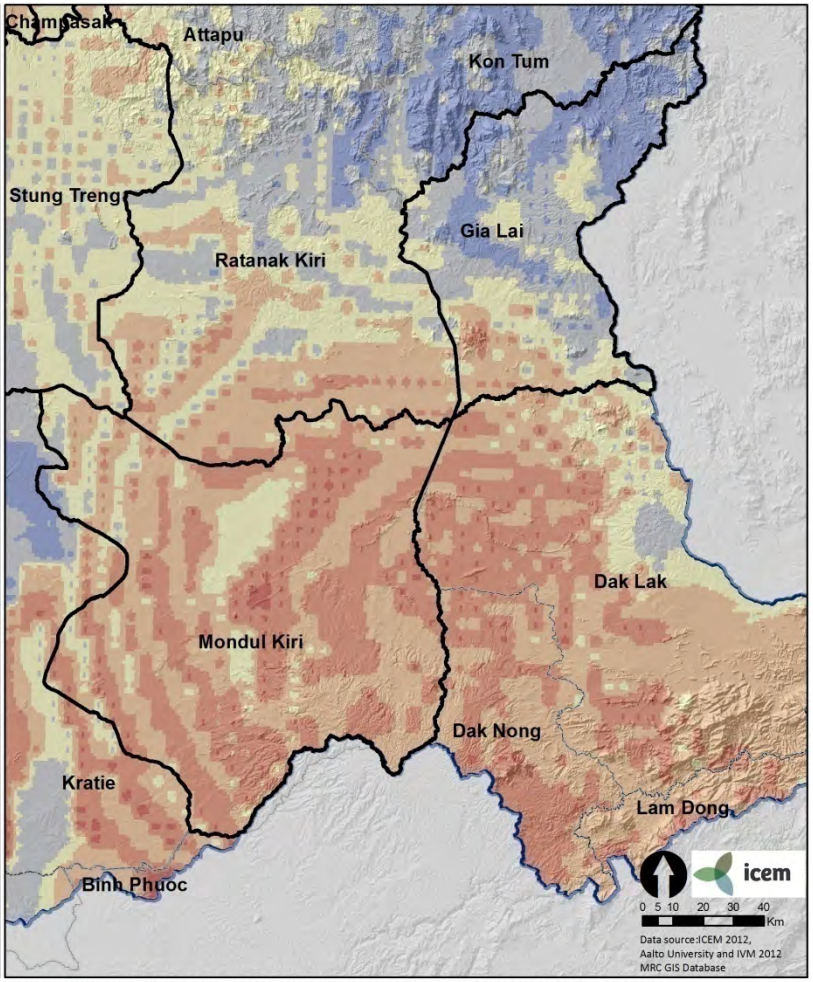
% Precipitation change in Wet Season

- 6.5 - 8
- 8.1 - 9
- 9.1 - 10
- 10.1 - 11
- 11.1 - 12
- 12.1 - 13.7



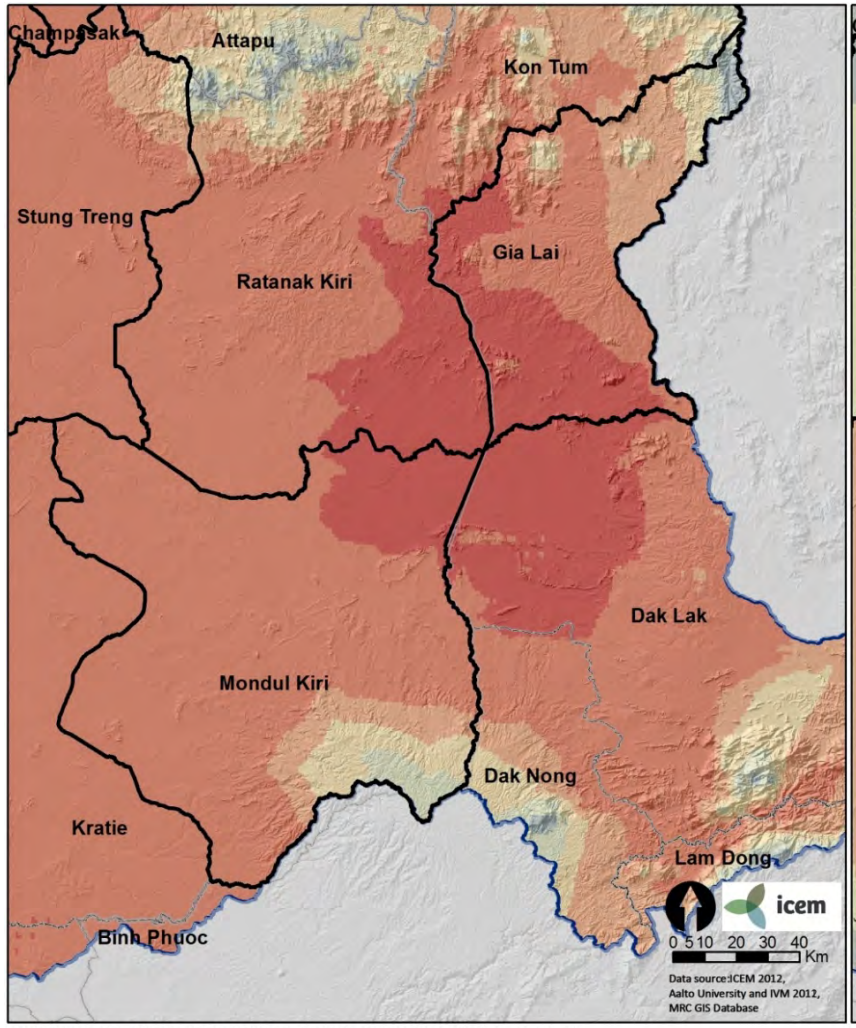
PRECIPITATION IN DRY SEASON (2050), MONDULKIRI & GIA LAI

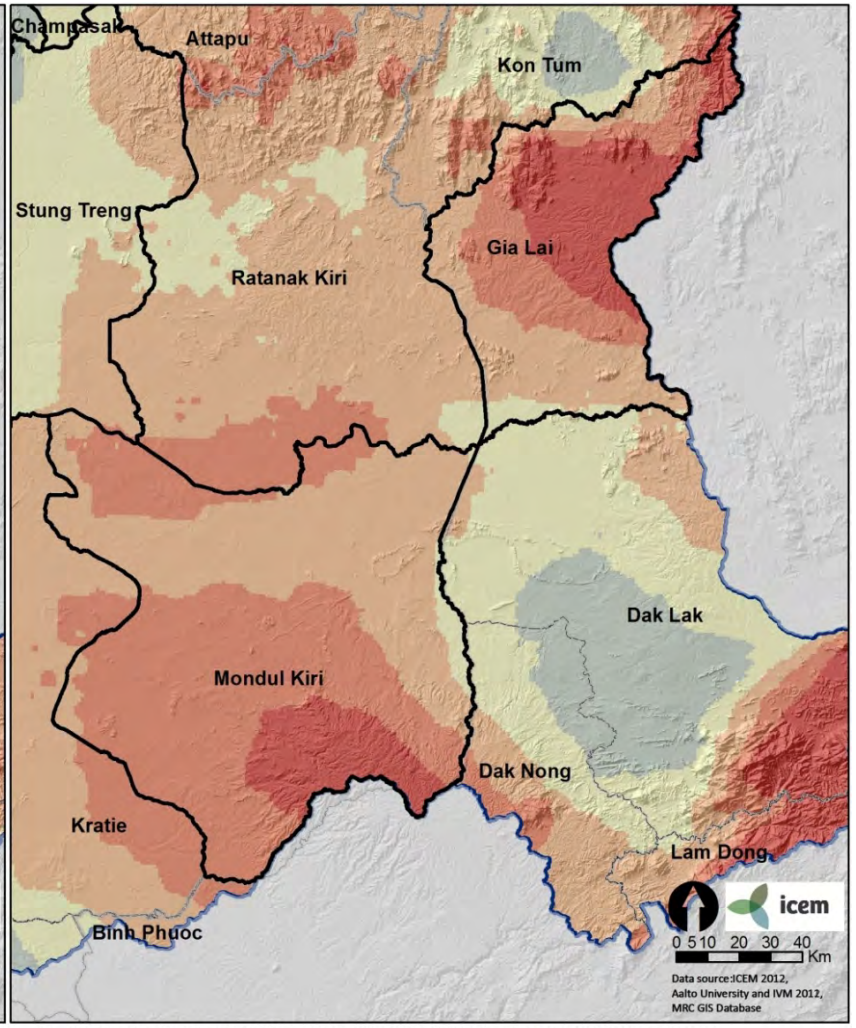
Lower Mekong basin	**Precipitation Dry Season**	301 - 350
Mekong mainstream	126 - 200	351 - 400
National border	201 - 250	401 - 450
Province border	251 - 300	451 - 575



% PRECIPITATION CHANGE IN DRY SEASON (2050), MONDULKIRI & GIA LAI

Lower Mekong basin	**% Precipitation change in Dry Season**	0.1 - 2
Mekong mainstream	-10.8 - -4	2.1 - 5
National border	-3.9 - -2	5.1 - 10
Province border	-1.9 - 0	10.1 - 23.4





AVERAGE MAX TEMPERATURE (2050), MONDULKIRI & GIA LAI

- Lower Mekong basin
- Mekong mainstream
- National border
- Province border

Average Max Temperature

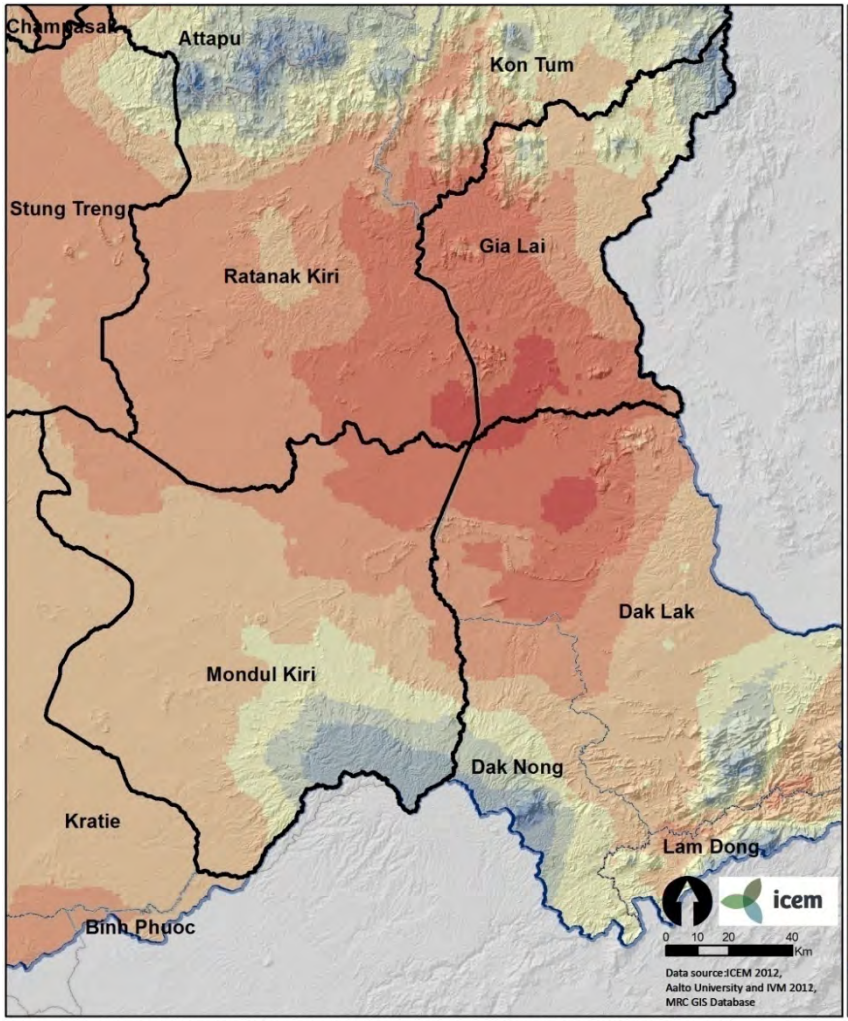
- 19.8 - 25
- 25.1 - 27
- 27.1 - 29
- 29.1 - 30
- 30.1 - 31
- 31.1 - 32
- 32.1 - 34
- 34.1 - 35.6

% AVERAGE MAX TEMPERATURE CHANGE (2050), MONDULKIRI & GIA LAI

- Lower Mekong basin
- Mekong mainstream
- National border
- Province border

(%)Temperature change

- 5 - 8
- 8.1 - 9
- 9.1 - 10
- 10.1 - 11
- 11.1 - 12
- 12.1 - 13
- 13.1 - 16.3

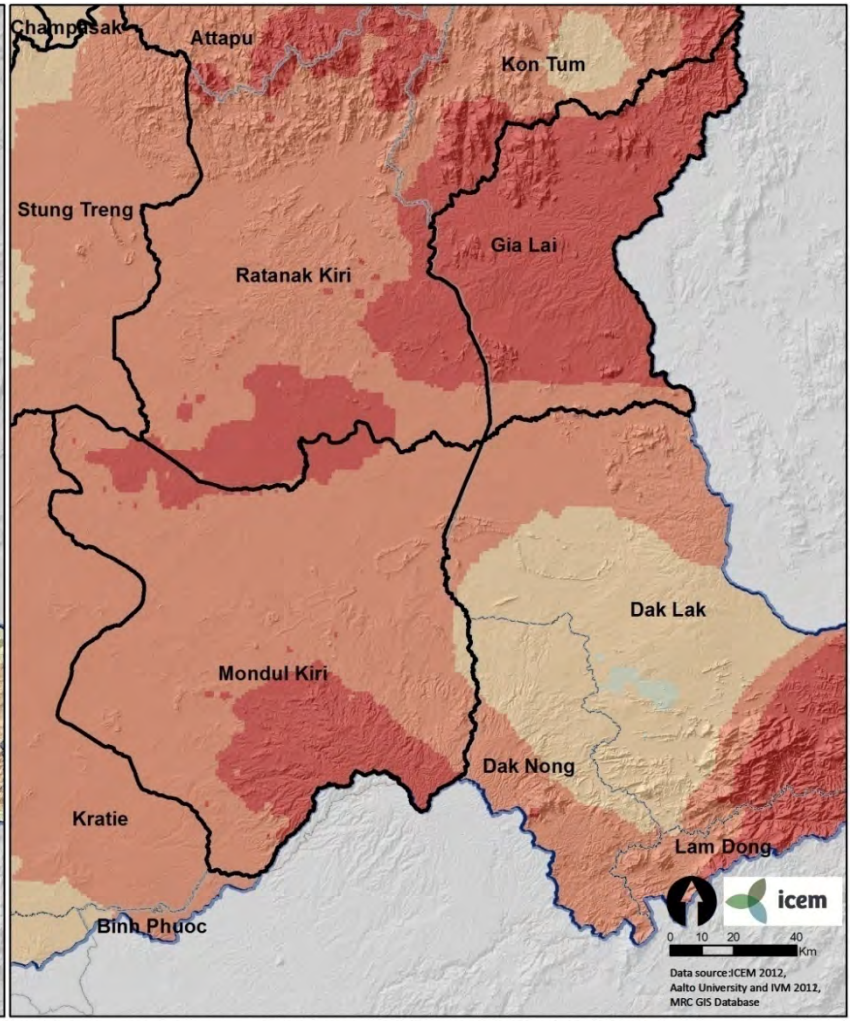


AVERAGE MAX TEMPERATURE IN WET SEASON (2050), MONDULKIRI & GIA LAI

Lower Mekong basin
Mekong mainstream
National border
Province border

Temperature Wet Season

21 - 28
28.1 - 29
29.1 - 30
30.1 - 31
31.1 - 32
32.1 - 33
33.1 - 34
34.1 - 35
35.1 - 35.4

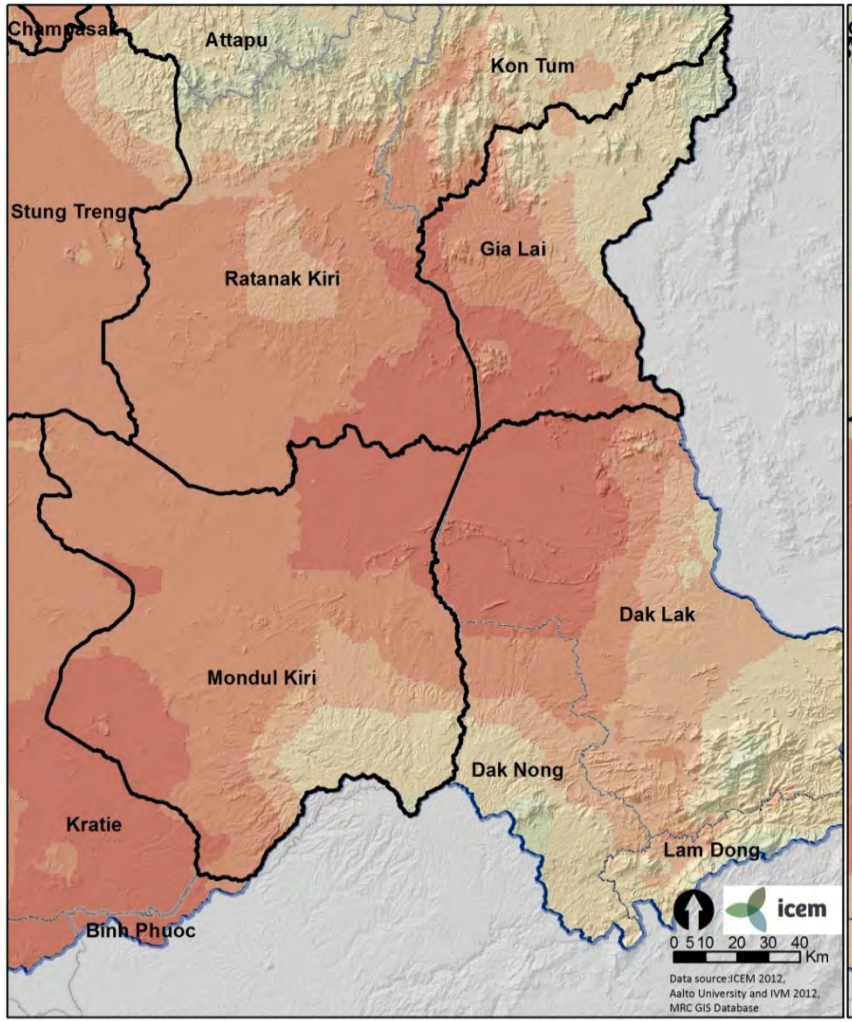


% TEMPERATURE CHANGE IN WET SEASON (2050), MONDULKIRI & GIA LAI

Lower Mekong basin
Mekong mainstream
National border
Province border

(%)Temperature change in wet season

5.22 - 7
7.01 - 8
8.01 - 10
10.01 - 12
12.01 - 14
14.01 - 19.91

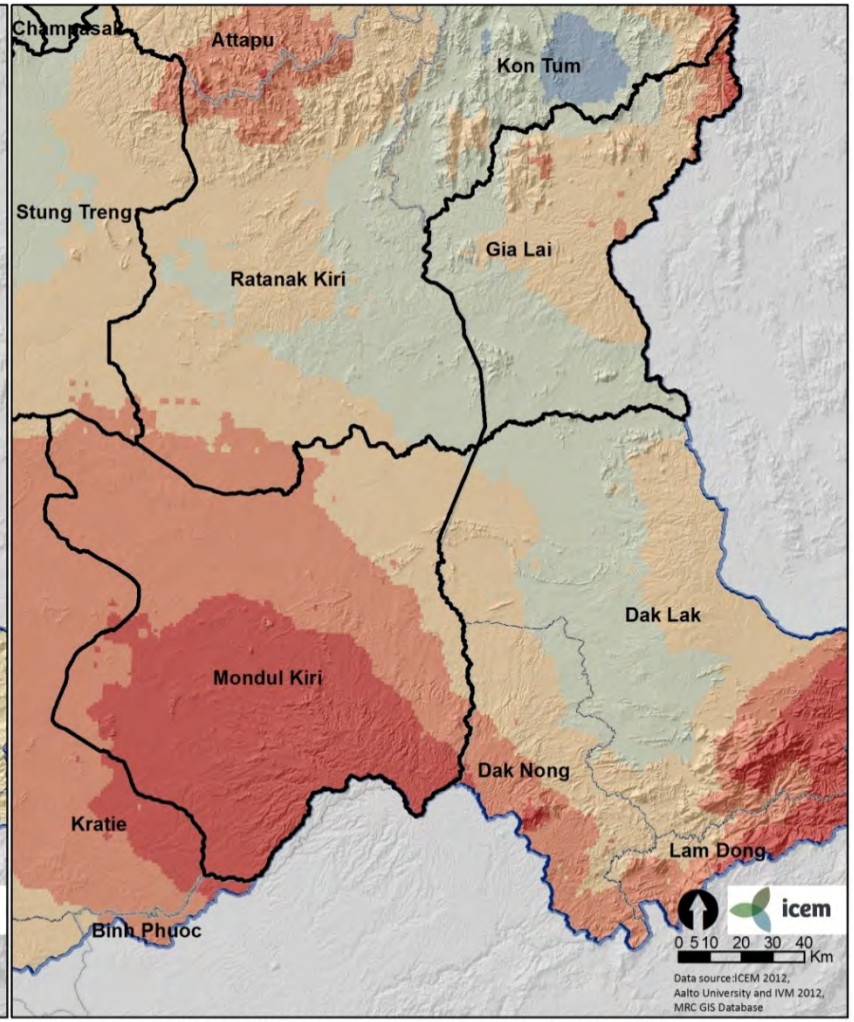


AVERAGE MAX TEMPERATURE IN DRY SEASON IN 2050, MONDULKIRI & GIA LAI

Lower Mekong basin
Mekong mainstream
National border
Province border

Temperature Dry Season in 2050 (C degree)

18.5 - 22
22.1 - 24
24.1 - 26
26.1 - 28
28.1 - 30
30.1 - 32
32.1 - 33
33.1 - 34
34.1 - 35
35.1 - 36



% TEMPERATURE CHANGE IN DRY SEASON (2050), MONDULKIRI & GIA LAI

Lower Mekong basin
Mekong mainstream
National border
Province border

(%)Temperature change in dry season

4.6 - 7
7.1 - 8
8.1 - 9
9.1 - 10
10.1 - 11
11.1 - 12.9

ANNEX F: PRIORITY PROVINCE THREAT PACKAGE EXAMPLE

To insert as PDF

ANNEX G: HYDROLOGICAL ANALYSIS OF THE IMPACTS OF CLIMATE PROJECTIONS FOR EIGHT MAINSTREAM MEKONG STATIONS

ANNEX H: NATURAL SYSTEMS GROUP SECTOR SPECIFIC CLIMATE CHANGE THREAT ANALYSIS

ANNEX I: CAM ASSESSMENT MATRIX SUPPORT TOOLS

Matrix support tool for identifying impact level from exposure and sensitivity

		Exposure of system to climate threat				
Sensitivity of system to climate threat		Very Low	Low	Medium	High	Very High
	Very High	Medium	Medium	High	Very High	Very High
	High	Low	Medium	Medium	High	Very High
	Medium	Low	Medium	Medium	High	Very High
	Low	Low	Low	Medium	Medium	High
	Very Low	Very Low	Low	Low	Medium	High

Matrix support tool for identifying vulnerability level from impact and adaptive capacity

		Impact				
Adaptive Capacity		Very Low *Inconvenience (days)*	Low *Short disruption to system function (weeks)*	Medium *Medium term disruption to system function (months)*	High *Long term damage to system property or function (years)*	Very High *Loss of life, livelihood or system integrity*
	Very Low *Very limited institutional capacity and no access to technical or financial resources*	Medium	Medium	High	Very High	Very High
	Low *Limited institutional capacity and limited access to technical and financial resources*	Low	Medium	Medium	High	Very High
	Medium *Growing institutional capacity and access to technical or financial resources*	Low	Medium	Medium	High	Very High
	High *Sound institutional capacity and good access to technical and financial resources*	Low	Low	Medium	Medium	High
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	Very Low	Low	Low	Medium	High

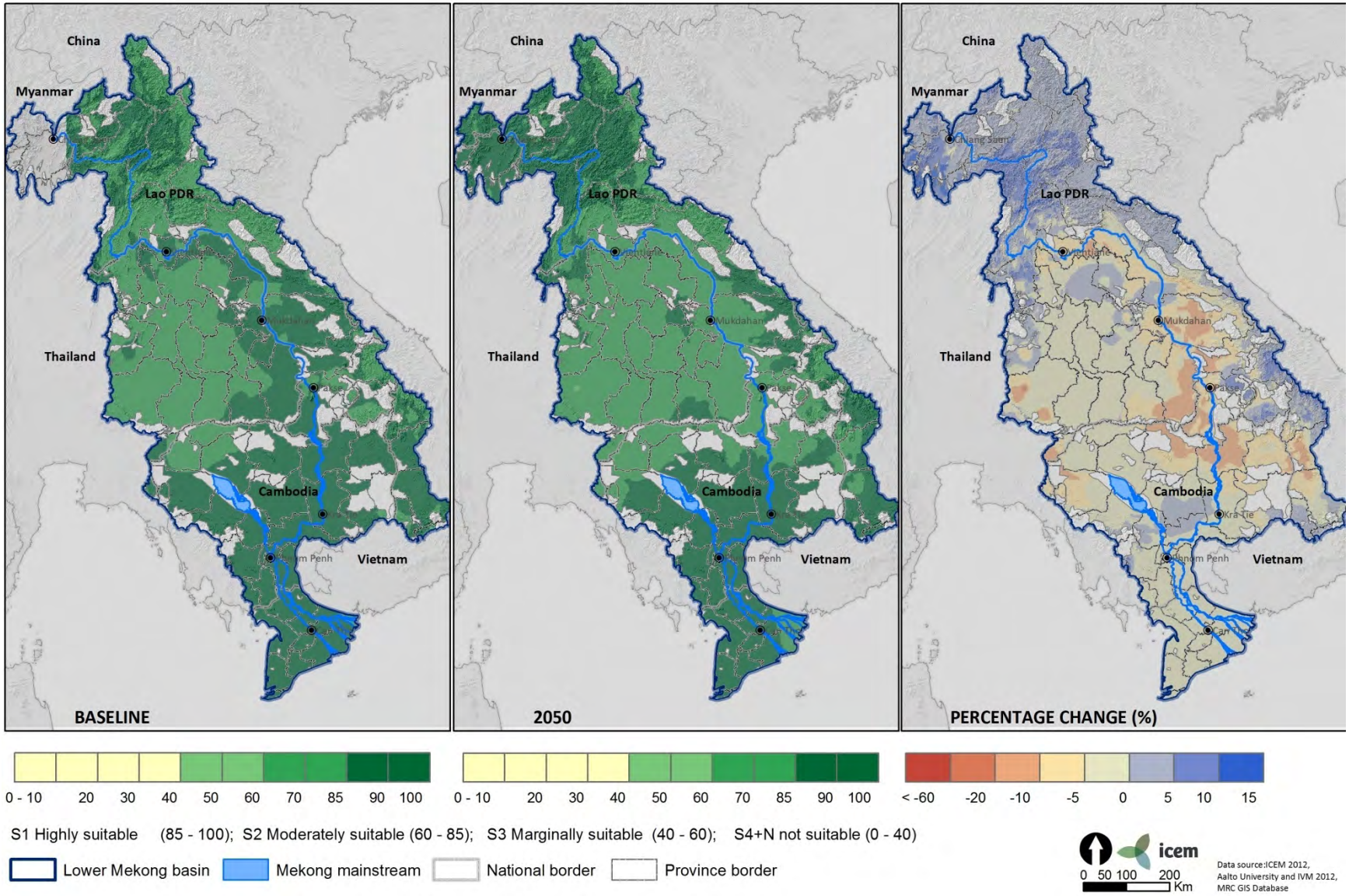
Matrix tool for CAM vulnerability assessment

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		written description of how the threat relates to the system component	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
	Change and shift in regular climate							
	Temperature							
	Precipitation							
	Water availability							
	Sea level							
	Salinity							
	Change and shift in events							
	Drought							
	Flooding							
	Flash floods							
	Storms							

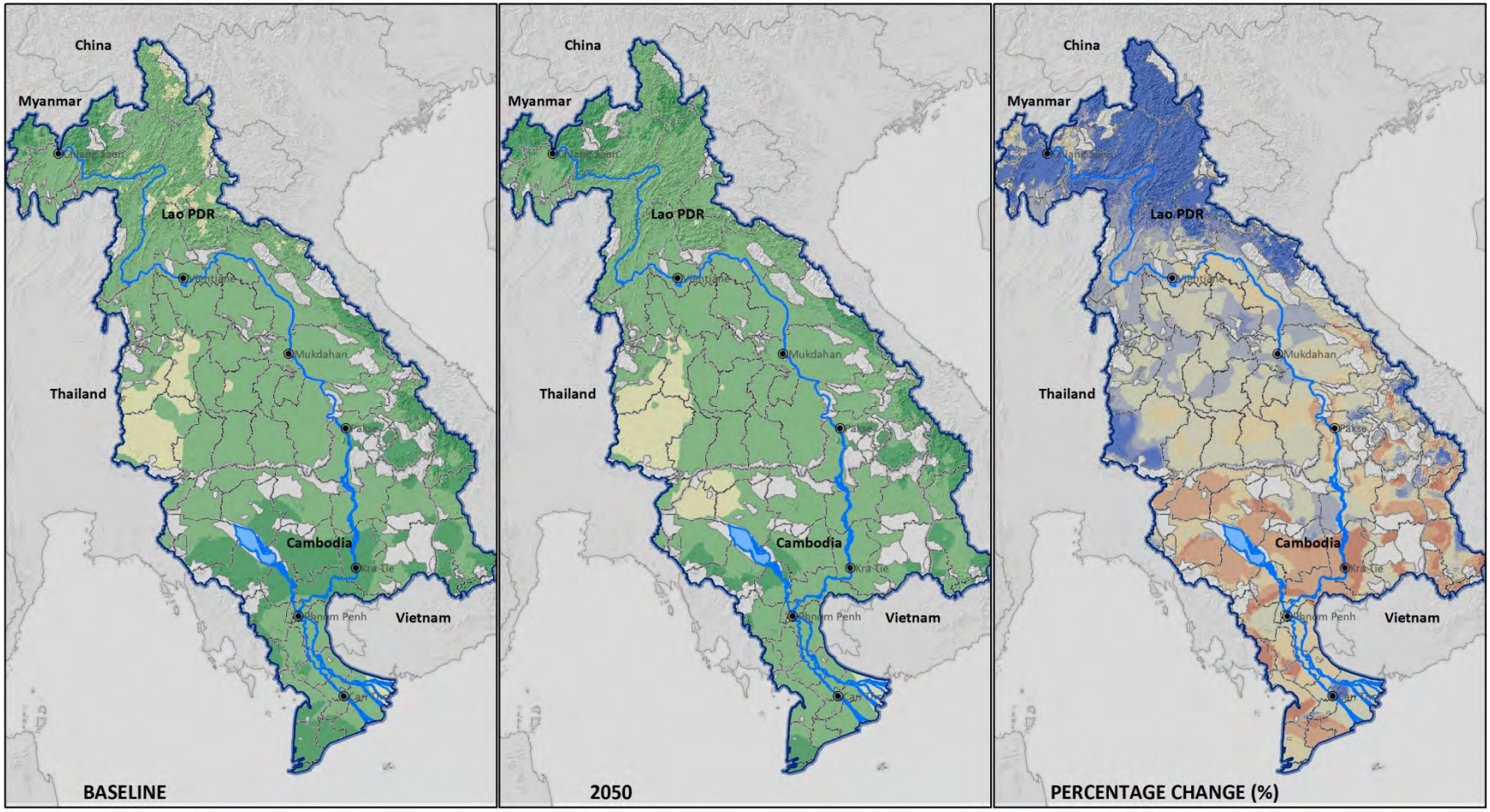
ANNEX J: BASIN-WIDE LAND USE SUITABILITY FOR CASSAVA, COFFEE ROBUSTA, MAIZE, RAIN FED RICE, RUBBER AND SOYA

IMPORTANT NOTE: Flood extents are still to be incorporated into these maps and, when included, will further restrict the area available for cropping particularly in areas around Tonle Sap and the Mekong Delta.

CASSAVA SUITABILITY FOR THE LOWER MEKONG BASIN



ROBUSTA SUITABILITY FOR THE LOWER MEKONG BASIN



0 - 10 20 30 40 50 60 70 85 90 100

0 - 10 20 30 40 50 60 70 85 90 100

< -60 -20 -10 -5 0 5 10 15

S1 Highly suitable (85 - 100); S2 Moderately suitable (60 - 85); S3 Marginally suitable (40 - 60); S4+N not suitable (0 - 40)

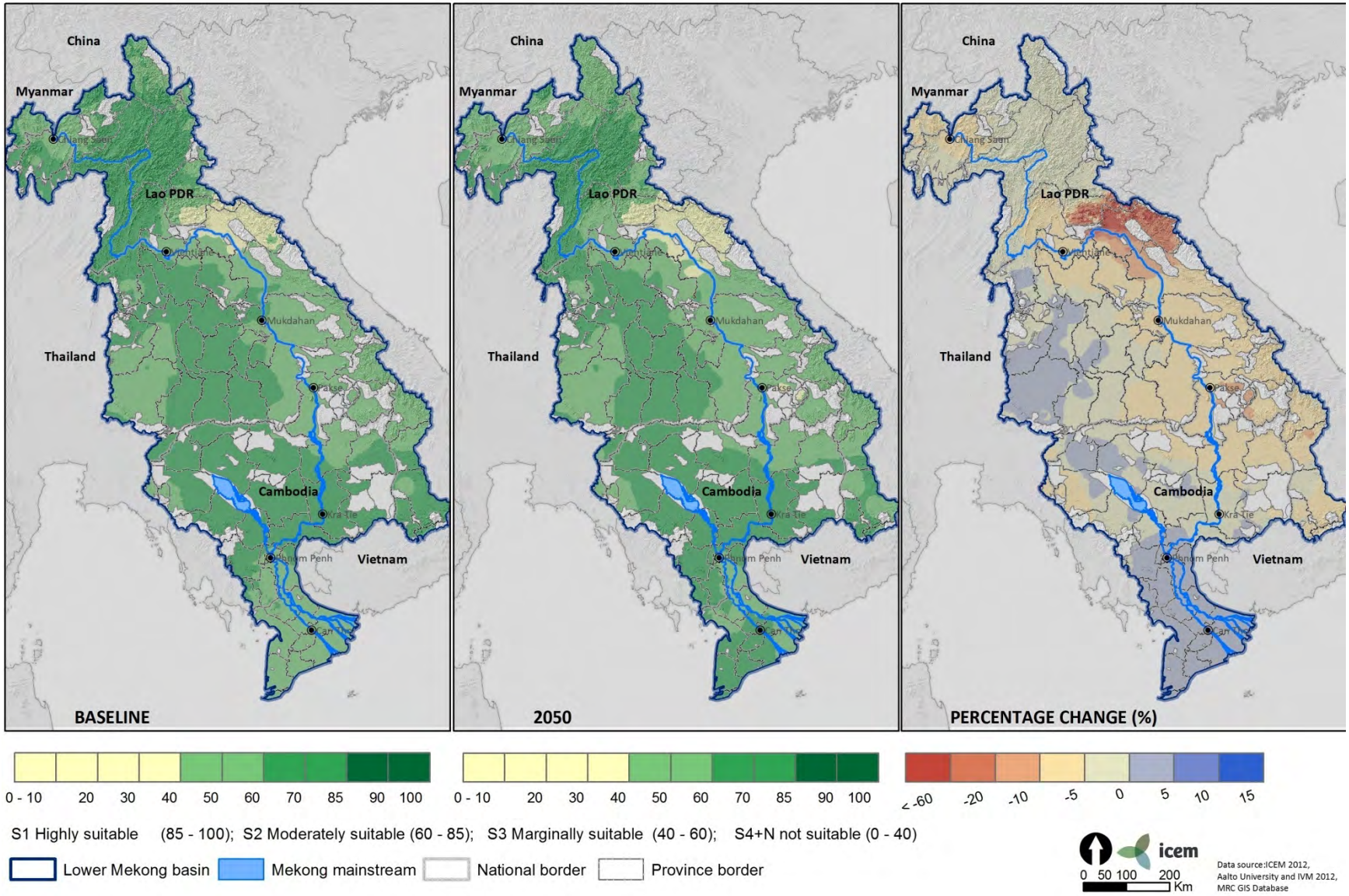
Lower Mekong basin | Mekong mainstream | National border | Province border

icem

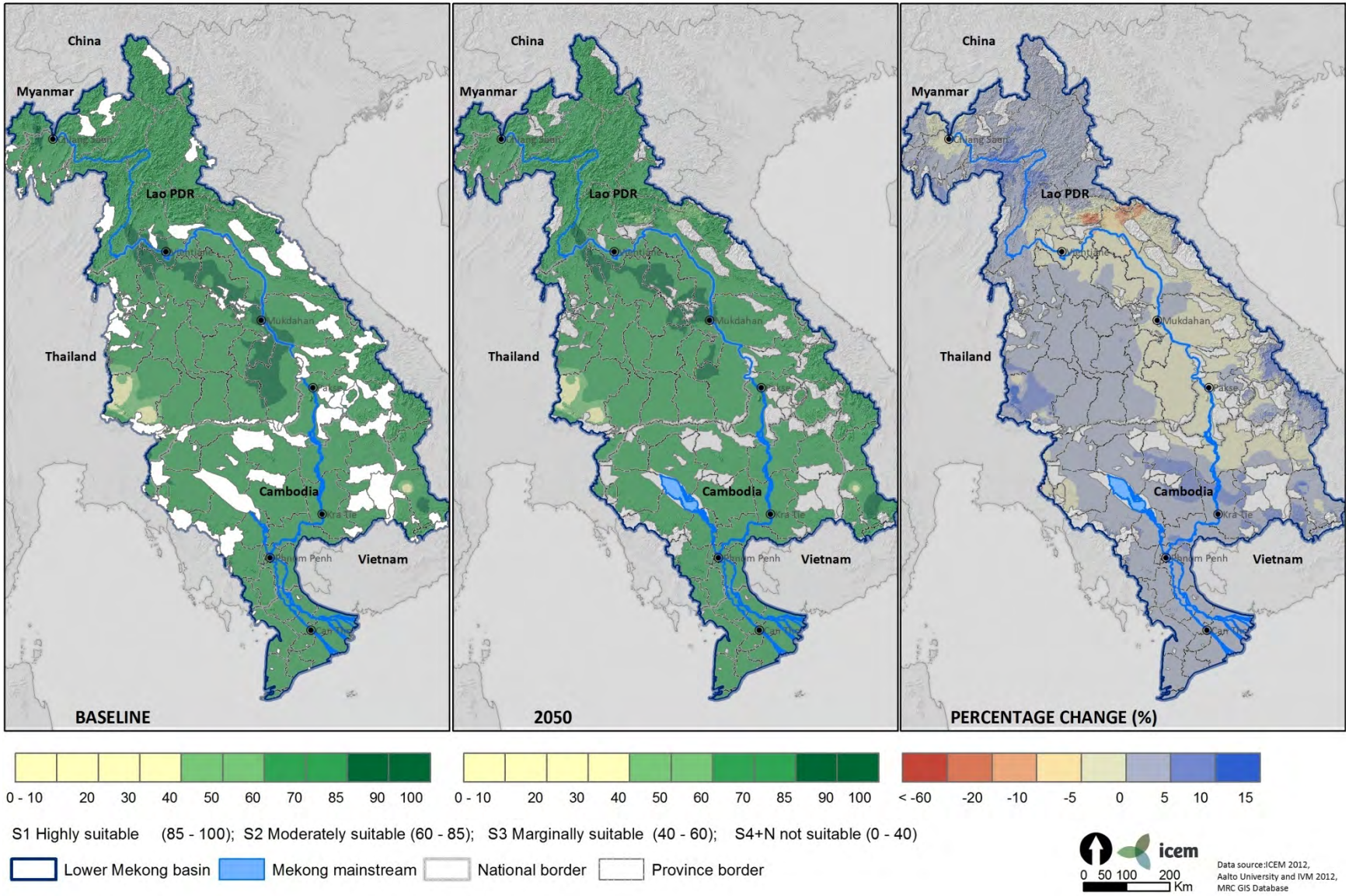
0 50 100 200 Km

Data source:ICEM 2012, Aalto University and IVM 2012, MRC GIS Database

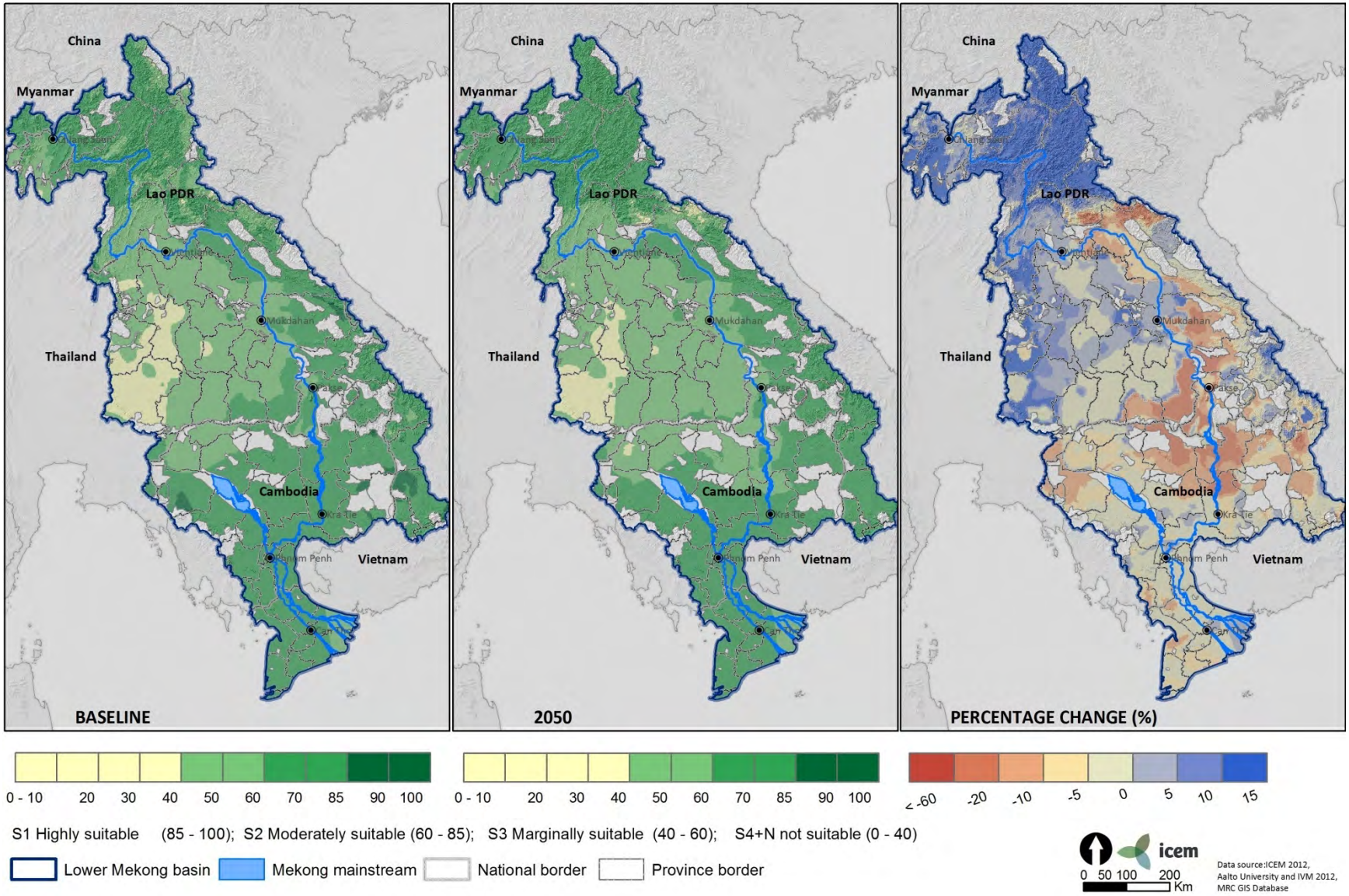
MAIZE SUITABILITY FOR THE LOWER MEKONG BASIN



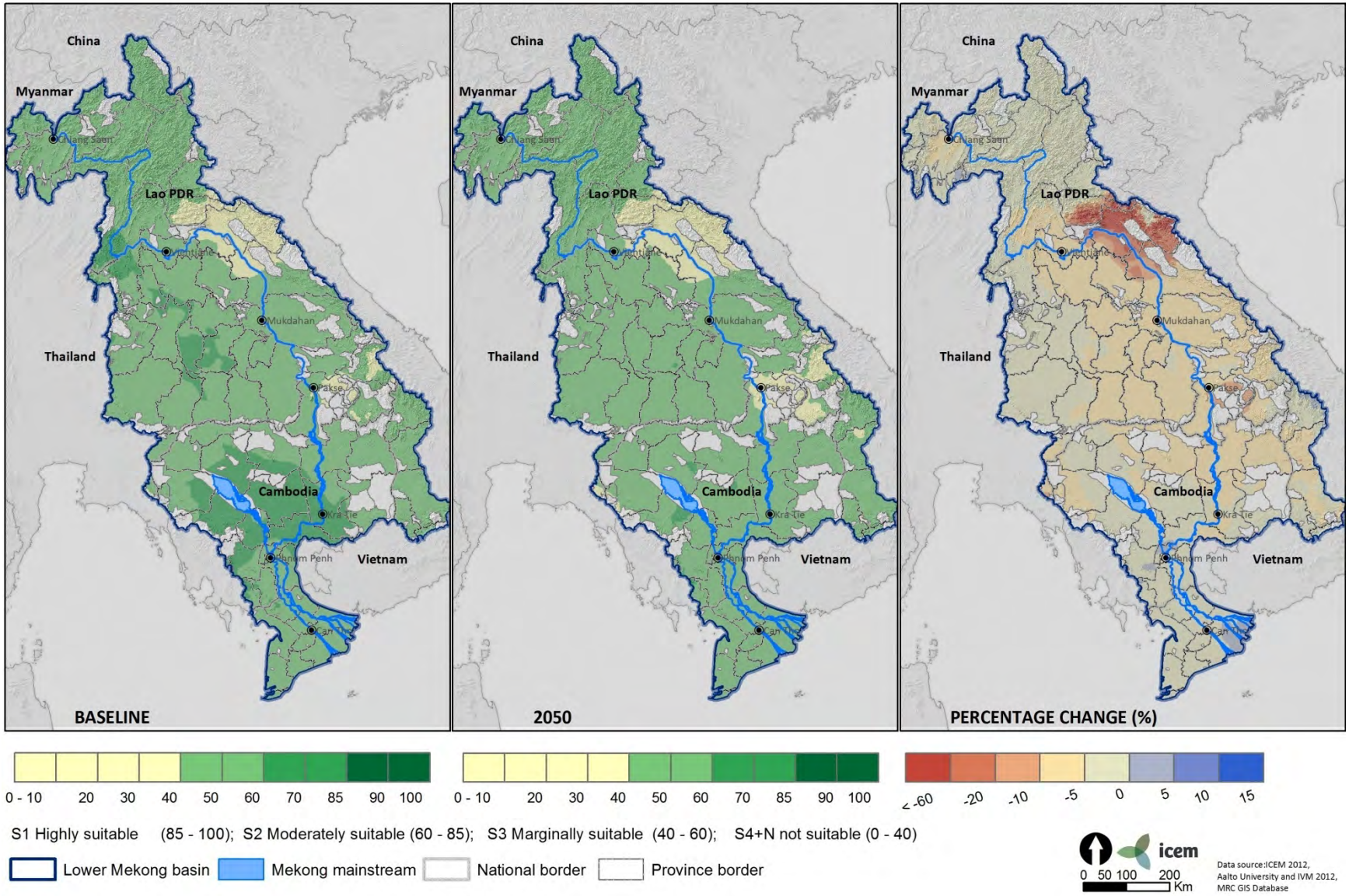
LOWLAND RAINFED RICE SUITABILITY FOR THE LOWER MEKONG BASIN



RUBBER SUITABILITY FOR THE LOWER MEKONG BASIN



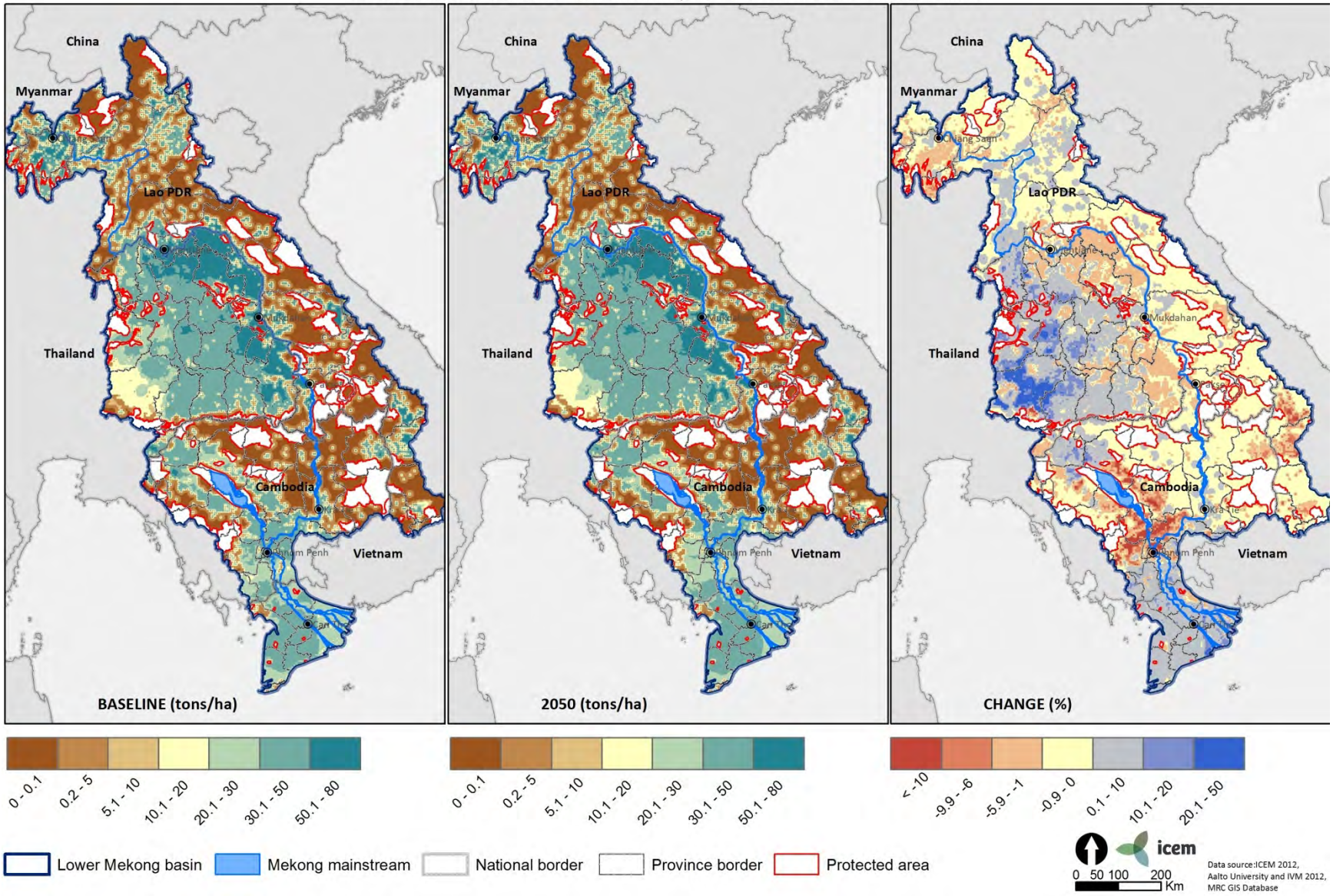
SOYA SUITABILITY FOR THE LOWER MEKONG BASIN



ANNEX K: BASIN-WIDE CROP YIELD MODELLING FOR RAIN FED RICE

IMPORTANT NOTE: Flood extents are still to be incorporated into this map and, when included, will further restrict the area available for cropping particularly in areas around Tonle Sap and the Mekong Delta.

CUMULATIVE RAINFED RICE YIELD, IN THE LOWER MEKONG BASIN



ANNEX L: PRIORITY PROVINCE CROP YIELDS FOR RAIN FED RICE AND MAIZE

MAIZE YIELDS

Province	Baseline maize yields (ton/ha)	% change in maize yields by 2050
Chiang Rai	4.22	-3.13
SakonNakhom	-	Increase to yield of 3.95 t/ha
Khammouan	4.74	-5.03
Champasak	5.08	-5.55
Gia Lai	3.54	-12.09
Mondulkiri	7.22	-6.77
Kampong Thom	3.06	-5.97
Ken Giang	-	Increase to yield of 3.85 t/ha

RAINFED RICE YIELDS

Province	Baseline rain fed rice yields (ton/ha)	% change in rain fed rice yields by 2050
Chiang Rai	3.4	-4.8
SakonNakhom	2.1	4.6
Khammouan	3.4	-0.1
Champasak	2.9	-5.6
Gia Lai	3.3	-12.6
Mondulkiri	2.1	-3.0
Kampong Thom	2.2	-3.6
Ken Giang	2.9	18.8

ANNEX M: ADAPTATION PLANNING METHODOLOGY

During a team meeting on 2-3rd November 2012, the Task 2 team refined and tested the adaptation planning methodology. The team now has a clear process and a number of tools to assist them in identifying adaptation options (Figure F-1).

Figure F-1. Adaptation planning methodology

The process has four stages:

1. Identify the most vulnerable assets and define the impacts which require adaptation response
    - The most vulnerable assets are identified directly from the CAM vulnerability assessment using the adaptation matrix tool.
2. Define the adaptation options for identified assets and impacts
    - Drawing from your own experience, international experience and what has worked in the region to address past extremes prepare adaptation options to address impacts and threats relating to each vulnerable asset (using the adaptation matrix tool).
3. Prepare guidance for adaptation planning
    - Phasing and priority setting – using the phasing table distribute options against (i) adaptation deficit, (ii) adaptation additions and (iii) system shift and also short, medium or long term.
    - Also provide text and analysis on the following:
    - **Integration and synergies** – identify opportunities for linkages and synergies in adaptation with other themes
    - **Adaptation impact assessment** – comment on potential for negative impact on other themes/sectors
    - **Geographic scope** – comment on geographic scope of adaptation from for example local/farm level, provincial, national, ecozone/livelihood zone to basin wide.
4. Upscale to ecozone or livelihood zone level