Climate Change Assessment

I. BASIC PROJECT INFORMATION

Project Title: Climate-Friendly Agribusiness Value Chains Sector Project

Project Budget: $46.23 million (ADB Grant: $40.50 million; Beneficiaries: $4.99 million; Government: $0.74 million)

Project Location(s): Provinces of Champasak, Khammouane, Saravan, Savannakhet, Sekong, and Vientiane Capital.

Sector: Agriculture and Natural Resources

Subsector: Agriculture, natural resources and rural development

Themes: Environment, Natural Resources & Agriculture

Brief Description of the Project:

The proposed Climate-Friendly Agribusiness Value Chains Sector Project (CFAVC) will support the implementation of the Lao PDR Government's Agricultural Development Strategy (ADS) to 2025 and the Vision to the year 2030. The strategy and vision aim to (i) ensure food security, and produce competitive agricultural commodities with comparative advantage, (ii) develop clean, safe and sustainable agriculture, and (iii) move gradually to the modernization of a resilient and productive agriculture sector linked to rural development and contributing positively to the national economy.

The project targets the value chains of rice and vegetable production in an amalgam of two groups of provinces which together contribute significantly to the country's agricultural GDP. The rice value chain will be targeted in Khammouane, Saravan and Savannakhet provinces and the vegetable value chain in Vientiane Capital Administration Authority, Champasak and Sekong provinces, along the Greater Mekong Subregion (GMS) central and east-west economic corridors.

The project is aligned with the following impact: agricultural competitiveness improved. It is achieved through enhanced productivity, quality and safety, value addition and rural household incomes. The project will have the following outcome: productive and resource efficient agribusiness value chains in project areas developed.

The project will have three outputs: (i) critical agribusiness value chain infrastructure improved and made climate-resilient; (ii) climate smart agriculture promoted; and (iii) enabling environment for climate-friendly agribusiness enhanced.

Implementation of the project is expected to result in:

(i) at least 20% increase in yields of rice and vegetables;

(ii) at least 30 agribusinesses become resource-efficient in terms of water savings (5-10% efficiencies) and reduce post-harvest losses for rice (from 25% down to 10%) and vegetables (from 35% down to 15%);

(iii) at least 30% increase in household income in rural areas; and

(iv) at least five agricultural cooperatives formed and operational. The project targets both domestic and export markets demanding high quality and safe agricultural products.

I. CLIMATE CHANGE TRENDS AND PROJECTIONS

(i) Historical and Projected Changes in Temperature

The average temperature for Lao PDR is 26.5°C. The southern provinces of Lao PDR currently have an annual temperature of between 20-30°C, with the average of 26.5–27.5°C.[1] Temperature peaks in April, which has an annual average monthly temperature of 29°C, and drops to an average of 21°C in December. Both Champasak and Khammouane already report higher than average maximum temperatures. Khammouane is not nearly as cool as Champasak and Vientiane in December and January, maintaining an average temperature of approximately 20°C. Temperature in the other target provinces go down to around 16°C.[2]

According to the Second National Communication on Climate Change of Lao PDR, mean annual temperature in Lao PDR and particularly in the southern provinces, has increased by 0.05°C per decade since 1950 (see Figures 1 and 2 in Annex 1). However, closer analysis of the average temperatures for Lao PDR provided by the Lao Statistics Bureau 2009 reports that since 1980 the average minimum and maximum temperatures of selected provinces has dropped in some cases by up to 2°C (footnote 1). The Mekong Adaptation and Resilience to Climate Change (ARCC) Lao PDR Climate Change Vulnerability Profile indicates that the country could be facing daily maximum temperatures increases of approximately 2°C–3°C by 2050,[3] with the highest increases anticipated in the south of the country. These increases are consistent with the wider temperature trends of Southeast Asia.

One of the target provinces, Champasak, is expected to witness a 2.5°C increase in its mean annual temperature, pushing the average daily maximum temperature from 33°C–36°C,[4] although it could exceed 44°C in some years (footnote 3). Khammouane could also see some dramatic changes to its climate due to its varied terrain. Temperature increases are set to be fairly moderate across the province, as Figure 3 illustrates, with a positive shift of 2°C in average daily maximum temperatures throughout the year predicted (footnote 3), although mountainous terrain could be facing increases in temperature up to 16%.[5]

(ii) Historical and Projected Changes in Precipitation

Lao PDR has a tropical climate, which is influenced by the southeast monsoon which causes significant rainfall and high humidity. The majority of Lao PDR's rainfall occurs between May and October during the rainy season. During this time current annual rainfall averages between 1,300–3,000 mm. The lower end of this spectrum reflects average rainfall in the dry northwest of the country, while the Annamite mountain range in the south can see up to 4,000mm in an average year.[6] Over the past 10 years, Vientiane and Khammouane have had similar monthly ranges in terms of precipitation, receiving an average of approximately 240 mm a month in the wet season, and peaking mid-season with an average around 350 mm. Precipitation at the peak of the wet season in Champasak averages out at almost 520 mm a month, although it is then almost entirely dry for the remainder of the year.[7]

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[1] Government of Lao PDR, Water Resources and Environment Administration. 2012. *Lao Environment Outlook*. Vientiane.
[2] World Meteorological Organization. https://www.wmo.int/pages/index_en.html (accessed 9 November 2016).
[3] USAID Mekong ARCC. 2014. *Lao PDR Climate Change Vulnerability Profile.* Bangkok.
[4] USAID Mekong ARCC. 2012. *Champasak, Lao PDR: Priority Province Profile Study.* Bangkok.
[5] USAID Mekong ARCC. 2012. *Khammouane, Lao PDR: Priority Province Profile.* Bangkok.
[6] AIT-UNEP Regional Resource Centre for Asia and the Pacific (RRC:AP). 2001. *State of the Environment Report: Lao PDR.* Bangkok.
[7] World Bank. World Bank Climate Change Knowledge Portal. http://sdwebx.worldbank.org/climateportal/ (accessed 9 November 2016).

These amounts are set to increase, with mean annual rainfall projected to increase by a substantial 10%–30 % during the rainy season in the eastern and southern provinces of the country. Specifically, Champasak and Khammouane provinces are set to see increases in their annual precipitation. Already one of the wettest provinces, Champasak is most vulnerable to these increases, and is projected to experience threats from increased precipitation of up to 175mm/year, increasing the monthly rainfall in December alone by 35%. Additional threats arise not just from a predicted increase in total precipitation, but the anticipated shift when this rainfall will occur. Mekong ARCC's Lao PDR Priority Province Profile for Champasak states that January and February will see a -12% reduction in average monthly rainfall (footnote 4). The corresponding report for Khammouane province indicates that it could see the largest single increase in precipitation across the Lower Mekong Basin, with monthly rainfall set to increase by up to 20% at certain times of year (footnote 5), as illustrated in Figure 4.

(iii) Historical and Projected Changes in Sea Level Rise

There is no direct projected impact from a change in sea level rise for Lao PDR as it is a land locked country.

(iv) Extreme Weather Events (floods, droughts, cyclones, hurricanes, etc.)

The increases in precipitation and variances in temperature widely predicted to come across Lao PDR are set to exacerbate the already regular floods the country faces, continuing the trend of the past four decades, in which flooding has become more frequent, intense and widespread, with 29 major flood events recorded, the majority of which occurred in the central and southern provinces (footnote 1). Recent disasters include the Kammuri flooding (August 2008) which affected about 200,000 people, followed by Typhoon Morakot (August 2009) and Typhoon Ketsana (September 2009). Typhoon Ketsana affected more than 180,000 people and resulted in $58 million of damages and losses – approximately 0.4% of gross domestic product. In 2011, the country was hit by Typhoon Haima and Typhoon NockTen causing $200 million in damages and losses. More than 500,000 people were affected and 38 deaths were reported.

The World Bank Climate Change Country Profile for Lao PDR, states that the projected increased runoff across the Mekong delta (21% by 2030), accompanied by the climate extremes in temperature and precipitation discussed previously could seriously impact downstream catchments all along the mainstream of the Mekong River.[8] Above the basin in the central area of Lao PDR surrounding Vientiane, the predicted increases in peak precipitation will contribute to an increase in events such as flash flooding, hillslope erosion and downstream flooding. Such storm events pose a real threat to the Bolaven Plateau located in Champasak province, which is vulnerable to strong winds.

Khammouane province in particular faces the threat of increased precipitation, with the Mekong ARCC study stepping up their prediction for the frequency of large rainfall events (defined as rainfall greater than 100 mm/day), as outlined in Figure 5.

Increasing temperatures without a corresponding increase in precipitation in the dry season has the potential to increase the frequency of droughts in Lao PDR. The higher evaporation rates caused by these conditions will especially impact the agricultural areas of the country, as they are more vulnerable to problems with water availability. Almost half of the droughts Lao PDR has experienced over the past forty years have been classified as severe, and flood-drought events have become more prevalent (footnote 1).

[8] World Bank. 2011. *Climate Change Country Profile - Lao PDR*. Washington.

Despite drought prevention being identified as a priority area for adaptation in the Lao PDR National Strategy on Climate Change in 2010, actions on a provincial level have not been prioritized in the same way. The Mekong ARCC Priority Province Profile Report for Khammouane predicts that the historical dry season will see no significant change in the number and pattern of drought months (footnote 5). However, the USAID-Mekong ARCC Climate Change Impact and Adaptation Study, carried out a year later and which takes a more long term view of the climate changes faced by Lao PDR and surrounding countries, predicts that for the south and east of the Mekong River Basin the period of agricultural drought per year may significantly increase by 2050.[9]

(v) Other associated events (landslides, etc.)

Landslide events in Lao PDR are mainly related to weather conditions, slope, vegetation cover and geology. According to the Developing a National Risk Profile of Lao PDR Report (2010), rainfall is the main triggering factor for landslide occurrences. Landslide hazard susceptibility in Lao PDR is classified into five zones (negligible, low, medium, high and very high) by using a semi-quantitative rating approach.

According to the Mekong ARCC study on Climate Change Impact and Adaptation (2014), Lao PDR will experience changes in rainfall and temperature patterns by 2050, with the central part of Lao PDR experiencing some of the largest relative increases in precipitation. This will cause floods and soil erosion as well as landslide events.

II. CLIMATE RISK, VULNERABILITY AND IMPACT ASSESSMENT

(i) Climate risk classification as per AWARE

The overall project risk rating in Lao PDR as per AWARE is High. The country will experience an increase in average temperature, a longer and warmer dry season, and more rainfall during the wet season. The critical topics of risk include the anticipated precipitation increase and at the same time precipitation decrease, incidence of flooding and extreme storm events, as well as the occurrence of landslide. As a low-income country with an agricultural-based economy, it is considered one of the most vulnerable countries to impacts of future climate change in the Southeast Asian region. The most vulnerable areas are the low lying areas along the Mekong River and its major tributaries in the central and southern regions, as well as the mountainous areas in the northern regions. The AWARE risk screening report is attached as a separate document.

(ii) Climate Risk Classification as per detailed assessment (Low, Medium and High)

Overall climate risk as per detailed assessment is “medium”. Project area is classified as “high” for precipitation decrease; “medium” for temperature increase and “medium” precipitation increase. Other categories which were rated “high” risk included flood, landslide, and onshore category 1 storms; wind speed increase was classified as “medium” risk.

[9] USAID-Mekong ARCC. 2013. *Climate Change Impact and Adaptation Study*. Bangkok.

(iii) Sensitivity of Project Outputs to Climate/Weather Conditions	
Output	**Activities sensitive to climate change impacts**
Output 1: Critical agribusiness value chain infrastructure improved and made climate-resilient	1. The upgrading of off-farm and on-farm water management infrastructure is at risk from uncharacteristic weather events, including flooding from storms, heavy rainfall events, landslide and drought periods.
	2. The construction of small scale post-harvest facilities, upgrading of biofertilizer factories, rice mill and vegetable hub infrastructure, and access road rehabilitation are potentially vulnerable to increases in uncharacteristic weather events including flooding, high winds and increased precipitation during storm events. Building designs will need to include high specification against weather events, and located outside flash-flooding zones where possible.

(v) Vulnerability Assessment (Sensitivity, Exposure and Adaptive Capacity)

The University of Notre Dame Global Adaptation Initiative (ND-GAIN), summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience considering exposure to climate related natural disasters human sensitivity and adaptive capacity of the government and infrastructure to combat climate change. Lao PDR is ranked in 2017 as 122 out of 181 countries for vulnerability.[10] According to the Notre Dame Adaptation Index, Lao PDR is the 53rd most vulnerable country and the 68th least ready country. It received a high vulnerability score and low readiness score placing it in the upper left quadrant of the ND-GAIN Matrix. It has both a great need for investment and innovations to improve readiness and a great urgency for action.

Lao PDR is particularly vulnerable to climate change due to (i) natural resource loss and degradation through unstainable wood extraction and large scale mining, infrastructure and hydropower projects; and (ii) socioeconomic challenges of the high dependence on agriculture and limited access to resources for the majority of the population. Smallholders and landless poor in Lao PDR face high risk of natural hazards and climate change. Over 95% of the farming systems are vulnerable to flooding, drought and delayed onset of the rainy season.

The government of Lao PDR has introduced initiatives such as the National Adaptation Program for Action (NAPA) which aims to build capacity for climate sensitive planning among Lao planners and decision makers. NAPA has identified four priority areas of response to climate change adaptation: agriculture, forestry, water and public health.

(vi) Impact assessment (key impacts on the sector and project)

Rice is the basis of the farming system in Lao PDR, with the rice planting area taking up greater than 80% of the nation’s cropped land. Lao PDR’s agriculture is heavily dependent upon a rainfed system, making climate the key driver for the socioeconomic status of the country. The impact of climate change on crop cultivation will vary across the different regions of Lao PDR. The table below shows the predicted effects of climate change for two project regions as presented by the Mekong River Commission (2009) and other reports.[11]

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10 University of Notre Dame. Global Adaptation Initiative. http://index.gain.org/ranking.

11 Synthesis Report on Vulnerability and Adaptation Assessment, Hatfield Consultants for PPCR Phase I project, January 2013.

In general, research has shown that increased temperature stresses and in particular high night-time temperatures and drought conditions have substantial effects on biomass production and the reproductive stages of several plants and crops.[12] Carbon dioxide concentrations on the other hand have some positive effects on photosynthesis. Increased temperature may also exacerbate pressures in water availability, accessibility, and quality.

Lao PDR, along with neighboring countries in the Southeast Asian / Great Mekong Sector region, is under the monsoon climatic zone and has been suffering from increasing droughts arising out of delayed and changing distribution patterns of precipitation. Prolonged dry spells increase the frequencies of wildfire in grasslands, forests, and range lands. The rain-fed crops of the plains are facing challenges from soil-moisture stress with projected droughts. Reduction in annual surface runoff is decreasing the ground and surface water with a negative effect on agriculture and water supply for industrial and domestic sectors. As droughts are exacerbating, the consequences are accelerating.[13]

The greatest potential impact from precipitation increase is the occurrence of flooding. Fifteen floods have occurred in Lao PDR from 1970 to 2010. Five storms or tropical cyclones have reached and affected the country over the last two decades. These storms as well as the impacts from southwest monsoons are estimated to have affected over 1.5 million people. In 1992, a heavy flood caused economic damage for over $21 million. An increase in floods is expected to have implications on the agricultural lands along the Mekong River and its tributaries. In addition, in 2005 and 2006, the damages on the irrigation system by floods caused more than $5 million worth of damage.

Lao PDR is very vulnerable to natural disasters, including extreme weather events which have been increasing in frequency and intensity. Almost all the country's farming systems are susceptible to flooding, drought and the late onset of the rainy seasons. With a high dependency on traditional agricultural systems and a predominance of smallholder farms, the impacts of such natural disasters can be all the more devastating.

III. CLIMATE RISK MANAGEMENT RESPONSE (Adaptation Measures) WITHIN THE PROJECT

A. Contribution of the project to National Climate Resilience Plans (identified in INDC, NAPA and other documents)

The project will contribute to the Government of Lao PDR's National Climate Change Strategy (NCCS) focusing on adaption and mitigation for the agriculture sector and food security by specifically (i) mainstreaming climate change in policies, strategies and plans, (ii) enhancing conservation agriculture, (iii) improving water management and flood control, (iv) financial instruments and community based measures, and (v) information dissemination and extension support. The NCCS highlights key adaptation strategies that have been integrated into this project such as: (i) increasing productivity through conservation agriculture; (ii) improving and monitoring water resources and water supply system; (iii) strengthening the financial instruments and capacity development for farmers; (iv) improving the development of small and medium sized farming in the rural areas; and (v) enhancing information dissemination and extension support to technical staff and Lao farmers in regard to climate change preparedness and responses.

[12] International Center for Tropical Agriculture. 2013. *Prediction of the impact of climate change on coffee and mango growing areas in Haiti.* Cali.

[13] M. A. Miyan. 2015. *Droughts in Asian Least Developed Countries: Vulnerability and Sustainability.* Washington. http://www.sciencedirect.com/science/article/pii/S2212094714000632

B. Contribution of the project to enhanced climate resilience

CFAVC will improve climate resilience of critical agricultural production and post-harvest infrastructure, intensification, and commercialization of rice and vegetables. Project activities directly addressing identified climate risks are listed below:

Project Outputs	Key Adaptation Measures
Output 1: Critical agribusiness value chain infrastructure improved and made climate-resilient	1. The upgrading of irrigation infrastructure will include interventions addressing vulnerability to increases in uncharacteristic weather events, including flooding from storms, and secure supplemental irrigation opportunities during drought periods. The introduction of improved water supply and improved management of water will be achieved through tertiary canal improvement from earth lined to brick or permanent concrete.
	2. The upgrading of organic biofertilizer factories with service provision to farmers will increase the use of biofertilizer and in turn improve soil health and reduce the risk of disrupting aquatic ecosystems with runoff.
	3. For the roads component, the project will assist coping with climate variability and change through activities focused on rehabilitation, and will specify stiff bitumen and use where appropriate of bioengineering applications to withstand projected rise in temperature and the potential impact of aggressive storm events. Additionally, specification clauses will ensure that design and construction standards are raised to appropriate levels.
	4. For areas situated within low lying flood-prone zones where infrastructure cannot be relocated, flood defense and mitigation measures will be implemented, including raising new infrastructure works to be positioned above the maximum projected flood level (taking into account maximum recorded levels and future flood level projections).
	5. Installation of stronger and more climate-resilient buildings; to include but not restricted to installation of pre-stressed, spun concrete poles for reinforcement purposes. In addition, it will be important that good quality materials combined with appropriate bioengineering technologies are used for ground cover, given the additional wear and tear and potential damage from future storms.
	6. Operations and Maintenance: Considering the vulnerability of various subproject areas to extreme weather events, regular operations and maintenance activities and equipment inspections will be carried out to help mitigate damage and ensure continuous operations and/or faster restoration after natural disaster events.
	7. Roads built in lowland and in close proximity to adjacent rivers will include additional protection works to resist erosion and scour.
	8. Integrated waste and energy systems will utilize and manage agricultural waste and residues in selected value chains, enhancing competitiveness, reducing environmental risk, reduce GHG emissions and increase resource efficiency.

Output 2: Climate smart agriculture (CSA) and agribusiness promoted	1. The development and distribution of climate-resilient seeds of rice and vegetables 2. Improved management of water to ensure availability during drought periods, will be achieved through capacity building of the farmers and Water User Groups (WUGs). 3. Capacity building of district environmental officers and project staff in undertaking safeguards due diligence to also incorporate climate change resilience procedures.
Output 3: Enabling environment for climate-friendly agribusiness enhanced	1. Capacity building of civil servants in enabling agribusiness policy/regulatory development will help in mainstreaming climate change concerns into agribusiness at policy and operational levels. 2. Climate risk sharing instruments such as crop Insurance and building capacity of financial institutions for climate-friendly agribusiness investments.

IV. Adaptation Finance

Amount of finance spent on adaptation activities: There is some considerable variance on finance spent on adaptation by activity. Adaptation of irrigation constitutes just over 20% of costs, access roads = approximately 15%, building and site specification / design = 18%, post-harvest improvements including improved milling and access to finance tools = 14%, and improvements to software associated with agricultural practices, market opportunities and thus product value can be as high as 22%. The total amount of adaptation finance is estimated at $7.53 million.

A wide range of climate adaptation practices has been evaluated for on-farm improvements but most results indicate higher yields alone will not be sufficient for farmers to adopt technical interventions. Practices are likely to be attractive only in combination with other benefits, such as reducing labor requirements and/or decreasing riskiness of production.

V. Greenhouse Gas (GHG) Emissions Profile (Country and Sector)

(i) Historical Trends of Emissions in the country (based on UNFCCC reports)

Lao PDR was, according to the first National Communication to the UNFCCC, [14] a net carbon sink in 1990 but in the year 2000 the country has become a net GHG emitter according to the Second National Communication to the Convention.[15] The emissions increased from -101,570 Gg to +41,764[16] GgCO_2. The increase was attributed to the rapid socioeconomic development and improved technical capacities and data availability.

(ii) Projected emissions by 2030 or 2050 by sector

Lao PDR is highly climate-vulnerable, and the country's net GHG emissions were only 41,765 GgCO_2 in the year 2000, which is negligible compared to total global emissions.

Lao PDR's SNC projects that methane emissions from paddy cultivation expansion will substantially increase from 150,000 Gg in 2001 to 300,000 GgCO_2 in 2020. In the same period the emissions from the livestock sector, primarily due to enteric formation of ruminants will increase from 120,000 to 250,000 GgCO_2.

[14] Initial National Communication to the UNFCCC 2000.
[15] Second National Communication to the UNFCCC 2013.
[16] 51,000 according to the INDC. The INDC however references the SNC in which 41,765 is reported.

Emissions in other sectors will also increase rapidly but remain relatively small compared to the agricultural sector. Emissions in the energy sector are expected to triple in the period 2010-2020, from about 1,000 Gg to 3000 $GgCO_2$ in 2020. In the industrial sector, the main source of emissions is the cement industry, whose emissions are projected to increase from 47.3 to 1,530 $GgCO_2$ by 2020.

Deforestation is the main driver behind emissions in the forestry sector. In 1990 the sector was a large sink (104,570 Gg CO_2) and in 2000 this decreased to just 2,047 $GgCO_2$. In the BAU scenario, forest cover would decline from about 10 million hectares in 2020 to 9 million hectares in 2020 and become a net source of emissions. Associated emissions and reduce in carbon sink capacity were not estimated in the SNC.

Implementation of the measures in the INDC, such as increasing forest cover to 70% in 2020 and maintaining it at that level forward, and with 100% of the electricity generated by renewable sources by 2020, could reverse this trend. The INDC did not identify measures to reduce emission in the agricultural sector.

(iii) Sector-related GHG emissions

Most of the CO_2 emissions are attributed to land-use change and forestry including biomass use (42,758 Gg) and only 1,004 Gg to the energy sector. Methane emission, a GHG with a global warming potential of 21 (as per IPCC 1996 revised guidelines) stood at 306.7 Gg (6,440.7 tCO_2e[17]) and the agricultural sector (rice cultivation, enteric fermentation) was by far the most important source of emissions (251,42 GgCH4 or 5,280 tCO_2e) and the remainder was from the land-use change and forestry sector. The agricultural sector was also mostly responsible for the N_2O emissions (7.7 out of 8.4 GgN_2O).

(iv) Key Mitigation Response Measures in the sector (in line with INDC)

Lao PDR has identified a number of actions which it intends to undertake in order reduce its future GHG emissions, subject to the provision of international support.

a) Implementation of Forestry Strategy to the year 2020 of the Lao PDR - To increase forest cover to 70% of land area (i.e. to 16.58 million hectares) by 2020. Once the target is achieved, emission reductions will carry on beyond 2020.

b) Implementation of climate change action plans to build capacity to monitor and evaluate policy implementation success, with a view to producing new policy, guidance and data. The objective is to develop and implement effective, efficient and economically viable climate change mitigation and adaptation measures.

c) Implementation of Renewable Energy Development Strategy that aims to increase the share of small scale renewable energy to 30% of total energy consumption by 2030.

[17] Calculated using the IPCCC SAR GWP of 310 for N2O and 21 for CH4 in line with Lao's SNC. IPCC AR5 has revised this figure to 298 and 34 respectively. $GgCO_2e$ = Gigagram CO2 equivalent.

VI. GHG Mitigation Response and Reduction Benefit Assessment

(i) Approach for computing GHG emissions. The GHG emissions are calculated using the latest IPCC guidelines (2006 version) for national GHG inventories and GHG emission mitigation assessments. The global warming potential (GWP) used are from the IPCC SAR report and are 21 and 310 for CH_4 and N_2O relative to CO_2 for a 100-year period. These warming potentials are revised by the IPCC's fifth assessment report to 34 and 298 respectively. The IPCC values of SAR have been used to remain consistent with Lao PDR's official reporting to the UNFCCC.

(ii) Project related emissions. (See SPS 2009)

Project related emissions include energy usage, vehicle and machinery emissions. There is however no activity data available on these sources and it is therefore not possible to estimate the project related emissions ex-ante.

(iii) Mitigation Measures in the project.

- Improved agricultural practices which emphasize increase in organic/carbon constituents in soils, and promotion of energy efficiency concepts, such as:
- The judicious use of organic fertilizers;
- Zero tillage to reduce carbon emissions from the soil;
- Upgrading of medium scale rice mill infrastructure with service provision to farmers to improve rice recovery rates amongst other activities; and
- Train 30,000 farmers, including 10,000 women and 3,000 ethnic group members on CSA, organic farming and agribusiness skills.

(iv) Direct GHG emission reduction (t CO_2 e):

Two mitigation measures estimates could be made on the emission reductions. Since this is a sector project and it is not known beforehand the reach of the project, the emission reductions have been calculated on a per unit basis. During project implementation, the exact emission reductions can be estimated by multiplying the impact with the calculated units.

a. Rice recovery rate increase: The project aims to increase average recovery rate of milled rice to 62% (2017 baseline = 55%). This improvement in efficiency will reduce the GHG emission footprint per unit of rice consumed by (1-65/55) 18%. The average per hectare emissions are 137.6 $GgCH_4$ in 2000 and with production figure of 1.8 million ton of rice in 2000[18], the per kg rice emission factor is 1.6 kg CO_2/kg. The project will reduce the per kg GHG emission intensity of rice by 18% or to 0.288 $kgCO_2$ /kg rice. The emission reduction in tCO_2 in year y can calculated by: Throughput of improved mills (in ton rice in year y) * 0.288.

b. Increase usage of biofertilizers

Increased production and application of biofertilizers will reduce emissions if this results in reduced use of chemical fertilizers. The application of biofertilizers, based on an equivalent of N/hectare does not result in emission reductions as per IPCC Tier 1 approach. The default emission factor is 0.01 kg N2O-N/kg N irrespective of the source of nitrogen. Field trials have indicated however that this is not the case when nitrogen is fixed organically, as it is in the case

[18] FAO. Special Report: FAO/WFP Crop and Food Supply Assessment Mission to Lao People's Democratic Republic. http://www.fao.org/docrep/004/x9978e/x9978e00.htm#P49_9751

of biofertilizers, and emissions can be up to 67% lower.[19] This result however depends on many variables and this should be assessed during the project implementation.

c. Fertilizer production

The production of chemical fertilizer is fossil fuel intensive. The EU fertilizer group has estimated the emission related to the production of various fertilizers at factory gate and these are shown below.[20]

MINERAL FERTILIZER CARBON FOOTPRINT REFERENCE VALUES: 2011

			GHG emissions (GWP 100 yrs: IPCC, 2007)							
Fertilizer product		Nutrient content	Fertilizer production	Fertilizer use (soil effects)					Fertilizer production + use	
			At plant gate	CO_2 from urea hydrolysis	Direct N_2O from use	Indirect N_2O via NH_3	Indirect N_2O via NO_3^-	CO_2 from liming and CAN	Total	Total
			kg CO_2-eq/ kg product						kg CO_2-eq/kg product	kg CO_2-eq/kg nutrient
Ammonium nitrate	AN	33.5% N	1.18	0.00	1.26	0.01	0.35	0.27	3.06	9.14
Calcium ammonium nitrate	CAN	27% N	1.00	0.00	0.89	0.01	0.28	0.20	2.40	8.88
Ammonium nitrosulphate	ANS	26% N, 14% S	0.83	0.00	1.10	0.02	0.27	0.40	2.62	10.09
Calcium nitrate	CN	15.5% N	0.68	0.00	0.65	0.00	0.16	0.00	1.50	9.67
Ammonium sulphate	AS	21% N, 24% S	0.58	0.00	0.98	0.02	0.22	0.50	2.30	10.95
Ammonium phosphates	DAP	18% N, 46% P_2O_5	0.73	0.00	0.76	0.01	0.19	0.34	2.03	11.27
Urea	Urea	46% N	0.91	0.73	2.37	0.28	0.48	0.36	5.15	11.19
Urea ammonium nitrate	UAN	30% N	0.82	0.25	1.40	0.10	0.32	0.24	3.13	10.43
NPK 15-15-15	NPK	15% N, 15% P_2O_5, 15% K_2O	0.76	0.00	0.56	0.01	0.16	0.12	1.61	10.71
Triple superphosphate	TSP	48% P_2O_5	0.26	0.00	0.00	0.00	0.00	0.01	0.27	0.56
Muriate of potash	MOP	60% K_2O	0.25	0.00	0.00	0.00	0.00	0.00	0.25	0.43

Emission reductions from reduced use of mineral fertilizer can be calculated by adding up the following emissions sources from the table above:

Fertilizer production (ton)+ CO2 from Urea hydrolysis + CO2 from liming

This excludes the emissions from the application which are as per IPCC 2006 guidance similar between biofertilizer and mineral fertilizer per unit of N. In case the fertilizer regime changes, i.e. less nitrogen is applied to the soil, also emission reductions from the application can be included.

Urea hydrolysis is the release of CO_2 that was fixed during the industrial production process. The emission factor is 0.20 CO_2-C/kg or 0.73 tCO_2/kg Urea when adjusted for the molecule/atom weight of CO2 and C respectively (44/12) (IPCC 2006). In the case of urea ammonium nitrate this is 0.25.

In the case of urea, savings associated with displacing it with biofertilizers can be calculated with the following equation:

CO2 emissions (tCO2) in year y= Amount of urea used in year y (ton) * EF (0.73 for UREA and 0.25 for urea ammonium nitrate); similar to the table above.

(**v) Indirect GHG emission reduction (t CO_2 e):**

Indirect sources of GHG emission are from running off and leaching of nitrogen fertilizer. These emissions however are, as per IPCC 2006 guidelines, the same for bio-fertilizers and mineral fertilizers per unit of N. Depending on the type of biofertilizer applied, the regime and the method, run-off may decrease. This should be assessed during the project implementation.

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[19] ADB. 2015. *Organic Agriculture and Post-2015 Development Goals: Building on the Comparative Advantage of Poor Farmers.* Manila.

[20] Fertilizers Europe. http://www.fertilizerseurope.com/.

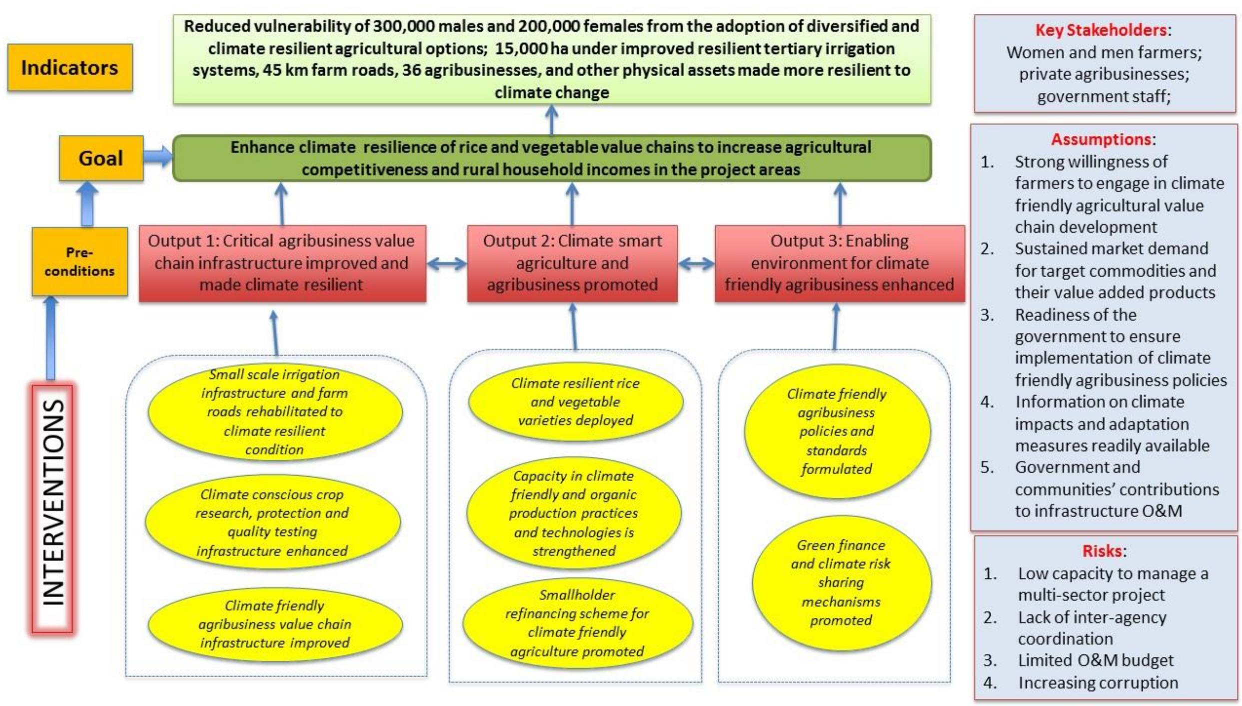
The project will therefore promote reduction of project-related anthropogenic greenhouse gas emissions in multiple ways.

VII. Concluding Remarks

Lao PDR is highly vulnerable to impacts of climate change because of low adaptive capacity of its population and heavy reliance of its economy on climate-sensitive sectors such as agriculture and water resources. Climate change projections to 2050 suggest increasing mean temperatures of 2-3°C and highly variable precipitation patterns leading to increased frequency and intensity of droughts and floods. Agriculture, which employs 65% of the working population in Lao PDR, is the most vulnerable sector to climate change. Upland farming systems are expected to see yield reductions and increasing rates of erosion, while lowland crop areas will face higher incidences of floods and associated damages. Without adaptation, the suitability and financial viability of cropping systems could be called into question in the long run. In this context, Lao PDR's Intended Nationally Determined Contribution (INDC) in 2015 clearly notes vulnerability of its agricultural sector to climate change and focuses on two main objectives: i) to promote climate resilience in farming systems and agriculture infrastructure, and ii) to improve appropriate resilient agricultural farming system practices and technologies to address climate change impacts. The limitation of existing, or nonexistence, of adaptation strategies will increase the vulnerability of rural livelihoods and lead to food insecurity. Investing in climate smart and sustainable agribusiness value chain infrastructure coupled with targeted policy support and capacity strengthening is vital.

Impact of these investments at a national level will take time but the CFAVC project contribution will be significant.

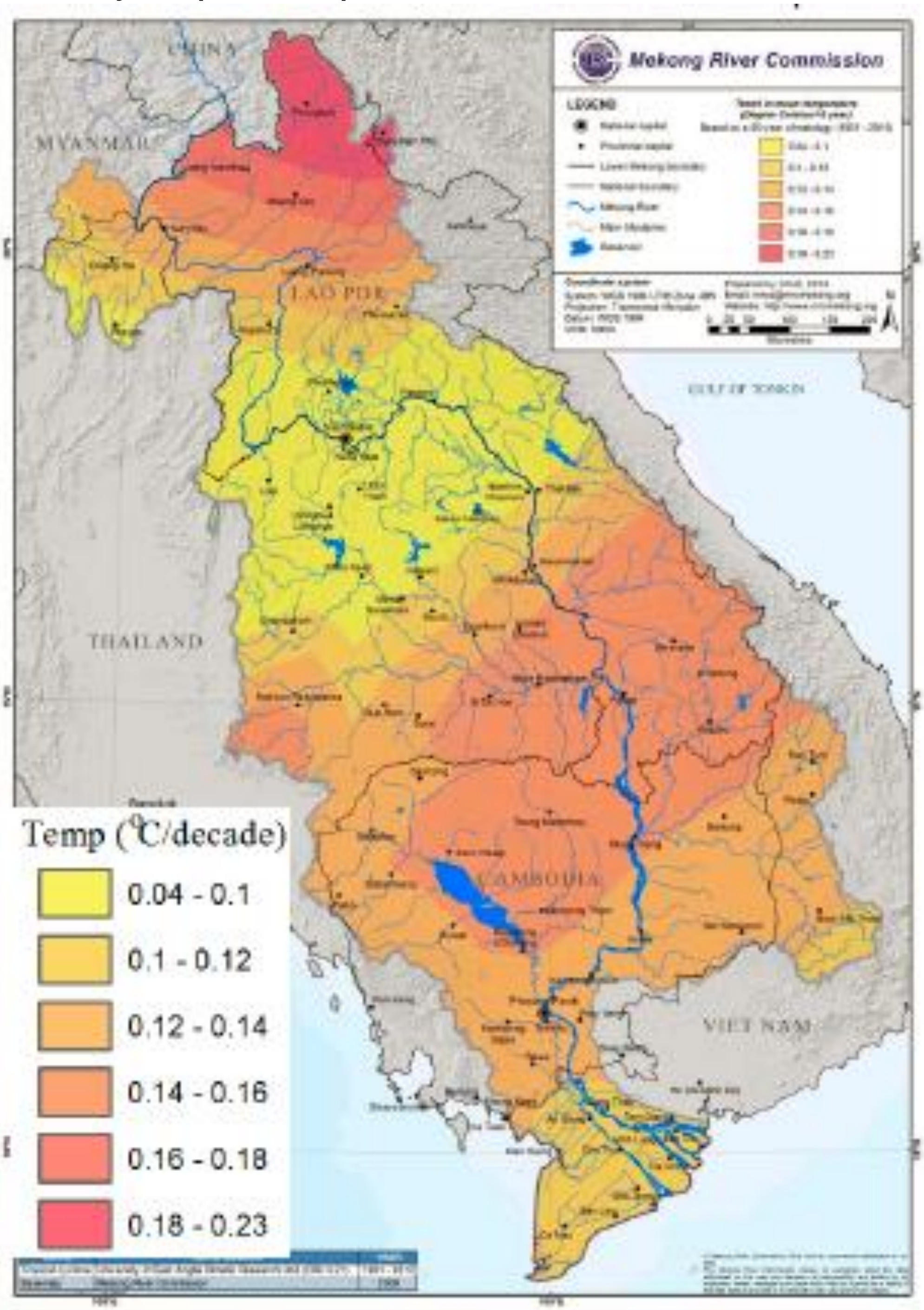
Theory of Change for the Climate-friendly agribusiness value chains sector project



Annex 1: Maps and Figures of climate change trends and projections in Lao PDR

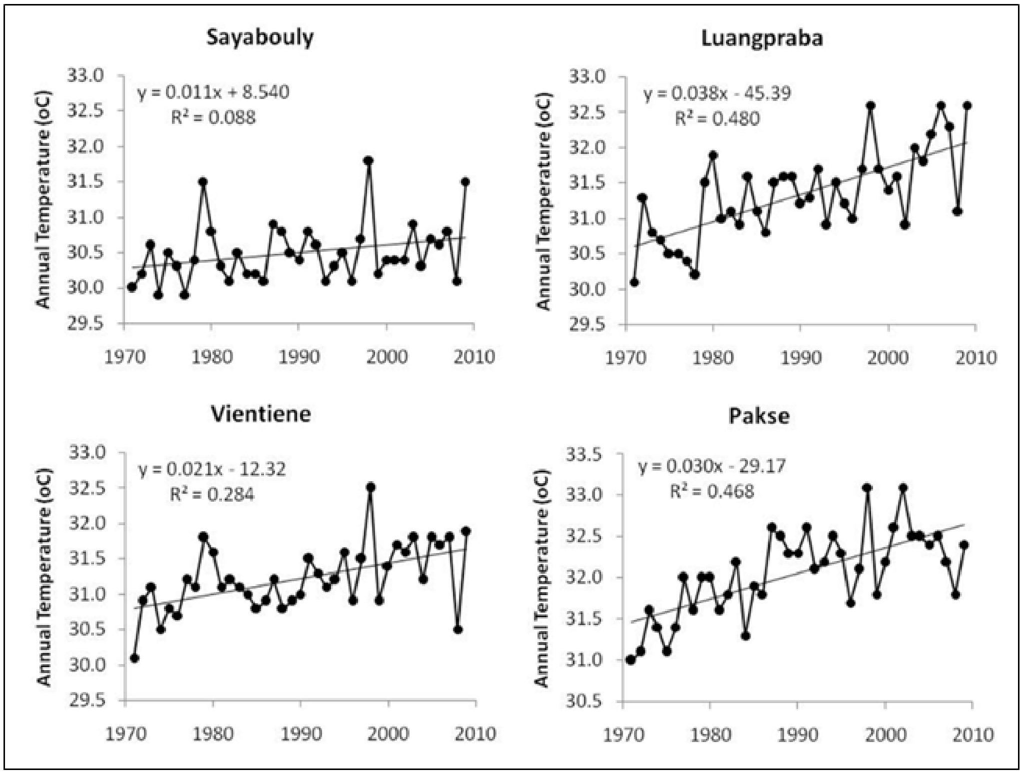
The following series of nine maps and accompanying tables illustrate current data projections for climate change.

Figure 1: Change of Temperature in the Lower Mekong Basin in the last 60 years (1951- 2010)



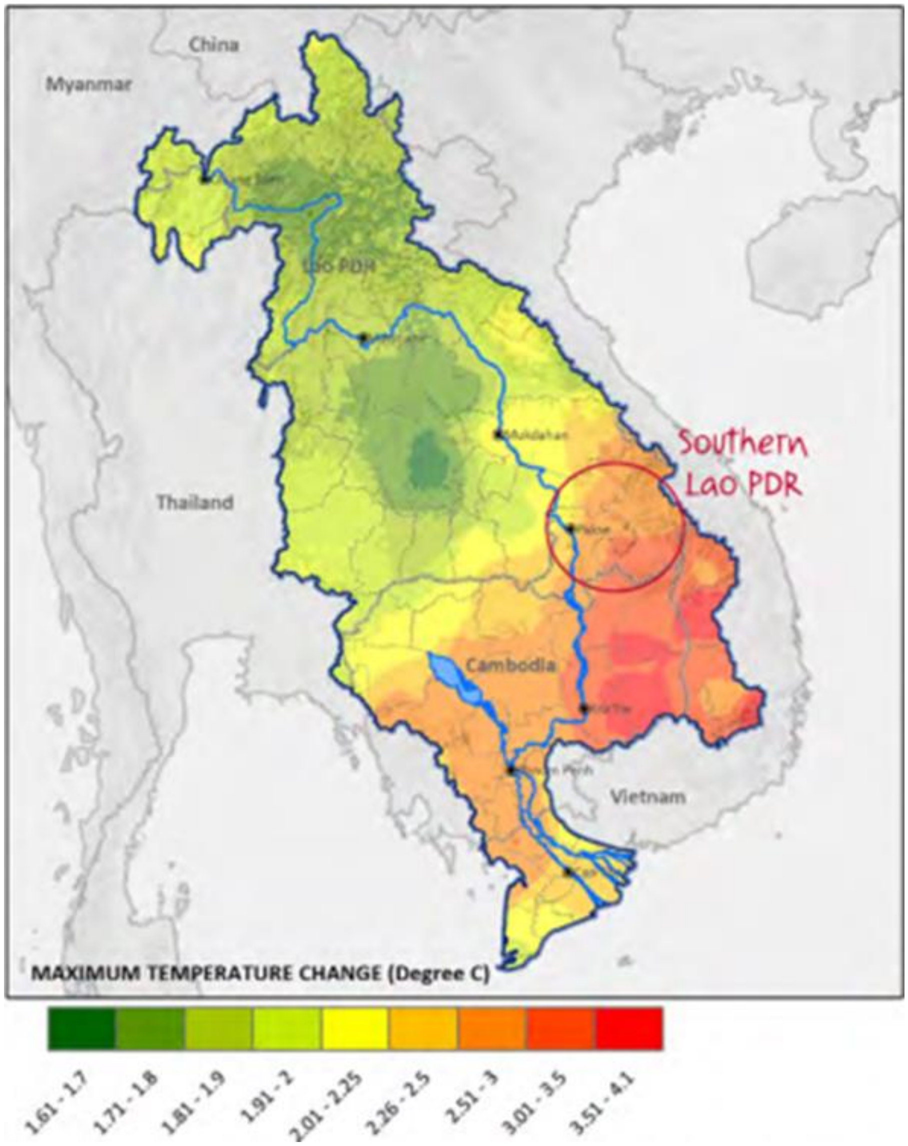
Source: Mekong River Commission, 2010.

Figure 2: Temperature Trends in Lao Provinces, 1970-2010



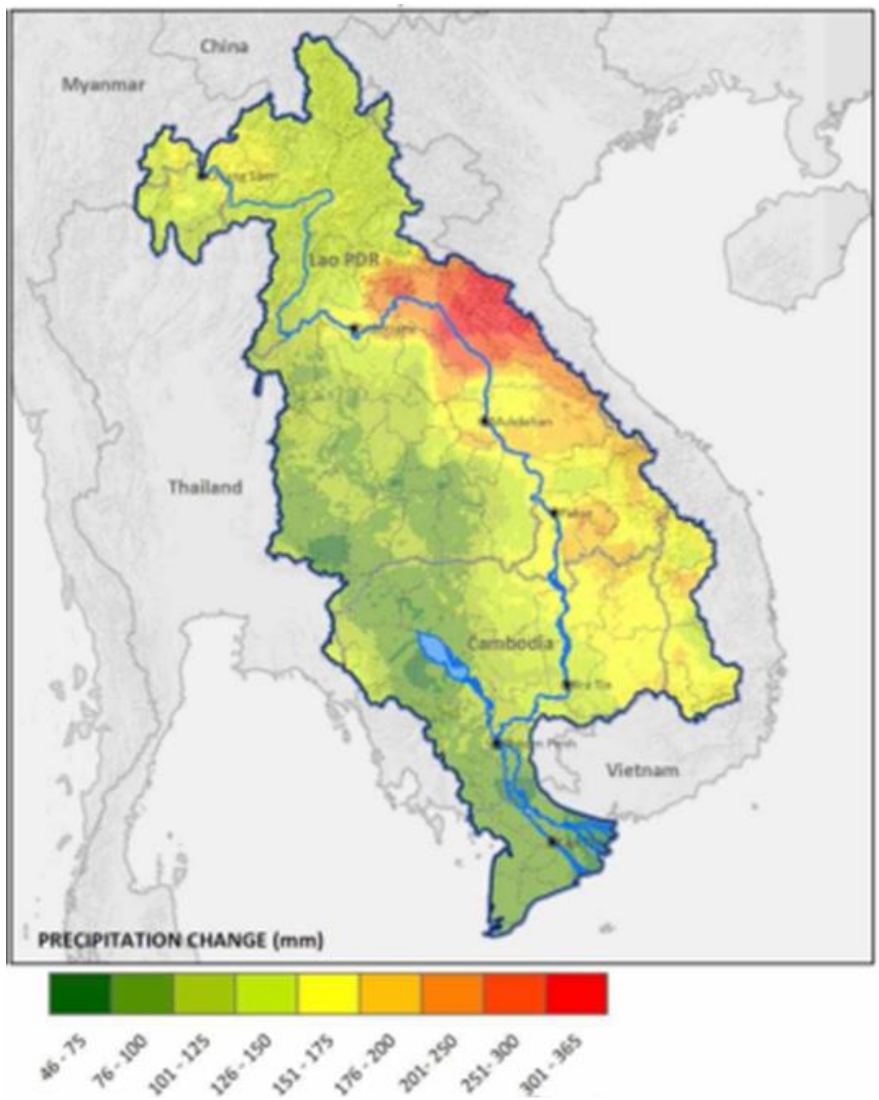
Source: The Second National Communication on Climate Change of Lao PDR, 2013

Figure 3: Projected annual average maximum daily temperature changes in the Lower Mekong Basin between 2005 and 2050



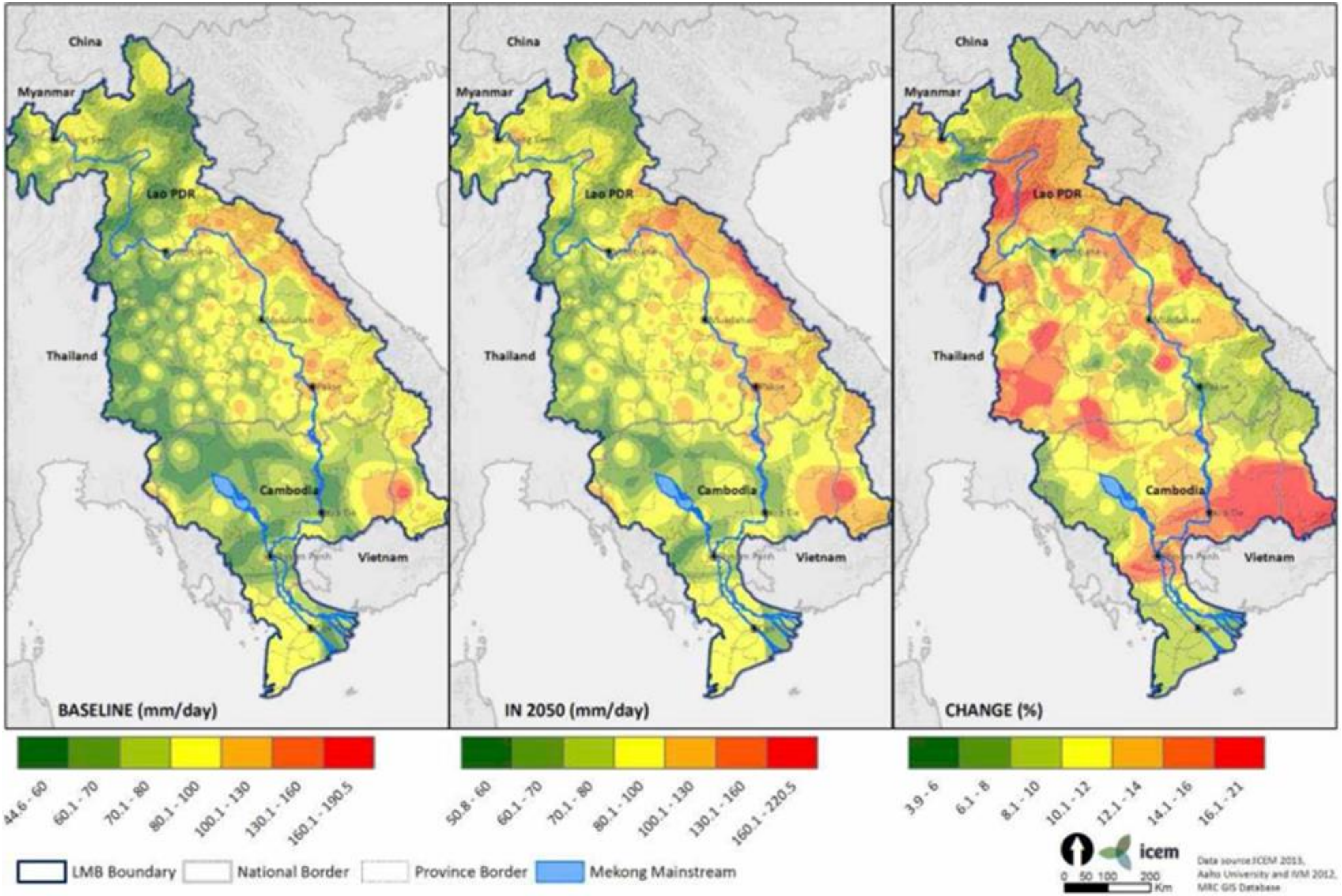
Source: Mekong ARCC Main Report, 2014.

Figure 4: Projected annual average maximum daily precipitation changes in the Lower Mekong Basin between 2005 and 2050



Source: Mekong ARCC Main Report, 2014.

Figure 5: Projected increases in peak daily precipitation for the Lower Mekong Basin



Source: Mekong ARCC Main Report, 2014.