MEKONG RIVER COMMISSION

THE COUNCIL STUDY

The Study on the Sustainable Management and Development of the Mekong River Basin, including Impacts of Mainstream Hydropower Projects

Social-Economic Impact Assessment

(Final)

Prepared by: Council Study Socio-Economic Team

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Abbreviations and acronyms

AIP	:	Agriculture and Irrigation Programme (of the MRC)
BDP	:	Basin Development Plan
BDP2	:	BDP Programme, phase 2 (2006 –10)
BDS	:	(IWRM-based) Basin Development Strategy
BioRA	:	Biological resource assessment team (under Council Study)
CCAI	:	Climate Change and Adaptation Initiative (of the MRC)
CIA	:	Cumulative Impact Assessment
CNMC	:	Cambodia National Mekong Committee
CS	:	Council Study
DMP	:	Drought Management Programme (of the MRC)
EP	:	Environment Programme (of the MRC)
FAO	:	Food and Agriculture Organisation
FMMP	:	Flood Mitigation and Management Programme (of the MRC)
FP	:	Fisheries Programme (of the MRC)
HH	:	Household
IBFM	:	Integrated Basin Flow Management (MRC study)
IFAD	:	International Fund for Agricultural Development
IKMP	:	Information and Knowledge Management Programme (of the MRC)
ILO	:	International Labour Organisation
IWRM	:	Integrated Water Resources Management
ISH	:	Initiative for Sustainable Hydropower (of the MRC)
JC	:	Joint Committee (of the MRC)
LMB	:	Lower Mekong Basin
LNMC	:	Lao National Mekong Committee
M&E	:	Monitoring and evaluation
MRC	:	Mekong River Commission
MRCS	:	Mekong River Commission Secretariat
MRC-SP	:	MRC Strategic Plan
NMC	:	National Mekong Committee
NMCS	:	National Mekong Committee Secretariat
NAP	:	Navigation Programme (of the MRC)
PMFM	:	Procedures for Maintenance of Flow on the Mainstream
PWUM	:	Procedures for Water Use Monitoring
SEDB	:	Socio-economic database (of the MRC)

SIMVA	:	Social impact Monitoring and Vulnerability Assessment (conducted by MRCS)
SoB	:	State of Basin report (of the MRC)
SocEc	:	Social Assessment team (of the Council Study)
TCU	:	Technical Coordination Unit (of the MRCS)
TNMC	:	Thai National Mekong Committee
UMB	:	Upper Mekong Basin
UN	:	United Nations
UNDP	:	United Nations Development Programme
VNMC	:	Viet Nam National Mekong Committee

1 Executive Summary

The social and economic assessment reports the results of the estimated consequences of the proposed development scenarios constructed for the Mekong River Basin corridor under the MRC Council Study. The analytical outputs are intended to inform the social and economic factors specific to each of the Thematic Teams engaged in the Council Study and provide data inputs for the Macroeconomic and Cumulative Impact Assessments of the Council Study.

The social and economic assessment report takes as its primary guidance the Inception Report of the Council Study and the ongoing comments and review provided by the MRC Member Countries' Technical Working Groups and National Committees. Discussions and individual consultations with members of the Thematic and Discipline teams of the Council Study (CS) have been integral factors in the overall design of the social and economic assessment.

A primary objective of the socio-economic assessment was the estimation of changes in social and economic conditions within the Lower Mekong Basin (LMB) associated with i) the three main water development scenarios and 13 sub-scenarios considered in the CS and ii) the socio-economic conditions associated with exogenous, or non-water development, factors and iii) estimated changes in socio-economic conditions expressed as a revised suite of socio-economic assessment indicators.

The three water development scenarios comprise: (i) the M1 2007 early development scenario, (ii) the 2020 M2 definite future scenario, (iii) and the 2040 M3 planned development scenario. The M1 scenario represents the 2007 baseline conditions and the reference conditions and attributes by which the other Council Study development scenarios are compared. The 2020 Definite Future Scenario (M2) includes all existing, under-construction, and firmly committed development in the six sectors which are expected to be in place by 2020. The 2040 Planned Development Scenario (M3) includes water resource developments, in addition to the M2 scenario, that are planned in the six sectors in the Mekong Basin and that would be in place in 2040 if fully implemented. The sub-scenarios address changes predicted by the CS Thematic teams to occur over a 24-year projection horizon. The changes focus on:

- Irrigated agriculture;
- Agriculture and land use change;
- Domestic and Industrial water use;
- Flood protection and management;
- Hydropower generation; and
- Mainstream navigation.

The M1, M2, M3 and M3CC main scenarios combine bundles of developments and investments to assess cumulative effects. Assessing cumulative effects has the advantage of accounting for synergistic effects in cases where outcomes of the combined effects differ compared to the sum of individual interventions. The assessment of larger bundles of investments does not however allow for the conclusive attribution of outcomes to either individual or combinations of individual investments. The Council Study (CS) introduced a set of thirteen sub-scenarios to assess the sector-specific variation of the M3 main scenario (as planned for 2040) to disaggregate the investment bundles of the main scenarios, improve the specificity of analysis and attribution of outcomes to specific investments and sector developments. That is comparisons were made when individual investments were switched on or off. The CS design logic focused on the comparison of the M3 main

scenario with all sub-scenarios to reveal the difference particular sector investment are likely to make. Each of the CS sectors are comprised of multiple projects and investments. The sub-scenario analysis assessment does not allow for project-specific attribution of outcomes and impacts. Additional disaggregation would require an assessment of individual projects (e.g. a specific hydropower dam or irrigation scheme) enabling a less granular assessment and the formulation more precise development strategies.

The attributes of the CS scenarios are based on recorded hydrological data from 1985-2008. The predictions of change estimated for the scenarios therefore rely on the same 24-year prediction horizon, regardless of the commencement year and independent of the level of development imposed on the Mekong River system.

The 13 corridor zones defined in the MRC SIMVA (2015) survey represent the primary spatial unit to establish the baseline conditions of the M1 scenario. The three primary regions assessed for the Council Study are i) the 15 km corridor on both sides of the mainstream from the Chinese border to Kratie (Cambodia) and continuing from Kratie to the Viet Nam border ii) the Cambodia Floodplains including the Tonle Sap River and Great Lake and iii) the Mekong Delta in Viet Nam.

The social and economic assessment considers changes in a suite of indicator dimensions in response to the development scenarios. Five dimensions comprise the strategic indicator of Living conditions and well-being defined by the four Member Countries. These are:

- **Water security** – *relating to access to safe water supplies, water availability for domestic and agricultural use and flood exposure; effects of floods and drought.*
- **Food security** – *relating to the ability to meet Recommended Daily Intakes (RDI) of) food grain (the primary source of Kcal/day/capita), protein and fat requirements through home production; and the ability to purchase food; proportion of the population undernourished and child wasting.*
- **Income security** – *relating to and having sufficient monthly income; diversity of employment and/or having sufficient income to pay for food and necessities; proportions of population below national poverty lines.*
- **Health security** – *relating to access to safe water, safe sanitation and access to health facilities.*
- **Energy security** – *the % of the rural population with access to electricity*

Two additional strategic indicators were later addendums to the social and economic assessment:

- **Employment** – *relating to the proportion of employment measured as Full Time Employment in MRC-related sectors; and*
- **Gender equity** - *relating to the favourable equity conditions brought about by achieving water, food, income and health security.*

Two critical factors were required to effectively conduct the Council Study social impact assessment. First, data needed to be either specific to the corridor zones, ideally as time series to reflect the 24-year projection horizon, or could be reliably interpolated from recognized national and international datasets. Second, the analytical variables and parameters needed to have a direct relationship to the Discipline and Thematic Team analyses to detect differences in the social and economic indicators between the Development scenarios and provide useful outputs for further Thematic Team analyses. Methods and tools were developed to conduct the food security, income security, employment security and the drought and flood indicators of water security. These are detailed in the Annex and are available to the Member Countries. Energy security, health security the access to safe water were constrained by one or both of these factors and assessment relied on historical trend analysis and survey data.

Main findings

In addition to it's iconic value, the Mekong River corridor as defined by the MRC is central to the social, cultural, ecological and economic status of the riparian countries. In conducting the Council Study, the near absence of social and economic data and information specific to the corridor and the 13 bio-zones has been evident. Two surveys have been conducted by the MRC that represent point data in time, although the differing survey focus and spatial boundaries limits their use as a panel data set. The data deficit severely limits the ability for National decision makers to understand the rapid and connected changes occurring in the Corridor and detect and manage points of effective intervention. **The riparian Member Countries could treat the Corridor as a defined administrative boundary, as part of their formal data collection activities, in addition to and complementing traditional census and natural resource management boundaries (Provinces, districts, eco-zones).**

Gender

Gender issues are relevant to water resource developments as women are more vulnerable than men during flood and drought due to their higher dependence on natural resources and the social barriers thought to limit their adaptive capacity. The lower median incomes of women compared to men vary from 22% in the Cambodian zones, 4% in Lao PDR, 14% in Thailand and 45% in Viet Nam. The equivalent dollar value of the subsistence incomes of women are from 3-5% higher than male counterparts. The incidence of women in the primary sector having incomes below national poverty lines is significantly higher than males except Lao PDR, varying by 12% in Cambodia, 4.6% in Thailand and 17% in Viet Nam. National aspirations of gender equity are generally not reflected in the Council Study assessment and indicate a need for sustained efforts to correct the imbalance.

Notably the MRC Social impact and vulnerability assessments (SIMVA) did not treat gender as a specific survey dimension and data class. **A central recommendation of the social and economic assessment is the future investigation of the status of gender equity in the corridor and the vulnerability and opportunities for women be undertaken by the MRC to correct this important omission.**

Capacity to maintain food security

Increasing food security is a priority for the Member Countries, particularly important to Cambodia and Lao PDR to graduate from LDC status. The analyses indicate that policies and initiatives to manage the potential for reduced food security will be one the most important deliberations to be undertaken by Member Country Governments. The analyses also highlight the interdependency between food water and energy security and the imperative for cross sectoral, collaborative decision making.

Differences between the M1 and main development scenarios revealed by the food security analysis are an indication of the main development scenario effects on fish and rice production and subsequent effects on food security. Daily food security/per capita needs for 100% of the population were kept constant across all development scenarios and the production surplus calculated as a measure of a countries capacity to meet predicted food shortfalls and maintain accepted levels of food security. The comparative aggregate reductions in surplus fish production after meeting food security across all corridor zones compared to the M1 baseline (year24) were summarized as reductions of:

M1-M2= -32%
M1-M3 = -43%
M1-M3CC = -40%

Aggregate fish surplus was estimated to be sufficient to provide essential protein and micronutrients for the corridor population, but subject to substantial regional variation and distributional factors.

Fish reductions were especially acute across all development scenarios in Lao PDR and Cambodia. Compared to the M1 baseline, the comparative aggregate increases in surplus rice production after meeting food security across all corridor zones were:

M1-M2= +6%
M1-M3 = +16%
M1-M3CC = +13%

Capacity to maintain food security, measured as food surpluses, declines in Lao PDR and Cambodia and remains relatively stable in Thailand and Viet Nam for the M2 and M3 development scenarios. The production of both rice and fish varies substantially across the 24-year projection horizon. EMRF **There is sufficient overall production and surplus in the Corridor to maintain 100% food security, but will require effective, willing distribution networks and cooperation of Member Countries to avoid significant increases in undernourishment.**

Increases in aquaculture production are likely to substitute protein deficiencies. Fish prices are likely to increase as fish catch declines, introducing an incentive to convert land to aquaculture. **Vigilance regarding the management of economic, social and environmental impacts of expanded aquaculture is recommended.** Current aquaculture production is capital and labour intensive and associated with widespread use of antibiotics, reductions in water quality and possibly water quantity due to the cumulative effect of dam impoundments.

Undernourishment as a measure of food security

The change in the level of household undernourishment was assessed according to the change in available rice production, which increases in M2 and M3, and fish production, which decreases. The number of undernourished people in Cambodia and Lao PDR increased in the M2 and M3 scenarios compared to the 2007 baseline, decreased in Thailand and remained relatively stable in the Viet Nam Delta. Reducing the level of hydropower development only (the H1a sub-scenario) improved the levels of undernourishment in Cambodia, Lao PDR and the Viet Nam Delta. Undernourishment generally increased due to the effects of climate change. Analysis of wasting in children under 5 could not be conducted due to very constrained data. **Child morbidity is an important indicator of food status and poverty. A concerted effort to improve the collection and availability of reliable data for the corridor is recommended.**

Consideration of the irrigation and land use scenarios suggests the reduction in fish catch is the primary factor in the change in undernourishment levels. A reduction of 380 tonnes of fish was estimated to correspond with an additional 1000 households defined as undernourished. An increase of 1250 tonnes of rice reduces the number of undernourished households by 1000.

Poverty

Poverty levels were measured as the proportion of people below national lines poverty lines. The changes in poverty levels across scenario comparison were not uniformly distributed both geographically and across the development scenarios. The M1 scenario corresponds to the lowest levels of poverty for all zones except 3C Thailand, 5B Cambodia and 6B Viet Nam. Poverty decreased in Lao PDR and Thailand, increased in Cambodia and remained relatively stable in the Viet Nam Delta. The latter are characterized by less than 0.2% difference across the scenarios. The highest levels of poverty were observed in the comparison of the M1 and M3 and M3CC scenarios, where poverty increases for Lao PDR were estimated at 1.7-3.7%. The increases in Cambodia ranged from -0.01% to 2.0%. Changes in Thailand and Viet Nam were estimated at less than 1%. The M3CC scenario corresponds to the lowest level of poverty for the 4A Cambodia zone.

Water security

Droughts and floods

The 1995-96 El Niño and 2000-2001 floods correspond to 2015-2017 and 2022-2024 of the projection horizon of the Council Study. The number of total people affected in a severe drought year ranged from M1: 700,527; M2: 745,593 and M3: 5387,288. The increase in the M2 scenario reflects the increase in some rainfed production and subsequent increase in the number of people with rice based livelihoods. The population estimated to be affected by the drought represents M1: 3.4%, M2: 3.3% and M3: 2.6% of the total corridor population in 2000 compared with 2003.

Rice production of a year in the CS projection horizon that corresponds with the 2000-2001 floods was compared with a non-flood year. The total number of people with rice based livelihoods affected in the corridor was estimated at 1,137,264 in the M1 development scenario, M2: 1,232,452 and M3: 818,887. The affected population represents M1: 4.8%, M2: 5.23% and M3: 3.5% of the total corridor population in 2000 compared with 2003.

The effects of flooding were not uniformly distributed across the corridor zones. The majority of affected people with rice based livelihoods were located in the Kratie to the Viet Nam Border (634,412 people) and the Tonle Sap River (419,376 people). Compared to the 2000 flood year, rice based livelihoods increased in the non-flood year by 50% and 105% in the Katie to the Vietnam border and Tonle Sap River zones respectively.

The social and economic assessment of the 1995-96 drought and 2000-2001 flood estimated a 10-11% decrease in rice production due to flood corresponds to 4.5-5% of the corridor population being affected; an 11% decrease in rice production due to drought corresponds to 3.1-3.3% % affected.

A drought similar in severity to the 1995-96 or 2015 El Niño or the 2000 flood coinciding with years of significant fish declines introduces the prospect of acute food shortages and reduced food security throughout the corridor, particularly Lao PDR and Cambodia. The analyses conducted by the CS BioRA and Modelling Teams indicate this is likely in at least four years of the 24-year projection horizon. Culturally, Corridor households are less well adapted to severe droughts compared to the natural flooding cycle including low to moderate floods. **Cross sectoral and transboundary planning with a focus on effective distribution systems will be necessary to avert the consequences of the fish-rice-drought-flood coincidence, which are likely to more acute in M2 and M3 scenarios.**

Access to potable water

Access to safe drinking water in rural communities has improved substantially in Lao PDR and Cambodia. Household access in Thailand and Viet Nam is close to 100%. Developing functional relationships between drinking water access and the attributes of the development scenarios is constrained by a deficit of time series data specific to the corridor. The national trends of improved rural water access to safe drinking water were assumed to continue and be independent of the development scenarios. However, MRC corridor surveys conducted in 2014 indicate the quality of water supply varies widely across the LMB.

River water used for drinking water is most frequent in Cambodia and Lao PDR. In terms of inputs to MRC activities, the finding that river water is extensively used for drinking water points to the importance of water quality monitoring. **Recommendations from SIMVA (2015) include developing an inventory of drinking water extraction sites from the Mekong** would be a worthwhile exercise that could more precisely identify critical spots where potable water quality is most important. Current Mekong water quality meets MRC guidelines. The Domestic and Industrial Water Theme recommends **vigilance in water quality monitoring, especially Total Suspended Solids as urbanization, industrial waste water and untreated sewage discharge increases**.

Energy security

Electricity as part of the rural energy mix is one of the most important factors for economic growth and human development. Energy access as a means for productive use is of key importance for rural communities to improve livelihoods and for the opportunities created. There are also strong linkages between rural poverty and electrification rates. The indicators for CS Energy Security are the proportion of the rural population with access to electricity and rural electricity pricing. As of 2014-2025 rural electrification in Thailand was 100%, 98.9% in Viet Nam, Thailand 58% in Cambodia (possibly as high as 68% EDC pers. comm.) and 68.1 % in Lao PDR. Available data are generally at national and provincial level and not specific to the corridor zones however. As Thailand and Viet Nam are at or close to 100% of electricity access, the social and economy assessment focused on the corridor zones in Cambodia and Lao PDR.

Electricity fees are charged as block tariffs in Lao PDR from 4c-12c/kWh. Tariffs in Cambodia are currently 9c-17c/kWh. Both the Lao PDR Government and the Royal Government of Cambodia have planned rural electrification of 90% and 70% national connection by 2030 respectively, comprised of grid and off-grid (renewable) supply. Mini-hydro, solar and biofuels are identified as important parts of the energy mix for rural communities in both Lao PDR and Cambodia.

The mix of renewable and grid electrification, funding from sources such as the Global Environment Fund, the ADB and World Bank and ongoing institutional support are likely to have a far greater influence on rural electrification than the investments proposed in the CS development scenarios. The increasing national trends from 2000 to 2015 projected to 2024 indicate the rates of rural electrification are likely continue independently of the CS development scenarios.

Employment

The M1 comparison across the 24-year time horizon indicates, that at current levels of agricultural productivity, there are substantial increases in the secondary, tertiary and navigation sectors and relatively modest increases in the primary sector across the majority of corridor zones. That is, projected increases in the working population over the 24-year project time horizon are sufficient to meet potential labour demands associated with expanding secondary, tertiary and navigation sectors.

The assessment of sector employment across the development scenarios indicates a potential shortfall in meeting the labour demands required for planned agricultural expansion and increases in the secondary and tertiary sectors in the M2 and M3 development scenarios. Viet Nam is less affected as there is no agricultural expansion planned in the development scenarios.

Resolution within the constraints of the CS, requires either i) agricultural productivity to increase in the order of 30-35% in Lao PDR and Cambodia, ii) reducing the level of either agricultural expansion, industry or both, or iii) increased reliance on migrant labour. Corridor surveys indicate 5-15% of the corridor population are working away from their home village, although migration was a less preferred alternative livelihood adaptations. This a complex issue involving the assessment of multiple interacting factors, including changes in wages, labour conditions, increasing foreign investment, cultural norms, institutional settings and migration patterns. These apply to conditions both within and outside the corridor zones.

National economic planning for the four member countries focuses on jointly expanding the agricultural, manufacturing and service sectors of their respective national economies. These are capital and labour intensive. The joint agricultural and secondary sector expansionary strategies potentially introduce conflicting labour demands in the M2 and M3 scenarios introducing the potential of stranded and underutilized infrastructure. Developing a dynamic modelling approach capable of the joint inclusion of these factors, including migration patterns, is recommended as a central feature of trans-boundary planning.

Household incomes

Households in the Lower Mekong undertake a diversity of concurrent livelihood activities expressed as multiple income sources. Undertaking a diversity of livelihoods represents a widely implemented risk management strategy for poorer and more vulnerable communities and households where endowments, entitlements and capacities allow.

The BioRA (fish biomass) and IWRM (rice yields and production area) are the primary data inputs to the social and economic assessment, establishing the functional relationships between the employment indicators describing the corridor zones and the CS main development scenarios and sub-scenarios. The estimates of fish and rice production therefore establish the foundation data to estimate the relative proportions of primary, secondary and tertiary sector employment and incomes. Multiplier effects and employment differences in urban centres were not included in the income estimates and year 1 estimates of median wages held constant for comparisons.

The estimated total corridor household income increased by US$ 6.4 billion when comparing year 1 with year 24 of the M1 baseline scenario. The gains in total income occur in the manufacturing sector, which increases by US $7.9 billion offset by primary sector income declines of US$ 1.48 billion.

The estimated M2 scenario total corridor income (year 24) declines by US$ 245 million compared to the M1 baseline. The main losses are in the manufacturing sector (-US$ 439 million) offset by a US$ 194 million gain in the primary sector.

The estimated M3 scenario total corridor household income (year 24) declines by US$ 630 million compared to the M1 baseline. The main income changes are in the manufacturing sector (-US$ 1.5 billion) offset by a US$ 881 million gain in the primary sector. The M2 and M3 scenarios are characterized by substantial declines in fish catch and increases in rice productions across the corridor zone.

Agricultural value

The mean fisheries value of the M2 and M3 scenario (year 1-24) was estimated to decline by US$ 1.04 and US$1.57 billion (-25% and -38% respectively) compared to the M1 baseline. The highest proportion of the decline in value occurs between the M1 and M2 scenarios (US$ 1.04 billion); the additional decline from M2-M3 equals US$0.52 billion or a further decline of 21%.

The mean value of rice production predicted to occur in the M2 and M3 scenarios (year 1-24) increases by US$ 0.34 and US$ 0.95 billion respectively compared to the M1 baseline. The predicted effect of climate change introduces a -6% decline in the value of the M3 scenario or US$ 0.135 billion.

Accounting for **subsistence livelihoods** and production and monetary equivalence is an important measure in substantial, non-market and hybrid agricultural economies such as the Lower Mekong Basin. Monetary poverty measures often fail to reflect the multiple dimensions of poverty and failure to account for subsistence production underestimates the productivity of traditional agricultural systems and contributions to national GDP calculations. The monetized value of subsistence rice production in the corridor was estimated at US$3.3. billion compared to a total value of US$9.75 billion: subsistence fish consumption was estimated at US$5.92 billion compared to a total production value of US$10.03 billion. **Cross sectoral collaboration will be required to assess and mitigate the effect of increasing urbanization on the reliance of households on subsistence production, the effect on livelihoods and the potential reduction in effective household income**.

Health security

The assessment of health and access to safe water for the Council Study relied on the findings of the SIMVA 2015 survey. The noted increases in improved access to safe drinking water and access to improved sanitation are expected to continue throughout the corridor independently of the development scenarios.

Income vulnerability

The reporting of the calculation and analysis of income related vulnerability was an additional indicator developed as part of the cumulative impact assessment. Income vulnerability was defined by a developed metric that classifies vulnerable households as those below the sectoral median income. The metric was developed to answer the question “do the development scenarios affect the numbers of (income) vulnerable people disproportionately across the corridor zones”?

Generally, vulnerability decreases in the Primary sector (that is less vulnerable people are employed) and increases mostly in in the Manufacturing sector, less so in the Service sector, but all zones are affected by both increases and decreases. The analysis revealed a disproportionate and non-uniform distribution of income vulnerability changes (both increases and decreases) across the corridor zones and the set of development scenarios. We caution against causal inference and attribution to the specific investments and initiatives that characterize the Council Study Development scenarios due to omitted key factors likely to influence household decision making and livelihood activities. A decrease or increase in income vulnerability in one sector, zone or country does not necessarily equate to net change in vulnerability within a zone or across the entire Mekong Corridor. **The categorization of income vulnerability points to changes in the corridor zones that warrant further investigation and deliberation regarding distributional equity and planned development trajectories. Although limited by data constraints, the analysis introduces a foundation for ongoing deliberations regarding the management of the Mekong Corridor where the imperatives of entitlement, distributional equity, benefit and cost sharing and procedural fairness are a priority.**

2 Introduction

2.1 Main purpose of this report

The purpose of this report is to present the results of the social and economic assessment the basin-wide development scenarios under the MRC Council Study[1]. The report also updates refinements and revisions of the datasets, methods and analytical tools developed to conduct the assessment. In addition, the analytical outputs are also intended to inform the social and economic factors specific to each of the Thematic Teams engaged in the Council Study and data inputs for the Macroeconomic and Cumulative Impact Assessments of the Council Study.

The report forms part of a larger main report on the "Results for the cumulative impact assessment of water resource development scenarios" to which this report is appended.

The social and economic assessment report takes as its primary guidance the Inception Report of the Council Study[2] and the ongoing comments and review provided by the MRC Member Countries' Technical Working Groups and National Committees. Discussions and individual consultations with members of the Thematic and Discipline teams of the Council Study have been integral factors in the overall design of the social and economic assessment.

The reported results rely on a revised and approved methodological approach described in the February 2017 "Approach and methodology for the socio-economic impact assessment of development scenarios".

2.2 Report contents

The Social and Economic Assessment report has four main sections:

The Council Study water development scenarios

Section 3, Background to the socio-economic assessment , sets out the planned social assessments under the Council Study. The Section also identifies the water resource and relevant exogenous development drivers within the Mekong Basin that need to be taken account of in making the assessments, and discusses the scope of those assessments. The Section concludes with a discussion leading to selection of assessment indicators.

Methods and social and economic indicators

Section 4, Approach and methodology, commences with the objective of the social assessment and an overview of assessment approach. A revised approach for the socio-economic assessment has been developed in consultation with Thematic and Discipline teams and the regional Technical Working Group to address data gaps and deficits. The main components of the socio-economic assessment approach are described, being data assembly and analysis, projecting the social situation in the LMB without water resources development and assessing the impacts with water resources development.

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1 The full title of the MRC Council Study is: "Study on the sustainable management and development of the Mekong River, including impacts of mainstream hydropower projects"

2 Inception Report of the MRC Council Study, Draft Final, 27 October 2014

Projected situation without water resource developments

Section 5 summarizes the estimates of population growth and distribution for the Council Study (CS) corridor zones over the 24-year time horizon, the calculation of food and nutritional security, estimates of livestock, fish (including aquaculture and other aquatic animals), rice production and prices over the 24-year period, the current and future status of water, income and health security for the CS corridor zones and current employment and income estimates. Details can be found in Annex C: trends and data assembly.

Development scenario analysis and Results

Sections 7 and 8 describe the development scenario impact analysis and the analytical results for the CS corridor zones. A description of the social and economic assessment tool and the employment and income tool developed specifically for the Couincil Study are summarized with details provided in the Annex. The results describe the analysis of Food Security (Agricultural production and food consumption) with a primary focus on meeting food security for the entire zone population and the residual food surplus for trade and food security improvement. The developed tools for the Council Study enabled a detailed Development Scenario analysis of the annual variance in rice and fish production over the 24-year period for each zone, the changes in the monetary value of agriculture and fisheries, the level of subsistence consumption compared to total consumption, levels of undernourishment and poverty andincome vulnerability. Detailed analysis of sector employment and incomes for the corridor zones concludes the section. Details of the analytical tools and calculations are provided in Annex B: Assessment Tools.

3 Background to the socio-economic assessment

This Section sets out the background to the socio-economic assessments of the Council Study. Water resource and relevant exogenous development drivers within the Mekong River Basin identified and addressed in the assessments are described. The Section concludes with a discussion of the temporal and spatial scope of the assessments and the corresponding socio-economic assessment indicators.

3.1 Socio-economic assessment in the context of the Council Study

3.1.1 Objectives

The main objectives of the Council Study (CS) are to: (i) further understand the environment, socio-economic impacts (positive and negative) of water resources developments; (ii) enhance the BDP process to support the Member Countries in the sustainable development of the basin; and (iii) promote capacity building, raise awareness and build trust.

A primary objective of the socio-economic assessment is the estimation of changes in social and economic conditions within the Lower Mekong Basin (LMB) associated with i) the three water development scenarios and six sub-scenarios considered in the CS and ii) the socio-economic conditions associated with exogenous, or non-water development, factors. Estimated changes in socio-economic conditions were reliant on a revised suite of socio-economic assessment indicators, originally detailed in the MRC indicator framework.

The Council Study will mainly concentrate on transboundary issues, including the regional distribution of benefits, costs, impacts and risks of basin developments. The results are intended to support cooperation on water resources development and management towards optimal and sustainable development.

The main aim of the development scenario assessment is to provide the MRC member states with an analysis of alternative development strategies, particularly with respect to their economic, social and environmental impacts, to reach a consensus on the key decisions that will shape the future development and management of the water resources within the LMB.

3.2 Structure of the Council Study

In addition to a Cumulative Assessment Team, six Thematic Teams have been established covering the important thematic IWRM sectors and sub sectors that contribute to development in the basin:

(i) **Irrigation** - including water use, return flows, water quality, and proposed diversions;

(ii) **Agriculture and Land use** - including watershed management, deforestation, livestock and aquaculture, and fisheries;

(iii) **Domestic and Industrial water use** - including mining, sediment extraction, waste water disposal, urban development, and water quality;

(iv) **Flood protection** structures and floodplain infrastructure;

(v) **Hydropower** - including potential of alternative energy options;

(vi) **Transportation** - including navigation, infrastructure to aid navigation, and roads on major floodplains.

These Thematic Teams are complemented by five **Discipline Teams** concerned with:

(i) **Climate change** – climate change predictions to be incorporated in the assessments and proposals for adaptation measures to be incorporated in the scenarios where relevant

(ii) **Hydrological, hydrodynamic and water quality modelling** – impacts of the scenarios on mainstream river flows, sediment flows and water quality

(iii) **Bio-resource assessment** – impacts of the scenarios and of the related changes in mainstream river flows, sediment flows and water quality brought about by the scenarios on bio-resources (including capture fisheries) and geomorphological stability of the mainstream system.

(iv) **Socio-Economic assessment**– estimate the macro-economic and social changes of river linked livelihoods and ecosystem services associated with the water development scenarios.

Identification of development drivers

Development impacts within the LMB arise from interventions taken up in the water sector together with those arising from exogenous developments in other sectors.

For the purposes of the cumulative impact assessment (CIA) under the CS, water resource developments are taken as those broadly within MRC's remit. They include irrigated agriculture, agriculture and land use change, flood protection and management, hydropower, mainstream navigation and domestic and industrial water use.

Exogenous developments arise from other development activities which have a bearing on conditions within the basin that affect the magnitude of changes in socio-economic outcomes and consequences caused by water resource developments. Exogenous developments are those developments which can be expected to happen even without water resource development occurring and which necessarily must be factored into the cumulative impact assessment of water resource developments as they affect the magnitude of those impacts[3].

Two exogenous developments have been incorporated into the main scenarios. First, a projected mean trend towards a warmer and wetter climate in 2040 has been included in M3 (M3CC: Table 2). Second, a projected trend of increased human settlements in the floodplains in 2020 and 2040 has been included in M2 and M3.

The advantage of including mean changes in climate and floodplain settlement within the main scenarios is they allow evaluation of the impacts of water resources to be made in the context of likely future changes, arguably more realistic conditions. The limitation of the design is that it is not possible to unambiguously attribute differences between scenarios. For example, when comparing M2 and M3, estimated differences cannot be claimed to have been due to planned development in the water sector between 2020 and 2040, because it may have been caused by differences in assumed climate or changes in land-use in the floodplains. To help overcome this limitation when

[3] To illustrate this point, increasing urbanisation by 2040 may mean there are less people in rural areas who would be affected by changing capture fish availability. Similarly, continued poverty reduction programmes may also mean that by 2040 the proportion of households dependent upon capture fisheries for their livelihoods is less. If both are true, then the impact of any reduction in capture fisheries would be lower in 2040 than if the same reduction were to occur today.

making interpretations, additional sub-scenarios were defined to allow more rigorous comparisons and thus analyses of the effects of different factors on the level of impacts. Taking the developments against each Thematic team as the guideline of what is under the CS, Table 1 sets out how developments are categorized for assessment purposes.

Table 1 Categorization of developments to be considered under the Council Study

Water resource developments *As defined by the CS thematic development scenarios*	**Exogenous developments** *As can be expected to happen with or without water resource developments*
▫ Irrigated agriculture [1] ▫ Agriculture and land use change [2] ▫ Domestic and Industrial water use [3] ▫ Flood protection and management [4] ▫ Hydropower generation [5] ▫ Mainstream navigation [6]	▫ Rainfed agriculture including livestock [2] ▫ Aquaculture [2] ▫ Mining, sand mining and industrial water use discharge [3] ▫ Changes in flood plain land use and asset values including urban sprawl, roads etc. [4] ▫ Capture fisheries and OAAs [BioRA] ▫ Climate change [CCAI] *Exogenous impacts on socio-economic conditions [CIA]:* ▫ Electricity distribution ▫ Poverty reduction support ▫ Externalities, such as remittances etc. ▫ Migration and demographic change ▫ Commodity prices

References given in the table are to Thematic and Discipline teams whose scope of work under the CS is related to these developments

3.3 Council Study Scenarios

The three development scenarios comprise: (i) early development scenario, (ii) definite future scenario, (iii) planned development scenario. The Early Development Scenario (M1 in Table 2) includes the infrastructure and the land cover in the 6 IWRM sectors as of 2007.

The M1 scenario represents the baseline conditions of the Council Study and the reference conditions and attributes by which the other development scenarios are compared.

The CS scenarios are based on recorded hydrological data from 1985-2008. The predictions of change estimated for the scenarios therefore rely on the same 24-year period, or prediction horizon, independent of the level of development imposed on the Mekong River system.

For several of the Thematic and Discipline teams, exogenous factors and impacts are treated as static throughout the 24-year prediction horizon. The Social and Economic assessment departs from a static analysis by predicting changes in for example rural and urban population, agricultural production (rice, fish, livestock) as annual time steps in the 24-year prediction horizon.

The Mekong River is in a state of dynamic flow and sediment equilibrium, with variable changes occurring through time and space, responding to annual or longer term variability (expressed as for example flood and droughts) and trends (for example climate change). The time-horizons of fluvial processes range from daily to hundreds of years, so the geomorphic status of a river at a specific time reflects the interaction of processes occurring over a range of time-horizons. The status of a river at a specific point in time represents a point on a continuum, rather than an end state. The Council Study relies on a 24-year time horizon to represent the observed variance of these fluvial processes. While the hydrological-geomorphic modelling predictions are pragmatically truncated at 24-years, the geomorphic, ecological and social responses to changes in the river's hydrology and

sediment transport can be expected to continue to evolve and alter the status of the river for decades into the future.

The Definite Future Scenario (M2) includes all existing, under-construction, and firmly committed development in the six sectors which are expected to be in place by 2020. The Planned Development Scenario (M3) includes in addition to contents of M2 water resource development that is planned in the six sectors in the Mekong Basin and that would be in place in 2040 if fully implemented.

With the study design in Table 2, comparison between M2 and M1 measures the effects of water resource development between 2007-2020, while comparisons between M3 and M2 estimate the effects of the planned developments between 2020 and 2040 in the context of a climate expected to be warmer and wetter and with expansion of human settlements in the flood plains. Flood protection infrastructure development is not included in the main scenarios for M2 and M3 so that the impacts of changes in flood regimes can be evaluated in the context of other expected changes, in particular expansion of human settlements into floodplains.

The socio-economic assessment estimates the consequences of six sub-scenarios: FPF2, FPF3, IRR1, DIW1, DIW2, and ALU3 (as defined in the Implementation Plan of the Council Study and the Cumulative Impact Assessment Report 2017). The time horizon and primary interventions for each development scenario are summarized in Table 2**.**

Table 2 Basin-wide development scenarios

	Development scenario	Time horizon	Primary interventions	Climate	Flood Plain Settlement
M1	Baseline development scenario	Up to 2007	Water resources infrastructure developed in the Lower Mekong Basin up to 2007	1985-2008	2007
M2	Definite future scenario	Definite future up to 2020	Early scenario plus water resources infrastructure developed, under construction and planned in the Lower Mekong Basin between 2007 and 2020	1985-2008	2020
M3	Planned development scenarios	Planned future up to 2040	Definite Future plus infrastructure planned for implementation in the Lower Mekong Basin between 2020 and 2040	Mean warmer &wetter	2040
M3CC	Sub-scenarios	Planned future: 2040	FPF2, FPF3, IRR1, DIW1, DIW2, and ALU3 (as defined in the Implementation Plan of the Council Study and the CIA 2017 report)	Mean warmer and wetter	Applied in specific years

ALU = Agric/Land use Change; DIW = Domestic and Industrial Water Use; FPF = flood protection infrastructure; HPP = hydropower; IRR = irrigation; and NAV = Navigation

3.4 Sub-scenarios

Additional sub-scenarios have been developed by the CS Thematic Teams in response to key policy questions arising from the stated objectives and assessment requirements of the Inception Report. The most rigorous study design compares the main scenario M3 with all sectors developed, with a sub-scenario having all the sector developments minus those in the target sector.

For example, three sub-scenarios for 2040 explore the interactions between water resource development and changes in climate (C1-C3). Comparisons between scenarios M3 and C2 for

instance measure the effect of water resources development at the level of 2040 under a climate that is even wetter than mean projections. The sub-scenarios which assume climate changes (M3, C2, C3) are derived from statistical downscaling of the outputs of a set of global circulation models driven with assumptions of intermediate levels of greenhouse gas emissions (RCP4.5) and using these estimates to adjust the reference 1985-2008 climate.

Table 3 summarizes the key scenario and sub-scenario comparisons to test for various socio-economic effects. Cells left empty have been designated as lower priority and may be evaluated after others have been completed. The matrix of scenario comparisons for the socio-economic assessment is consistent with the CIA assessment.

Table 3 Scenario and sub-scenario comparisons for the socio-economic assessment

Effects tested	Scenario Comparisons	Socio-economic
Overall water resources development	M3 vs M2	X
	M2 vs M1	X
Climate change	M3CC vs C2	X
	M3CC vs C3	X
	M3 vs M3CC	X
Irrigation development	M3 vs Irr1	X
	M3 vs Irr2	X
Hydropower development	M3 vs H1a	X
	M3 vs H1b	X
	M3 vs H3	X
Navigation development	M3 vs N1	X
Agriculture & land-use development	M3 vs A1	X
	M3 vs A2	X
Flood protection infrastructure development	M3 vs F1	X
	M3 vs F2	X
	M3 vs F3	X

A= Agriculture and Land use: C= climate change: I =irrigation development; H=Hydropower; N=Navigation development; D=domestic water use; F=Flood protection

3.4.1 Agricultural land-use sub-scenarios

To address a key policy goal in the Inception Report of assessing the relative costs and benefits of agriculture and land-use development, comparisons are made between the main scenario M3 and sub-scenario A1 (Table 4). An alternative scenario with more land-use changes (A2) is compared with M3 or A1.

Table 4 Sub-scenario to test the effects of future agricultural land-use

	Scenario	Level of Development for water-related sectors[1]						Climate	Flood-plain
		ALU	DIW	FPF	HPP	IRR	NAV		
M3	Planned Development Scenario 2040	2040	2040	2040	2040	2040	2040	Mean warmer & wetter	2040
A1	Planned Development 2040 without ALU	**2007**	2040	2040	2040	2040	2040	Mean warmer & wetter	2040

A2	High level ALU implementation	**HIGH**	2040	2040	2040	2040	2040	Mean warmer & wetter	2040

3.4.2 *Flood protection sub-scenarios*

To assess the positive and negative impacts of flood protection infrastructure comparisons will be made between main scenario M3 and sub-scenario F1 (Table 5). Two other alternative flood protection strategies (F2 and F3) will also be compared with F1 or M3.

Table 5 Sub-scenarios to test the effects of future flood protection investments.

	Scenario and sub-scenarios	**Level of Development for water-related sectors**						Climate	Flood-plain
		ALU	DIW	FPF	HPP	IRR	NAV		
M3	Planned Development Scenario 2040	2040	2040	2040	2040	2040	2040	Mean warmer & wetter	2040
F1	Planned Development 2040 without FPF	2040	2040	**2007**	2040	2040	2040	Mean warmer & wetter	2040
F2	Planned Development 2040 with FP2	2040	2040	**FPF2**	2040	2040	2040	Mean warmer & wetter	2040
F3	Planned Development 2040 with FPF3	2040	2040	**FPF3**	2040	2040	2040	Mean warmer & wetter	2040

3.4.3 *Irrigation sub-scenarios*

To assess the positive and negative impacts of irrigation infrastructure overall comparisons will be made between main scenario M3 and sub-scenario I1 (Table 6). Another sub-scenario with even more irrigation infrastructure (I2) will also be compared with I1 or M3.

Table 6 Sub-scenarios to test the effects of water resources development in the irrigation sector.

	Scenario and sub-scenarios	**Level of Development for water-related sectors**						Climate	Flood-plain
		ALU	DIW	FPF	HPP	IRR	NAV		
M3	Planned Development Scenario 2040	2040	2040	2040	2040	2040	2040	Mean warmer & wetter	2040
Irr1	Planned Development 2040 without IRR	2040	2040	2040	2040	**2007**	2040	Mean warmer & wetter	2040
Irr2	Planned Development 2040 with IRR HIGH	2040	2040	2040	2040	**HIGH**	2040	Mean warmer & wetter	2040

3.4.4 *Hydropower sub-scenarios*

To assess the positive and negative impacts of hydropower development will be made between main scenario M3 and sub-scenario H1 (Table 7). Two other alternative flood protection strategies (H2 and H3) will also be compared with H1 or M3.

Table 7 Sub-scenarios to test the effects of water resources development in the hydropower sector.

	Scenario and sub-scenarios	Level of Development for water-related sectors						Climate	Flood-plain
		ALU	DIW	FPF	HPP	IRR	NAV		
M3	Planned Development Scenario 2040	2040	2040	2040	2040	2040	2040	Mean warmer & wetter	2040
H1	Planned Development 2040 without HPP	2040	2040	2040	**2007**	2040	2040	Mean warmer & wetter	2040
H2	Planned Development 2040 with HPS1	2040	2040	2040	**HPS1**	2040	2040	Mean warmer & wetter	2040
H3	Planned Development 2040 with HPS2	2040	2040	2040	**HPS2**	2040	2040	Mean warmer & wetter	2040

3.4.5 Navigation sub-scenarios

To assess the positive and negative impacts of navigation infrastructure comparisons were made between main scenario M3 and a single sub-scenario N1 (Table 8).

Table 8 Sub-scenarios to test the effects of water resources development in navigation sectors.

	Scenario and sub-scenarios	Level of Development for water-related sectors						Climate	Flood-plain
		ALU	DIW	FPF	HPP	IRR	NAV		
M3	Planned Development Scenario 2040	2040	2040	2040	2040	2040	2040	Mean warmer & wetter	2040
N1	Planned Development 2040 without NAV	2040	2040	2040	2040	2040	**2007**	Mean warmer & wetter	2040

3.5 Scope of socio-economic assessment

3.5.1 Sectoral Scope

The sectoral scope of the socio-economic assessment estimates the changes in social and economic conditions within the LMB, driven by all MRC-related basin-wide water resource developments summarized in Table 1 above.

The nature and magnitude of these water resource development impacts accounts for the impacts of exogenous developments and their estimated impact on socio-economic conditions since the early 1900's in 2007 (Year 1 of the M1 (no dams) baseline reference), the 2020 water development scenario (M2) and the 2040 water resource developments (M3) throughout the basin.

3.5.2 Spatial Scope

The assessments are to be conducted for the LMB corridor impacted by water resources development, with a focus on those areas directly impacted by changes in mainstream hydrology and bio-resource conditions (see CS Inception Report), referred to throughout this report as being within the corridor.

In addition, other areas within the basin will be impacted by water resources developments and need to be factored into a fully basin-wide assessment. These areas, referred to as outside the corridor, are those areas principally where:

- Irrigation development occurs;
- Reservoirs are developed behind tributary dams; and
- Urban and rural water supply and sanitation is developed.

The approach and methodology for the socio-economic assessment primarily addresses the changes in socio-economic conditions within the Mekong River corridor and where data availability and reliability allows, outside the corridor.

The first assessment step established the spatial boundaries and zones of the socio-economic assessment. The SIMVA 2011 and 2015 datasets represent data compiled through randomized household interview responses specific to the CS regions. The associated zones and sub-zones represent the primary spatial unit and source of data for the M1 scenario. The three regions assessed for the Council Study are i) the 15 km corridor on both sides of the mainstream from the Chinese border to Kratie (Cambodia) and continuing from Kratie to the Viet Nam border ii) the Cambodia Floodplains including the Tonle Sap River and Great Lake and iii) the Mekong Delta in Viet Nam (Figure 2).

National Data supplied by Member Countries and external international data sets from for example FAO and WDI have been referenced and calibrated against the SIMVA sub-zone data.

3.5.3 Temporal scope

The assessments address the cumulative impacts of water resources development at three time steps as defined by the CS, being the state of mainstream water developments in 2007 (M1), 2020 (M2) and 2040 (M3). For the purposes of the CS, cumulative water resources development is taken as that which has taken place in the modern era dating from the early 1900's. The social and economic assessments were conducted over a 24-year projection horizon reporting conditions in Year 1 and Year 23. The projection horizon corresponds to the hydrological and sediment regimes modelled over 24-years (1985-2008) and the BioRA DRIFT models.

3.5.4 Livelihood and wellbeing Indicators

The socio-economic impact of the development scenarios was guided by the socio-economic assessment indicators in the MRC Indicator Framework. Within this, under the socio-economic dimension, two strategic indicators have been agreed with Member Countries:

- Living conditions and well-being; and
- Employment in MRC sectors.

The current draft of the MRC Indicator Framework[4], describes a proposed set of socio-economic assessment indicators that remain un-finalized. Under *Living conditions and well-being*, three assessment indicators have been proposed: *demographic features*; *level of resilience at household level*; and, *level of resilience at community level*. Under *Employment in MRC sectors*, two assessment indicators have been proposed: *proportion of population engaged in MRC sector activities*; and *proportion of people engaged in MRC sectors vulnerable to change*.

Whilst recognizing the usefulness of the indicators above in monitoring overall conditions of people living within the basin, the requirements of the Council Study are to attribute changes in socio-

[4] MRC indicator framework for managing the Mekong Basin, BDP, draft 19 June 2015

economic conditions arising from water resources development. As framed above, the assessment indicators do not readily distinguish between the impacts arising from water resources developments and those related to exogenous development.

Since 2008-10 when the last basin-wide assessment was conducted by BDP2, major efforts have been made by MRC to improve knowledge of social and economic conditions within the basin. Two surveys have been completed in the mainstream corridor and flood plains (SIMVA 2011, SIMVA 2015) and a MRC/BDP basin-wide socio-economic database has been initiated and partially populated.

In the light of the increased data holdings, it is now possible to build on the earlier work of BDP, IBFM and SIMVA to develop a more comprehensive assessment approach than has been hitherto possible. Accordingly, a review has been conducted of whether more appropriate assessment indicators can be formulated for the purposes of the CS. The review considered:

- The need to align with the scope of the Council Study, namely to provide MRC with a comprehensive overview of the consequences of water resources at specific time steps;
- The need to select indicators that are responsive to the changes brought about by water resources development;
- The requirement to reflect international best practice, but to tailor this to the specific needs of the MRC; and
- The desire to maximize the use of assembled data and minimize further data collection needs.

As re-stated in the Basin Development Strategy 2016-20, a fundamental objective of the 1995 Mekong Agreement is cooperation to achieve "*the full potential of sustainable benefits to all riparian countries and the prevention of wasteful use of Mekong River Basin waters*". This aim is complemented with the Shared Vision for "*an economically prosperous, socially just and environmentally sound Mekong Basin*". Within the socio-economic dimension, water resources development can contribute to this objective by addressing the core issues of livelihoods, living conditions and employment within the LMB.

Following a review of international practice in this area[5] and in the light of the considerations above, the MRC Socio-Economic Assessment Methodology November 2015 review concluded that the following assessment indicators should be adopted in the Council Study, measured at the district and SIMVA 2015 sub-zone levels. The district and sub-zone levels correspond to the highest resolution administrative level of Council Members and distinguish the composite livelihood consequences of water resources development compared to livelihood estimates household and village levels.

Four dimensions comprise the strategic indicator of **Living conditions and well-being**:

- **Water security** – *relating to access to safe water supplies, water availability for domestic and agricultural use and flood exposure, exposure to floods and drought;*
- **Food security** – *relating to the ability to meet Recommended Daily Intakes (RDI) of) food grain (the primary source of Kcal/day/capita), protein and fat requirements through home production; and being above the poverty rate as a measure of ability to purchase food;*

[5] Sources consulted include: UN-Water, 2013 for water security, FAO for food security, ILO for income security, WDI (2016), UNDP (1994) for health security and IFAD for gender equity.

- **Income security** – *relating to and having sufficient monthly income; diversity of employment and/or having sufficient income to pay for food and necessities*
- **Health security** – *relating to access to safe water, safe sanitation and health facilities.*

Under the strategic indicator of **Employment in MRC sectors**:

- **Employment** – *relating to the proportion of employment in MRC-related sectors*; and
- **Gender equity** - *relating to the favourable equity conditions brought about by achieving water, food, income and health security*[6] *(as determined above*).

Secure livelihoods and well-being for the M1 scenario were measured by the number of people who are in communities in a secure situation. Employment was measured in terms of the numbers of full-time equivalent (FTE) jobs available for each of the four CS sectors; agriculture and fisheries, manufacturing and services and navigation. Gender equity was measured by the numbers (or percentage) of females and males living in secure conditions, assessed as the exceedance of defined thresholds for the six livelihood assessment indicators.

Care was taken in formulating the assessment indicators above based on the availability of sufficient social and economic data to evaluate the consequences of water resource development for each indicator. This is demonstrated in Section 3 where details are given of how each assessment indicator was measured at a disaggregated level that the data allow.

However, data availability and limitations, the capacity to reliably formulate response functions to water developments of each indicator, and the influence of exogenous developments need to be addressed in the assessments.

It should be also noted that the emphasis throughout the socio-economic assessment is primarily on the rural communities within the basin. Urban communities can be impacted by floods and are clearly dependent upon water supply and sanitation services, but in general their condition is much more influenced by exogenous developments, such as economic growth and industrialization, compared to water resource developments. The impacts of flooding on urban centres are addressed nevertheless under the economic assessments undertaken for the CS in terms of flood risk and related damages.

[6] Gender issues are believed to be relevant to water resource developments since women are more vulnerable than men during flood and drought due to their higher dependence on natural resources and social barriers that limit their adaptive capacity. Given the greater vulnerability of women to extreme floods, disaster risk reduction contributes to promoting gender responsive planning. Furthermore, gender inclusive development contributes significantly to economic growth and poverty reduction as well as to equity objectives by ensuring that all groups share development benefits, acknowledging that women and men are impacted differently by water resources development. In the context of the assessments made under Council Study, it is suggested that achieving water, food, income and health security will contribute to favourable conditions for women, rendering more equitable conditions with men.

4 Approach and methodology

This Section commences with an overview of the assessment approach. A conceptual socio-economic assessment methodology is described that addresses current data availability. The four main components of the approach are described, being data assembly and analysis, projecting the socio-economic situation in the LMB without water resources development, assessing the impacts with water resources development and, finally, the planned deliverables and reporting.

4.1 Objective of the socio-economic assessment

In response to CS objectives, the socio-economic assessments are designed to evaluate cumulative impacts at each time step (2007, 2020 and 2040). In this regard, the approach has been designed to provide:

- A projection of the changes in socio-economic conditions and consequences of the 2007, 2020 and 2040 Development Scenarios at the end of the proposed CS 24-year time horizon.
- Alignment with the concept of the State of the Basin monitoring of actual development impacts to measure whether these consequences are occurring; and
- The basis to assess incremental socio-economic changes between time steps, paving the way for later exploration of sustainable development pathways.

4.2 Overview of assessment approach

The approach and methodology to the socio-economic assessment set out in this report conforms to Council Study requirements of being triple-bottomed line in a manner that integrates social, economic and environmental assessment. The approach builds on that used in previous assessments by BDP and IBFM and those already initiated by other teams in the Council Study. It also seeks to capture the gains made by MRC in assembling a much more comprehensive social and economic data base than was available for previous assessments.

The assessment approach has also been improved by factoring in the historic development trends and exogenous development of LMB livelihood related variables, together with greater opportunities to employ spatial (GIS) analysis.

The key components of the assessment approach are illustrated in (Figure 1). The following section outlines the proposed socio-economic assessment conducted through a sequence of six methodological steps.

Step 1: Consultation with Thematic and Disciplinary teams to confirm indicators and variables; compile data sets for pre-development evaluation and trend analyses.

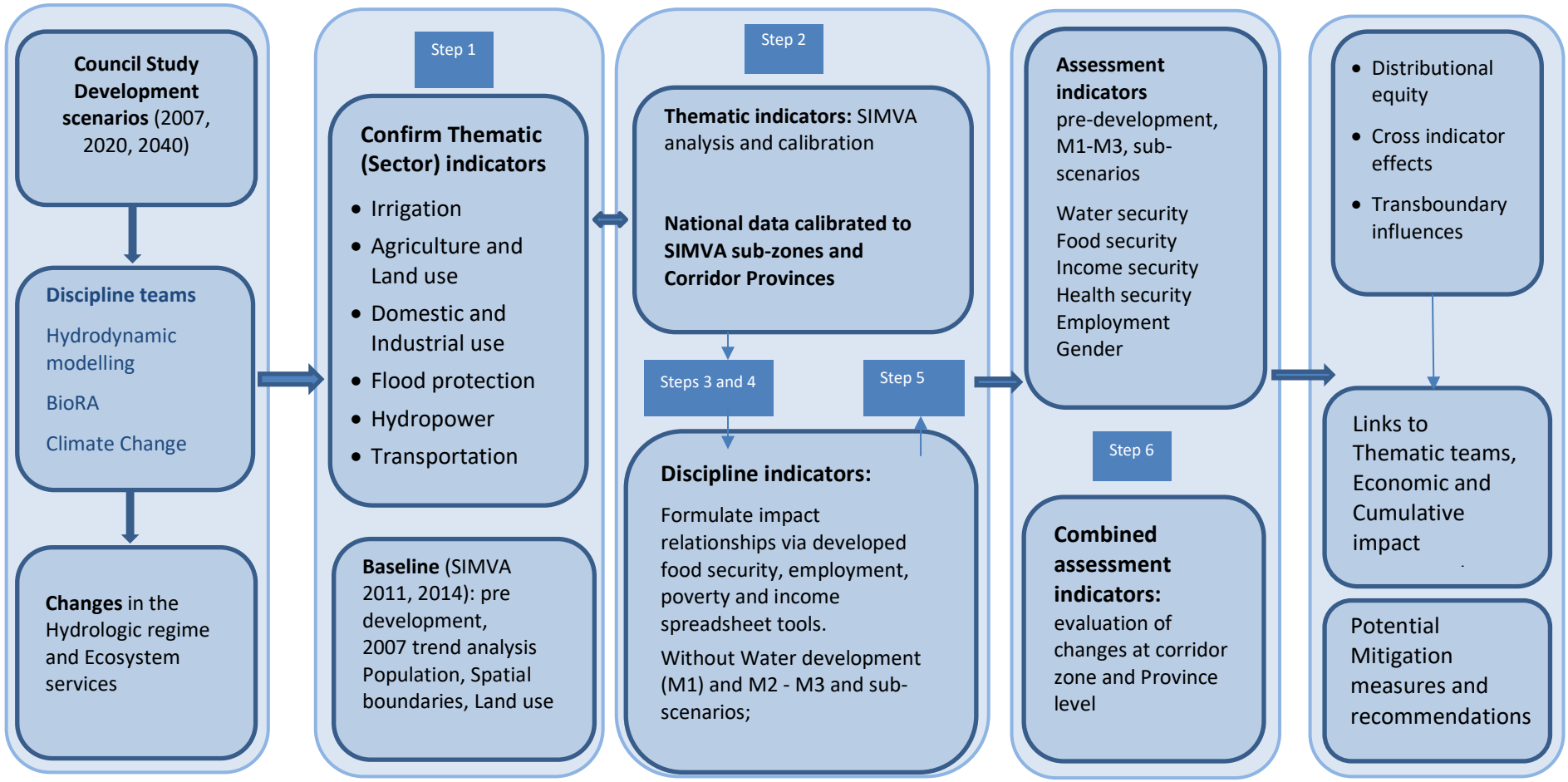
Step 2: a) Calibrate the SIMVA data sets to the non-sampled households in each corridor sub-zone and by extension to adjoining Provinces, assuming uniform distribution; b) calibrate complementary National level data sets to the SIMVA data.

Steps 3 and 4: Formulate the water development and non-water development relationships between the modelled changes in Thematic indicators and the set of Assessment Indicators in response to the Development Scenarios.

Step 5: Calculate the changes in the assessment indicators associated with the Development Scenarios for the Corridor sub-zones and the adjacent Provinces where feasible.

Step 6: a) Combine the assessment indicators to evaluate changes in livelihoods and wellbeing, Employment and Gender associated with the Development Scenarios; b) Estimate the cross-indicator relationships (e.g. the effect of a change in Water Developments on Food Security); and c) provide inputs to the CS Economic and Cumulative Impact Assessments.

Figure 1 Overview of methodology and approach to socio-economic assessment



4.3 Data assembly and analysis

The socio-economic assessment has used the bio-physical zones identified by both BioRA and Social Impact and Vulnerability Assessment (SIMVA; MRC 2011 and 2015) to divide the focal areas of the Council Study into distinct regions relevant to the bio-physical impacts being assessed within the Mekong River corridor. Data representative of district and/or provincial administrative boundaries were assimilated into the assessment, contingent on the social and economic data held by MRC.

SIMVA data are point data and the socio-economic characteristics have been drawn from the sampling points within each zone, taking into consideration the sample size and spatial distribution. Data from the MRC/BDP socio-economic database were aggregated data within the administrative boundary, however these data were limited in the usefulness for the CS assessment. Where applicable, these data are assumed to be uniformly distributed across the corridor-zones and administrative boundaries.

4.3.1 SIMVA (2015) as the primary reference data

Estimating representativeness of the SIMVA 2011 and 2015 datasets to non-sampled regions was a central task of the socio-economic assessment. The degree of representativeness is answered by the sample size combined with the sampling rationale (for example do respondents self-select, are they selected to meet a specified quantum, is selection stratified, or are they randomly selected). Representativeness determines whether the SIMVA data can only be used to describe survey respondents, whether different groups of respondents can be statistically compared and finally whether the analysis of respondents can be inferred to households who were not part of the survey sample. That is, the degree the SIMVA data represent the corridor zones and by extension the adjoining Provinces.

The SIMVA 2011 focused on livelihood activities and food nutritional security across eight defined hydro-ecological zones of the Mekong corridor; SIMVA 2015 focused on flood and drought exposure and household resilience and vulnerability across 13 socio-ecological zones defined for the corridor. Both surveys deployed a proportional probability sampling regime (PPS) of villages geographically dispersed across the respective sub-zones and randomized selection of village households.

The 13 zones used in SIMVA 2015 are illustrated in Figure 2. Sampling error at a 95% confidence interval for SIMVA 2011 is ±2.7% and ±1.9% for SIMVA 2015 and p. 24 2012. The socio-economic assessment assumed the data gathered through PPS sampling, the sample size and randomized household selection used in SIMVA (2011 and 2015) are sufficient representations of non-sampled households residing in the CS zones, contingent on the respective sampling errors.

The rationale for the 15 km corridor is that analysis of the SIMVA 2011 primary data revealed that resource use decreases substantially with distance from the Mekong River. Analysis indicated that people tend to make use of aquatic and riparian ecosystems that can be reached, on average, within 15 to 20 minutes. Beyond 10 km to 15 km, distance becomes a constraint, even for those with access to vehicles. Beyond 15 km, it is assumed that river resource use becomes rare, except under special circumstances such as the seasonal migration of farmers to the Tonle Sap during peak fishing periods, many of who are likely come from outside the corridor.

A weakness of the approach used for determining the corridors is that it does not take this seasonal use into account. Nor does it consider how topography will affect the travel time to access the Mekong.

Aggregation of household response to CS bio-zones and administrative levels are critical to subsequent socio-economic assessment as the data are the only available, empirically based foundation detailing household livelihood activities, food security, water security, food sources and nutritional status, family attributes, adaptation responses and exposure. Aggregation is also a critical step to the Economic and Cumulative Impact Assessments to estimate baseline Basin GDP, changes in sectoral GDP in response to the scenarios, estimates of the meta indicators of the Cumulative Impact Assessment and to the estimated monetized values of ecosystem services (that is the Resource Economics component).

The same calibration approach used to extrapolate the SIMVA data to provincial areas outside the corridor was used to calculate and calibrate the correspondence of international and national data to the CS corridor sub-zones. Where applicable, attributes and variables derived from the SIMVA analysis were assumed to be uniformly distributed across respective Provinces.

4.3.2 Exploring Mekong Region Futures livelihoods survey

A randomised survey of LMB communities (n=4,980) was conducted in 2011-2012 as part of the Exploring Mekong Region Futures (EMRF) project. Interviews were conducted with household members located in Hua Sai Bart, Thailand; Nam Ngum River basin, Lao PDR; the Tonle Sap region, Cambodia; and the Viet Nam Delta. (Foran et al. 2013, Hassenforder et al. 2015, Smajgl et al. 2015a, Smajgl and Ward 2013, Smajgl et al 2013, Smajgl et al. 2015b, Hammond et al. 2017, Ward and Poutsma 2013, Ward et al. 2016).

Consistent with the SIMVA 2011 and 2014 surveys livelihood survey, 20 households were randomly selected by lottery for interview from each of the 50 randomly selected villages for each of the four case study sites (i.e. n ~ 1000).

The design of the survey questionnaire concentrated on compiling data classes that enabled a reliable evaluation of the factors that explain the diversity of current livelihood strategies and those factors that motivate future Household adaptations and behaviour.

The questionnaire data classes, were comprised of:

1. Age distribution, gender and education;
1. Household assets;
2. Livelihood activities;
3. Livelihood factors: (presented as their perceived likelihood of occurring and the expected impact on individual Households);
4. The main factors that comprise a household's self-assessed subjective wellbeing;
5. Human values and value orientations that act as guiding life principles and the foundation of beliefs and behaviours; and
6. Intended adaptation strategies and future behaviour in response to specified changes in livelihood circumstances and factors.

Sampling points were geo-referenced for GIS purposes and to compile a spatial database of all required socio-economic data drawn from the existing sources listed by sub-zone.

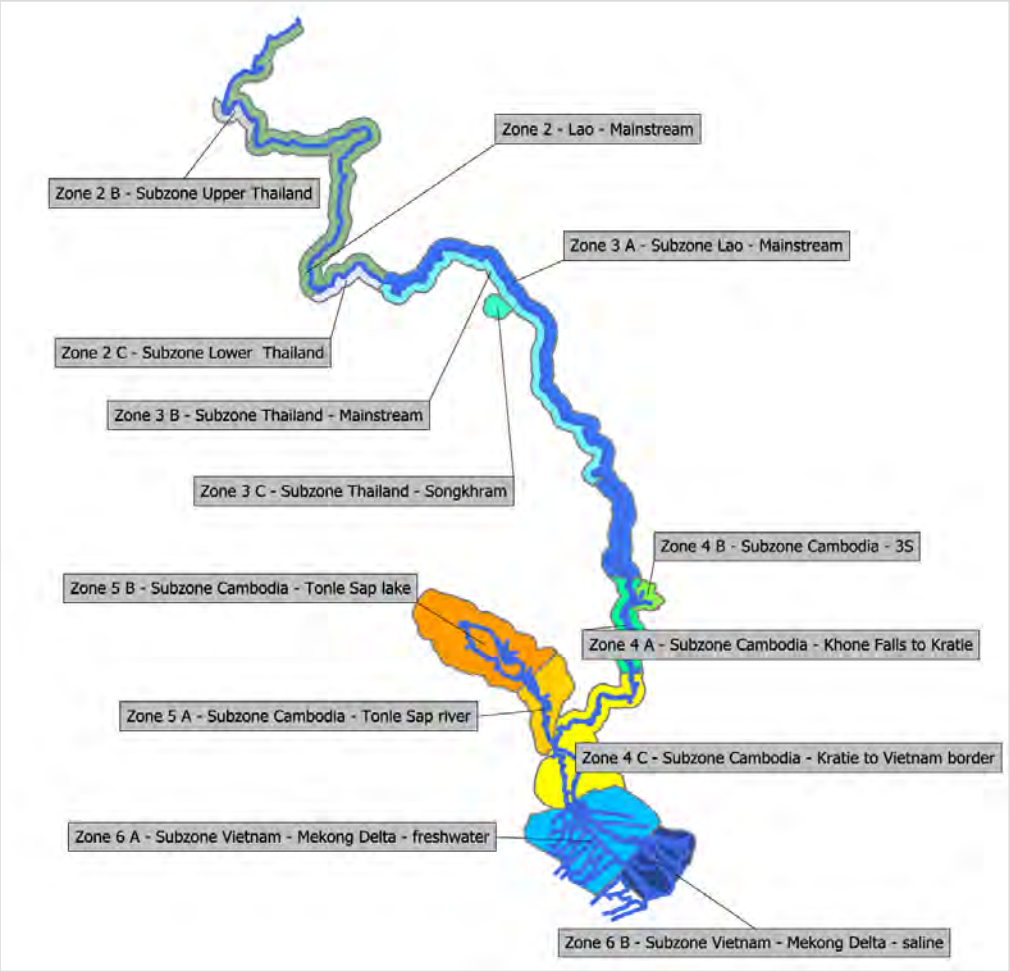


Figure 2 Map Sub-zones of SIMVA 2015 (source SIMVA 2015)

4.3.3 Existing socio-economic data

SIMVA 2011, SIMVA 2015 and national statistics compiled in the MRC/BDP socio-economic database constitute the main data sources for the CS socio-economic assessment. From the preliminary analysis conducted in preparing the report, the following datasets have been collated as set out in Table 10. These are termed in this report as being the discipline specific indicators for assessment purposes.

Table 10 also lists the available data in the National MRC socio-economic database. The current MRC social and economic database is comprised of non-uniform temporal data across non-commensurate administrative levels. Substantial effort was made to identify valid and relevant National level data sets from the FAO and World Development Index as a contingency.

The data listed in Table 10 was collected in different years. Whilst preserving the base data for future reference, these data were adjusted to a common year before assessments were conducted. This forms part of the trend analyses described in Annex 11.

4.3.4 Formulation of relationships between assessment indicators and discipline specific indicators

(i) ***Living conditions and well-being***

Two critical factors were required to effectively conduct the Council Study social impact assessment. First, data needed to be either specific to the corridor zones, ideally as time series to reflect the 24-year projection horizon, or could be reliably interpolated from recognized national and international datasets. Second, the analytical variables and parameters needed to have a direct relationship to the Discipline and Thematic Team analyses to detect differences in the social and economic indicators between the Development scenarios and provide useful outputs for further Thematic Team analyses. Methods and tools were developed to conduct the food security, income security, employment security and the drought and flood indicators of water security. These are detailed in the Annex and are available to the Member Countries. Energy security, health security the access to safe water were constrained by one or both of these factors and assessment relied on historical trend analysis and survey data. Each of the selected Assessment Indicators under the strategic indicator of Living conditions and well-being estimate the levels of Health, Water, Food and Income security likely to be achieved under the CS Development Scenarios and are related to different conditions being met.

The indicators to assess these requirements are set out in Table 11 in a manner that provides transparent and robust assessment criteria for assessing whether a state of “security” has been achieved for each of the four assessment sub-indicators.

Use was made of the extensive data collected by SIMVA, allowing the complex relationships between socio-economic, hydrological and bio-physical conditions to be evaluated. National level data collated by the FAO national data for the four member countries provide current and time series socio-economic data outside the corridor complementing the SIMVA based assessment approach.

The results are set out in Section 7 of the report and the indicator numerical, % change and values detailed in tabular form in the food-nutritional security and employment and income assessment spreadsheets developed for the Council Study. The spreadsheet enables rapid recalculation if different values are reported. Details of the tools are provided in the Appendix (Section 10.2).

Table 9 Discipline specific indicators to be abstracted from SIMVA and socio-economic database for assessment purposes

SIMVA2011	SIMVA2014	MRC/BDP Socio-economic database				
			Cambodia	**Lao PDR**	**Thailand**	**Viet Nam**
▫ % of HHs with access to safe water ▫ % of HHs whose primary domestic water sources runs dry for more than x weeks in the dry season ▫ % of HHs affected by water shortages that resulted in crop damage ▫ % of HHs affected by water excess that resulted in crop damage ▫ Production of livestock (head count) ▫ Percentage of non-food expenditure ▫ Annual income (multiple Livelihood activities) ▫ Number of income sources (fish/OAAs/river bank/non-aquatic resource) ▫ HHs expenditure (and EMRF datasets) ▫ Number of HHs with access to safe water	▫ List of communities that have health facilities ▫ Village population by gender	Population	District	District	Province	Province
		Dependency ratio	District	District	Province	Province
		Population density	District	Province	Province	District
		Population growth rate	District	Province	Province	Province
		Migration	Province	Province	Province	Province
		Household size	District	District	Province	Province
		Household expenditure	Awaited	Province	Province	Awaited
		Poor people	Awaited	Province	Province	Awaited
		Poverty rate	National *	Province	Awaited	Province
		Households with access to safe drinking water	Awaited	Province	Province	Awaited
		Households with access to sanitation	Awaited	Province	Province	Awaited
		Households with health facilities	Awaited	Awaited	Awaited	Awaited

Table 10 Formulation of assessment indicators related to Living conditions and well-being

	Assessment criteria *to assess whether security has been achieved*	**Discipline specific indicators**	**Data source**
Water security	▫ HHs have access to safe water;	% of HHs with access to safe water	SIMVA2011 FAO adjusted
	▫ HHs have reliable primary domestic water sources;		SIMVA2011
	▫ HHs report water shortages that result in crop damage in	% of HHs exposed and affected by drought	
	▫ HHs report of water excess that results in crop damage in	% of HHs exposed and affected by floods	SIMVA2011
Food security	▫ Within the assessment sub-unit per capita Kcal/day,	Crop Production (t)	AIP, FAO adjusted, EMRF
	HHs expenditure on food per capita (National poverty levels)	% of population below the national poverty	
Income security	▫ HHs have income above the poverty line;	Monthly income	SIMVA 2011, EMRF
		Poverty rate	MRC SEDB FAO
	▫ HHs have alternative income sources;	Number of income sources	SIMVA 2011, EMRF
		Income from agriculture	AIP, EMRF
	▫ HHs have income more than expenditure	HHs income, poverty level	SIMVA 2011, EMRF
Health security	▫ HHs have access to safe water;	Number of HHs with access to safe water	SIMVA 2011
	▫ HHs have access to sanitation;	Number of HHs access to sanitation	MRC SEDB FAO adjusted
	▫ HHs Has access to local health facilities	List of communities that have health facilities	SIMVA 2015 (Village data)
Energy security	▫ HHs have access to rural electrification	% of rural electrification	WDI and National statistics

4.3.5 Trend analyses

Trend analyses were conducted on the assembled *discipline specific indicator* data sets, accounting for the BDP's Development Trends Report, the BioRA findings on environmental conditions, FAO country indicators and other national statistics useful to determine demographic and socio-economic trends.

The objectives of the trend analyses were to:

(i) Calibrate and transpose the discipline specific indicator data sets to a common year basis;

(ii) Establish, to the extent that information allows, a retrospective picture of socio-economic conditions in the pre-development situation subject to access to reliable data (note; FAO data extends back to 1961); and

(iii) Project the values (forward and back) of the discipline specific indicators expected in the pre-development situation in 2007 (year 1) and 2030 (year 24) without water resources development occurring.

The analyses provide the foundation for the socio-economic assessments conducted with and without water resources development and are described in Annex C: Trends and Data assembly.

5 Projected situation without water resources development: the M1 development scenario

5.1 Overview

Once the data were assembled, the assessment indicator formulation calibrated and trends established, the next main step was to estimate socio-economic conditions without water resources development. In common with the approaches being adopted for the environmental and economic assessments, an understanding of the cumulative impacts of water resources development can be deduced if there is first an understanding of what conditions would have been like within the LMB had there been no water resources development. It is widely appreciated that there are many different drivers of development and those exogenous to the MRC-related water resources sector (see Table 1) have, and are continuing to have, a substantial effect on the basin's population.

Substantial national efforts and investments made in recent years have substantially reduced rural poverty and malnutrition and these trends can be expected to continue[7]. Reducing malnutrition and child under-nourishment remain as primary national challenges for both Lao PDR and Cambodia (Bouapao *et al*. 2016 and NIS et al. 2015 respectively) [8] as economic growth, improved health, education, job creation and externalities such as growing remittances from abroad have all contributed to the improvement.

Agricultural productivity has been increasing, contributing to increased food grain availability. Dietary preferences are also changing with per capita rice consumption declining coupled with increasing demand for meat products. The CS BioRA team reports concurrent increased pressure on fisheries and the wider environment, in part due to population growth and pressure on the eco-system since the 1960's.

In common with other countries, the LMB is subject to greater industrialization, direct foreign investment and urbanisation, placing pressures on the cities and creating urban sprawl. Flood plains, which were formerly untouched wetlands and more recently have been exploited for agriculture and fisheries purposes, are increasingly being developed with factories, housing and roads and are of rising value. Given the abundance of Mekong river flows, most, if not all, of these developments would have occurred whether water resources development had or had not occurred. It is thus appropriate that an understanding is reached first of the impact of these exogenous developments before considering the incremental impacts caused by water resources development.

[7] Development trends and future outlook in the Lower Mekong Basin Countries, MRC Basin Development Programme (November 2015)

[8] Bouapao, L. Insouvanh, C., Pholsena, Armstrong, J.,and M., Staab, M. (2016) Strategic review of food and nutrition Security in Lao People's Democratic Republic. Report commissioned by the World Food Programme.

National Institute of Statistics, Directorate General for Health, and ICF International, 2015. *Cambodia Demographic and Health Survey 2014.* Phnom Penh, Cambodia, and Rockville, Maryland, USA: National Institute of Statistics, Directorate General for Health, and ICF International.

The analysis and review of exogenous variables and factors are located in Annex C: Trends and Data assembly. The Annex contains details of:

- Calculation of population estimates,
- National level trends of rice and livestock production,
- Capture fisheries and estimates of fish catch for each corridor zone;
- Sectoral and household incomes,
- Corridor employment and adaptive capacity;
- Calculation of food balances and nutritional security; and
- Estimates of market prices for rice livestock, fisheries (by five guild) and otheraquaitic animals in the LMB.

6 Scenario analysis with water resources development

6.1 Overview

The third main step shown in Figure 1 represents analyses undertaken to estimate the socio-economic impacts of water resources development. The analyses were undertaken for each scenario projected for the scenario years 1 (2007) and 24 (2030), taking into account demographic trends and exogenous developments determined in the previous step (Section 5). Accounting for exogenous developments in the M1 pre-development scenario provides a more realistic appraisal of water resource development impacts than has been hitherto possible. The assessments focused on the incremental impacts of water resource developments predicted to have been developed in 2007 (M1-no dams baseline), 2020 (M2), 2040 (M3) and 2040 with climate change (M3CC); sub-scenarios in each assessment zone over and above those predicted to occur as a result of exogenous developments described in Section 5.

Analysis of water resources development impacts nevertheless requires an understanding of the influence that developments in each thematic area will have on the communities where those developments occur and/or where those developments have impacts.

In developing the methodology for the assessments, it was necessary to establish the linkages between water resource developments in each sector, together with relevant exogenous developments (see Table 1), on the discipline specific indicators that underpin each assessment indicator (see Table 11 and Table 83). The linkages are set out in in the Appendix, Table 55, and based on consultation with the Thematic and Discipline teams, coupled with stakeholder feedback.

The key steps in undertaking the impact assessment are:

- Take receipt of the required data from the Thematic and Discipline teams, prepare spatial overlays of the impact areas associated and abstract relevant data by assessment sub-unit and enter these in the overall assessment spreadsheet;
- Taking into consideration the nature of the data received, to build functional relationships between the discipline specific indicators and the development impact data; and
- To undertake the assessments making use of (i) and (ii) above, estimating the projected changes that development impacts would cause to the discipline specific indicators and applying the assessment criteria given in Table 11 and Table 83 to determine the effect on the assessment indicators.

The data assembly corresponds to Step 2 illustrated in Figure 1. Two main categories of impact data were taken into account in the assessment process. Bio-physical related impacts, such as the impacts on wetlands and on capture fisheries, reported in relation to the bio-physical zones used by both BioRA and SIMVA. Unless guidance was given by those generating the data, these are assumed to be uniformly distributed across each of the Corridor zones. Second, other water resource development impacts not associated with changes in bio-physical conditions (such as irrigation development, reservoir development) were also assumed to be uniformly distributed within the Corridor zones.

Steps 3 and 4 (illustrated in Figure 1) estimate the functional relationships between the discipline specific indicators and the development impact data to regions inside the corridor. The relationships are conceptually similar to the "response curves" developed by BioRA and served a similar purpose by linking the impacts of changes in development conditions to changes in the discipline specific indicators. The information provided Table 55 coupled with extensive consultation with the Discipline teams represented the starting point for the analysis.

6.2 Social and economic assessment tools

6.2.1 Development Scenario Impact assessment

Impact assessment was conducted for each Corridor zone using the spreadsheet tool built for the purpose (Steps 5 and 6 in Figure 1). The advantages of using a spreadsheet for this purpose are: (i) transparency in the formulation of the assessment; (ii) increased usability allowing non-specialists access to the process; and (iii) rapid development of the tool and associated cost effectiveness.

A series of bespoke spreadsheet tools were developed for the social economic assessment. First the food-nutritional security tool estimates the total production of rice, livestock and fish for each zone as annual time steps of the 24-year projection horizon. Inputs were derived from the IWRM modelling team (rice yields /ha), fish catch and composition (BioRA) and livestock (FAOSTAT 2017).

The tool partitions total production into two components:

1) the requirements for the population in each corridor zone for each year to meet the kcal/day/capita, protein gms/day/capita and fat gms/day/capita listed in Table 62 and Table 64.

2) the agricultural surplus for each zone after meeting the food security levels available for either additional consumption, to manage the risk of food security shortfalls or market trade.

Note that if food production in each zone is insufficient to meet food security requirements of the population for any given year, the calculator estimates a negative surplus, implying that food will need to imported into the zone from other corridor regions.

Figure 3 Main elements of the social and economic food security assessment tool

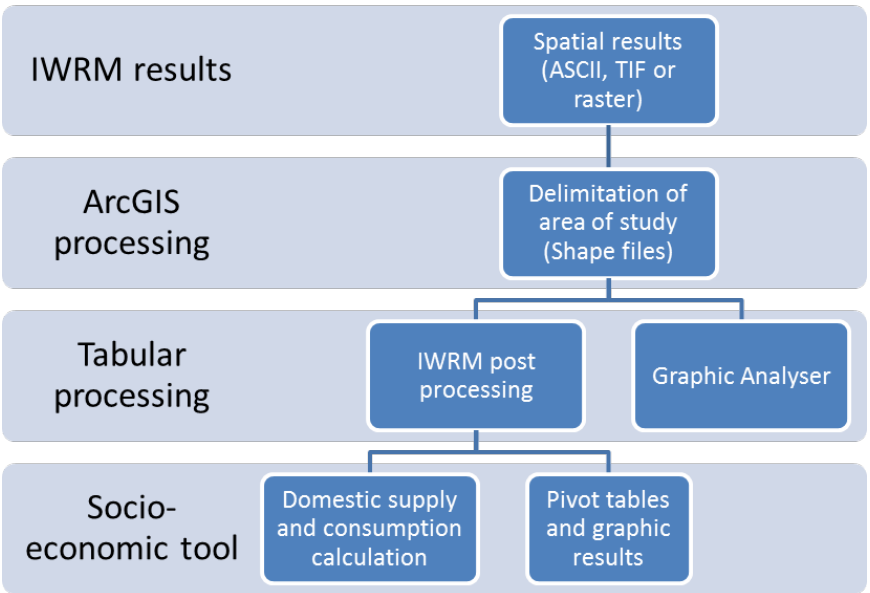
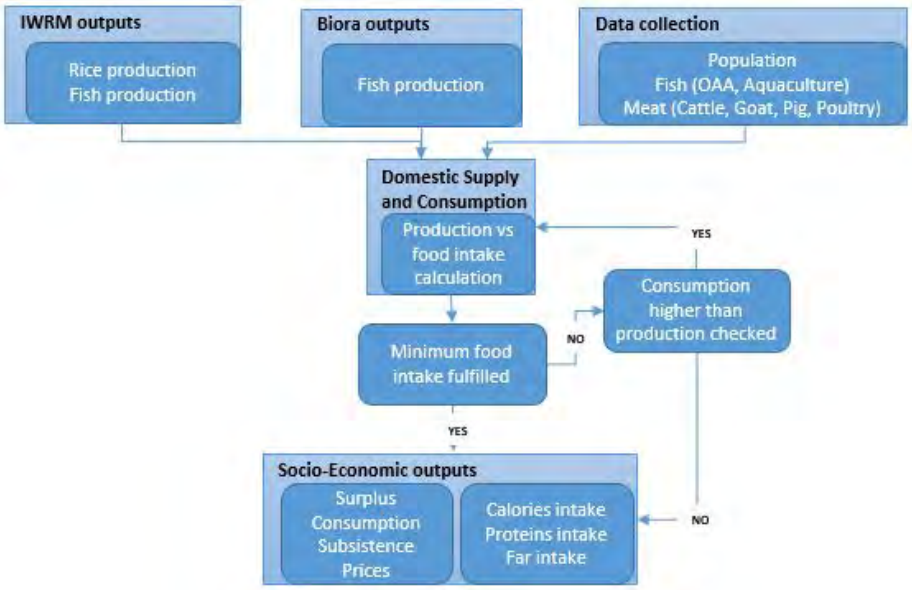


Figure 4 Flow chart of the food security assessment calculator



The socio-economic assessment involves input information and output information utilizing a central processing calculator. The calculation process is relatively straight forward when applied to an individual Corridor zone and for one specific condition. The complexity arises when automating the calculations involving multiple social and economic variables that depend on a zone and year specific calibration as well revising each input variable to create rigorous estimating conditions sufficient to reliably to run the model.

The amount of each food source available for consumption was initially derived from the national FAO Food Balance sheets for the four LMB countries and calibrated to the corridor zones. The scaling factors to estimate the contribution to daily nutrient intakes from the total production values was calculated from the FAOSTAT data. The coefficients to calculate the daily food inputs for rice, fish, meat and fish are reported in Table 12. The coefficient estimates for daily nutrient contribution of Other Aquatic Animals (OAA) were assumed to be equivalent to fish.

In Table 12:

1. % production factor (minus exports) represents the total production of each main food source available for consumption or sale. The coefficient was calculated as the FAO Total food available (= production-losses and waste) / amount available for food consumption. The coefficients were assumed to be constant through the main scenarios M1, M2 and M3 and M3CC and all sub-scenarios. The FAO production factors were used as a starting value for the food security calculations.
2. The coefficients for KCal/Day/capita and protein and fat gms/day/capita were estimated for rice, meat, fish and OAAs as:
    a. FAO kcal/day/capita/∑ kg/year/capita;
    b. FAO protein gms/day/capita)/∑ kg/year/capita;
    c. FAO fat gms/day/capita)/∑ kg/year/capita.
3. Rice represents milled equivalent; meat represents the sum of all livestock and poultry; and fish represents the sum of all capture fisheries, OAA and aquaculture products consumed.

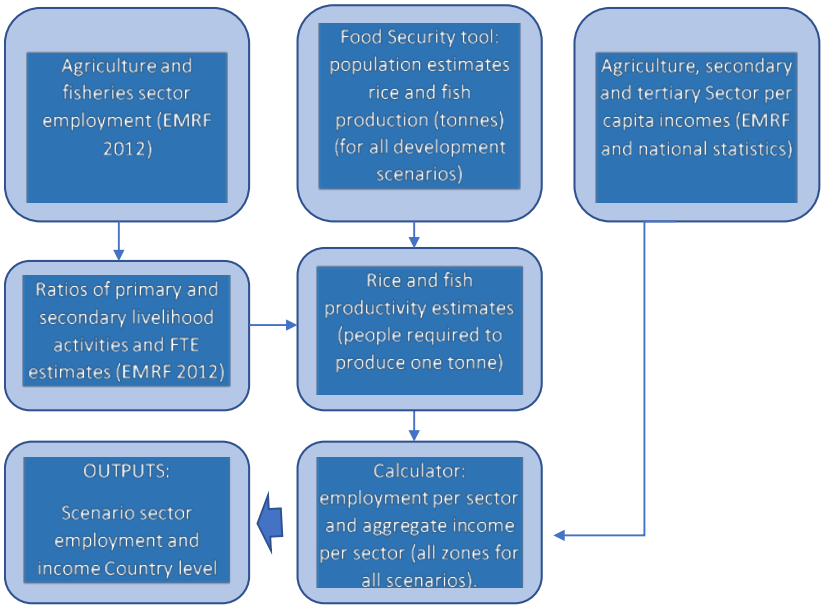
The 2015 market prices for fish (by five fish guilds), livestock, and rice were imputed according to the values detailed in Annex 11.5.4. Annual population estimates and nutritional requirements were kept constant for the scenario analyses. A full description of the food security estimating tool can be found in Appendix 10.2.

Table 11 Production coefficients to estimate daily intake for the four LMB countries

		% initial production factor	Coefficient KCal/Day/ capita	Coefficient Protein gms/day/ capita	Coefficient fat gms/day/ capita
Lao PDR	Rice	0.54	9.55	0.19	0.03
	Meat	1.00	7.36	0.34	0.66
	Fish	0.98	2.07	0.32	0.07
Cambodia	Rice	0.50	9.55	0.19	0.03
	Meat	1.00	7.36	0.34	0.66
	Fish	0.98	2.07	0.32	0.07
Thailand	Rice	0.57	9.93	0.17	0.02
	Meat	1.00	6.49	0.32	0.57
	Fish	0.82	2.20	0.34	0.08
Viet Nam	Rice	0.63	9.61	0.20	0.03
	Meat	1.00	7.36	0.31	0.67
	Fish	0.81	1.59	0.26	0.05

The second spreadsheet tool (Figure 5) utilizes the outputs of the food security tool and employment percentages to estimate 1) the labour required to produce the current and forecast agricultural production and fish catch for each zone for each year; and 2) sector incomes for each zone for each development scenario. Labour surplus to meet agricultural production and fisheries was assigned to either secondary, tertiary or the navigation sectors according the ratios described in Annex 11.8.

Figure 5 Flow diagram of inputs outputs of the employment and income calculator



A full description of the employment and income tool can found in Appendix 10.3.

The spreadsheet tools, include:

(i) An estimation of population growth over the 24-year projection horizon which are held constant across all development scenarios;

(ii) Attribution to each sub-zone of the values associated with each discipline specific indicator and the year the data relates to;

(iii) Trend functions (estimated from trend analysis) to convert the attribution data to the common year 1 of the 24-year projection horizon (see Section 4.3.5);

(iv) Data adjusted to the M1 (2007) pre-development situation and to the, M2 (2020) and M3, M3CC (2040) scenarios and sub-scenarios;

(v) Tables describing impact relationships with formulae and logical statements developed from Table 55;

(vi) A listing of development impact data (see Table 55) attributed to each sub-zone for the pre-development and scenario situations without and with water resources development for M1, M2 and M3 (and M3CC) (including sub-scenarios);

(vii) A listing of development impact assessments for each scenario and for each socio-economic assessment indicator computed based on the impact relationships and assessment criteria;

(viii) Export tables to send selected data and results to GIS to be mapped; and

(ix) Reporting tools to summarize assessment indicator values generated for each corridor zone, across each of the 24-year projection horizon for each scenario; and to compare between scenarios.

7 Results

The results section describes the food security, levels of undernourishment, poverty levels, the impact of floods and drought, sector employment and income estimates for each of the corridor zones for the Baseline M1, M2 and M3 and M3CC main water development scenarios. The estimates of the sub-scenarios are also reported and several sets of GIS maps presented in Annex C, section 9.

The Food Security spreadsheet tool compiles data from the IWRM, BioRA and Thematic teams and calculates total production of food sources central to food and nutritional security of rural populations in the corridor zones. The analytical outputs of the model are the foundation for deriving estimates of the numbers of undernourished people and households, people under national poverty levels, annual food security and nutritional balance analyses over the 24-year projection horizon of the development scenarios. The outputs are also the foundation for the total production value, sector employment and household income estimates.

The food and nutritional security results are first reported followed by the levels of undernourishment and poverty levels. The results are reported at the corridor level and aggregated to country level. For the purposes of the social and economic assessment and food security analysis year 1 of the 24-year projection horizon was assumed to commence in 2007 and end in 2030.

Corridor zone population growth, increases in livestock and aquaculture, prices and productivity calculated for the 24-year period were held constant for analyses. This allows a more direct comparison of the effects of the investments specific to each development scenario. The M1 development scenario represents the baseline reference period: year 1 is compared to year 24 as a control for all analyses.

Food security was calculated according to the estimated production levels (area under cultivation and annual yields) of rice, livestock and fish for each of the 13 Corridor Zones across the development scenarios. The reported production surplus represents the residual production after food and nutritional security needs have been achieved. Where production was insufficient to meet food security needs within the zone (a negative surplus), the negative surplus represents the estimated amounts of rice and fish required to be imported from adjacent zones to meet minimal food security needs.

Rice, fish and livestock production for Cambodia, Lao PDR, Thailand and Viet Nam represent 66%, 65%, 33% and 57% of the national agricultural production respectively and constitute the major food sources for food security in the LMB corridor (FAO 2017). The contribution to food balances of non-rice, fish and meat sources were derived from FAO country level food balance calculations and held constant for the scenario analyses (see Table 64).

A central assumption of the modelling rationale was agricultural production was sufficient to meet 100% of all food and nutritional needs. Food security levels and population growth estimates were held constant across all development scenario analyses.

Employment was measured as the number of fulltime employment (FTE). Estimates are reported for the main Council Study sectors: agriculture, fishing, secondary, tertiary and navigation. The initial proportions and numbers of people employed in each sector were derived and extrapolated from field surveys conducted as part of the EMRF project (2012) and reported in Table 86. Aggregate incomes for the agriculture, navigation, manufacturing and service sectors were estimated by multiplying the FTE calculated for each sector by the median sectoral incomes derived from the SIMVA (2011) and EMRF (2012) data.

7.1 Food Security: Agricultural production and food consumption

Baseline (M1) food surpluses

Surplus rice and fish production indicate the capacity of countries and zones to respond to and manage years of acute food deficiencies and shortfalls. Annual surpluses can be either traded or act as a buffer against below average production. An increase in surplus roughly corresponds with increased response capacity; surpluses at zero or near zero indicate zones would need to import food if decreases in food production were to occur.

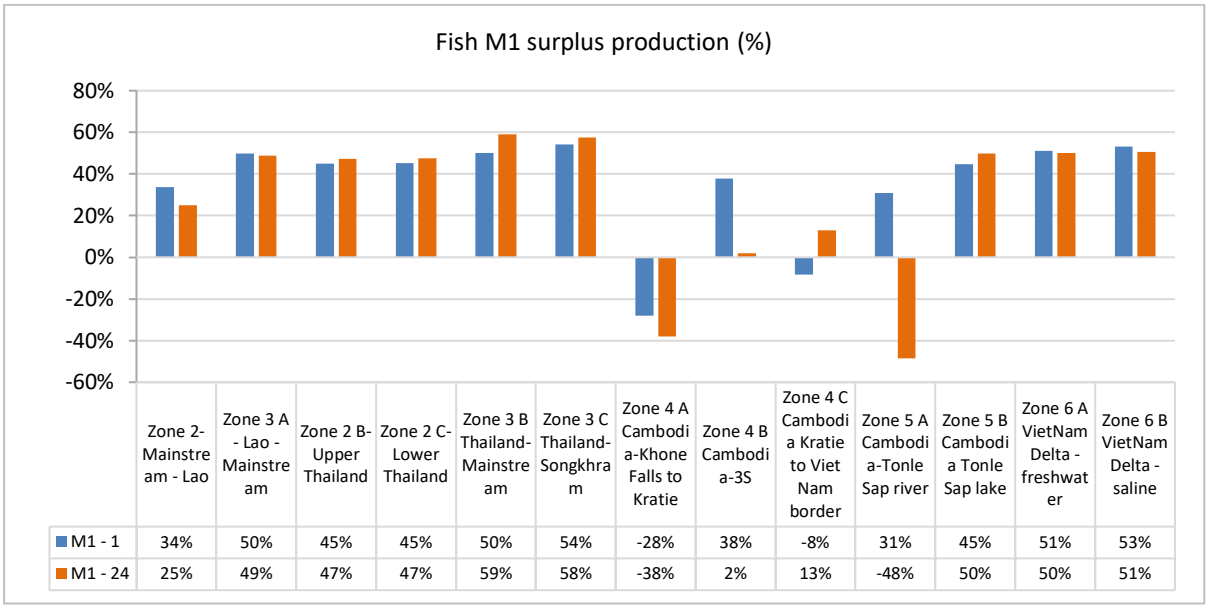
The pre-development M1 baseline scenario represents the reference data of the social and economic assessment against which the development scenarios are compared and evaluated. The comparison of surplus production of fish and rice in the corridor zones for year 1 and 24 are summarized in Figure 6 and Figure 7 respectively and the mean values over the 24-year time horizon detailed in Table 13.

The differences between year 1 and year 24 represent the additional food production required to meet the food security demands of the predicted increases in population for each of the corridor zones, while holding other scenario development conditions constant. Fishing effort and agricultural management, productivity and technology were also held constant across the 24-year time horizon.

Fish surpluses decrease across all zones except the Kratie to the Viet Nam Border, which is also associated with an increase in livestock consumption as a supplement to protein intake. Reductions in fish surplus are highest in the Lao PDR and the Khone falls zones. Rice surpluses decrease across all zones from Year 1 to Year24 in the M1 scenario except zones 3 B and 3 C in Thailand and zone 4 C in Cambodia, where modest increases of 6%, 1% and 37% were estimated respectively.

Note that the rice production in the 4 A and 4 B and 4C Cambodian zones are primarily rainfed production and varied by up to 140% in response to the variance in modelled yields and the area of hectares suitable for cultivation.

Figure 6 Fish: surplus production after food security met: M1 years 1 and 24 by corridor zones



	Zone 2- Mainstream - Lao	Zone 3 A - Lao - Mainstream	Zone 2 B- Upper Thailand	Zone 2 C- Lower Thailand	Zone 3 B Thailand- Mainstream	Zone 3 C Thailand- Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta - freshwater	Zone 6 B VietNam Delta - saline
M1 - 1	34%	50%	45%	45%	50%	54%	-28%	38%	-8%	31%	45%	51%	53%
M1 - 24	25%	49%	47%	47%	59%	58%	-38%	2%	13%	-48%	50%	50%	51%

Figure 7 Rice: surplus production after food security met: M1 years 1 and 24 by corridor zones

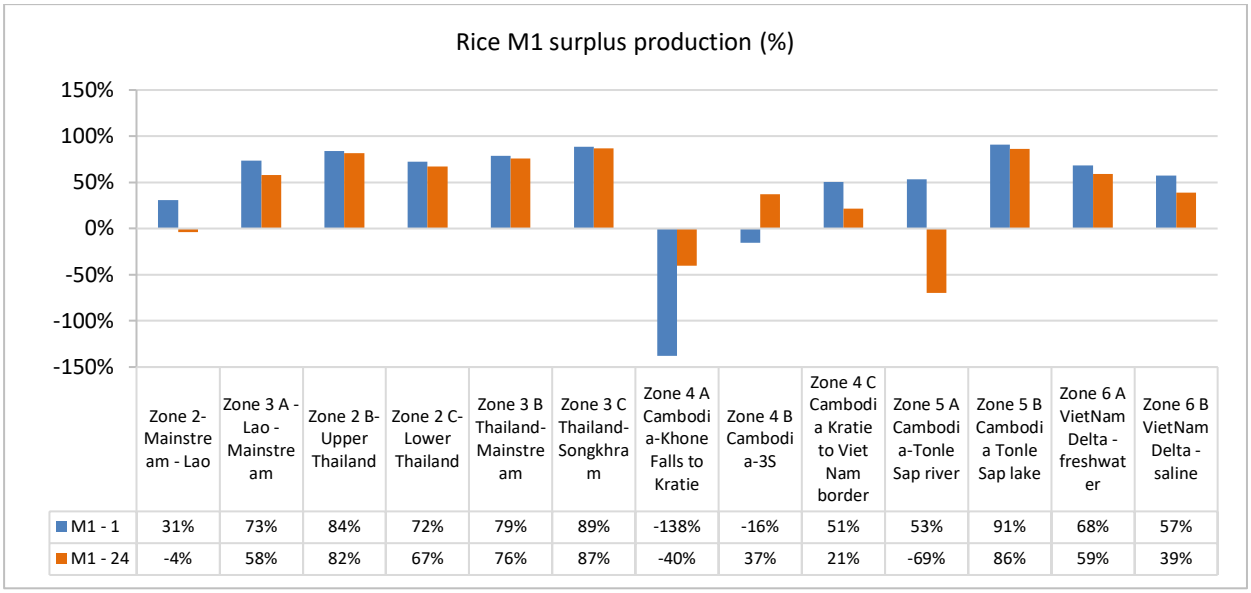


Table 12 Corridor zone M1 food production and surpluses (mean years 1-24)

SIMVA Zone	M1 Mean annual production ('000 tonnes)				M1 Mean annual surplus ('000 tonnes)			
	Fish	Rice	OAA	Livestock	Fish	Rice	OAA	Livestock
Zone 2-Mainstream - Lao	36.9	98.1	5.4	13.4	12.8	17.7	1.1	5.4
Zone 3 A - Lao - Mainstream	105.5	468.7	6.1	26.8	57.5	309.0	0.0	10.8
Zone 2 B-Upper Thailand	10.8	67.5	1.5	2.8	7.1	56.2	0.6	0.6
Zone 2 C-Lower Thailand	12.2	36.0	1.0	2.8	8.2	24.7	0.0	0.6
Zone 3 B Thailand-Mainstream	112.2	425.7	6.2	24.8	78.2	330.4	-0.1	7.1
Zone 3 C Thailand-Songkhram	22.0	78.6	0.7	2.8	18.0	67.3	0.0	0.7
Zone 4 A Cambodia-Khone Falls to Kratie	19.7	6.2	4.3	0.9	-8.5	-2.7	-2.1	-0.5
Zone 4 B Cambodia-3S	4.5	0.7	0.1	0.1	1.4	0.1	0.0	0.0
Zone 4 C Cambodia Kratie to Viet Nam border	127.0	1304.7	34.5	20.1	5.7	555.5	-0.7	2.1
Zone 5 A Cambodia-Tonle Sap river	172.7	404.8	12.7	13.7	13.7	179.9	-1.2	0.5
Zone 5 B Cambodia Tonle Sap lake	181.6	1309.9	31.7	7.4	127.1	1152.5	13.5	0.8
Zone 6 A Viet Nam Delta - freshwater	1180.8	3932.2	51.3	336.6	762.2	2555.3	-0.6	104.0
Zone 6 B Viet Nam Delta - saline	497.7	1169.6	20.5	170.0	325.2	602.2	-0.3	74.1
Total	2487.6	9302.8	175.8	622.2	1408.5	5848.1	10.2	206.3

Main development scenario food surpluses compared to the M1 baseline

Differences between the M1 and main development scenarios revealed by the food security calculations and estimates are an indication of the main development scenario effects on fish and rice production and subsequent effects on food security.

The ratio of fish and rice surplus (excess to meeting food security) to total production for the four main scenarios across the 13 corridor zones are summarized in Figure 9 and Figure 11 respectively and detailed in Table 14and Table 15. The percentage changes in fish and rice production, surplus to meeting food security needs, between the M1 baseline and the three main development scenarios (M2, M3 and M3CC) are detailed in Table 16.

The comparative aggregate reductions in surplus fish production after meeting food security across all corridor zones compared to the M1 baseline (year24) were:

M1-M2= -32%

M1-M3 = -43%

M1-M3CC = -40%

Compared to the M1 baseline, the comparative aggregate increases in surplus rice production after meeting food security across all corridor zones were:

M1-M2= +6%

M1-M3 = +16%

M1-M3CC = +13%

Main national findings for changes in fish production and surpluses after food security needs met.

Cambodia: Fish catch declines across all Cambodian zones across the M2, M3 and M3CC development scenarios.

- Khone Falls to Kratie: The M2 fish surplus decreases by 22%, 25% (M3) and 24% (M3CC) compared to the M1 year 24 baseline.
- Cambodia 3S: fish surpluses are estimated to decline by up 1-2%% across all scenarios;
- Kratie to Viet Nam Border: compared to the M1 baseline, the M2 fish surplus decreases by 21%, 38% (M3) and 32% (M3CC).
- Tonle Sap River: fish declines from 53% (M2) to 36% (M3) and 32% (M3CC) compared to the M1 year 24 surplus;
- Tonle Sap Lake: fish surpluses for the Tonle Sap decline by 11%-13% across the M2, M3 and M3CC scenarios.

Lao PDR: Fish significantly declines across both Lao PDR zones across the M2, M3 and M3CC development scenarios

- Upper Mainstream: fish surpluses are estimated to decline by 91% (M2) and up to 100% (M3 and M3CC);
- Lower Mainstream: surpluses are predicted to decline by 54% for the M2 (year 24) scenario, 84% (M3) and 85% (M3CC) compared to the M1 year 24 baseline.

Thailand: Fish declines across all Thai zones for the M2, M3 and M3CC development scenarios

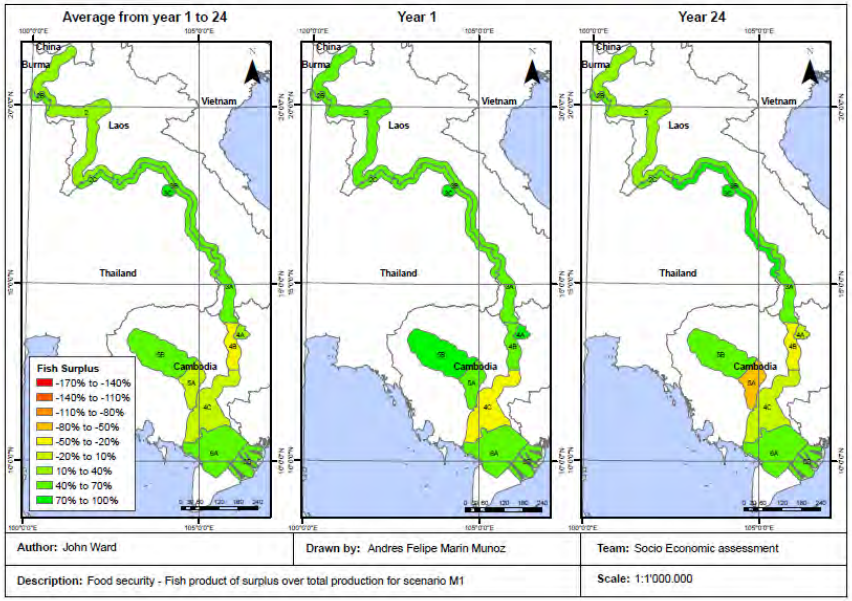
- Upper mainstream: fish production surplus to food security needs declines by 33% (M2), 68% (M3) and 73% (M3CC);
- Lower Mainstream: fish production surplus to food security needs declines by 47% (M2), 83% (M3) and 90% (M3CC);
- Mainstream: fish production, surplus to food security needs declines by 39% (M2), 622% (M3) and 69% (M3CC);
- Songkhram: fish production surplus to food security needs declines by 36% (M2), 57% (M3) and 63% (M3CC);

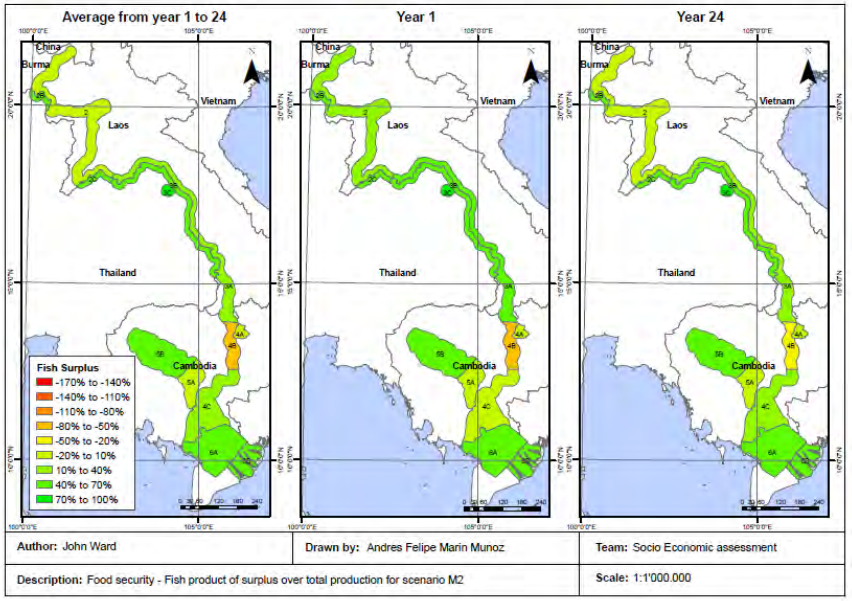
Viet Nam: Fish declines across both Mekong delta zones

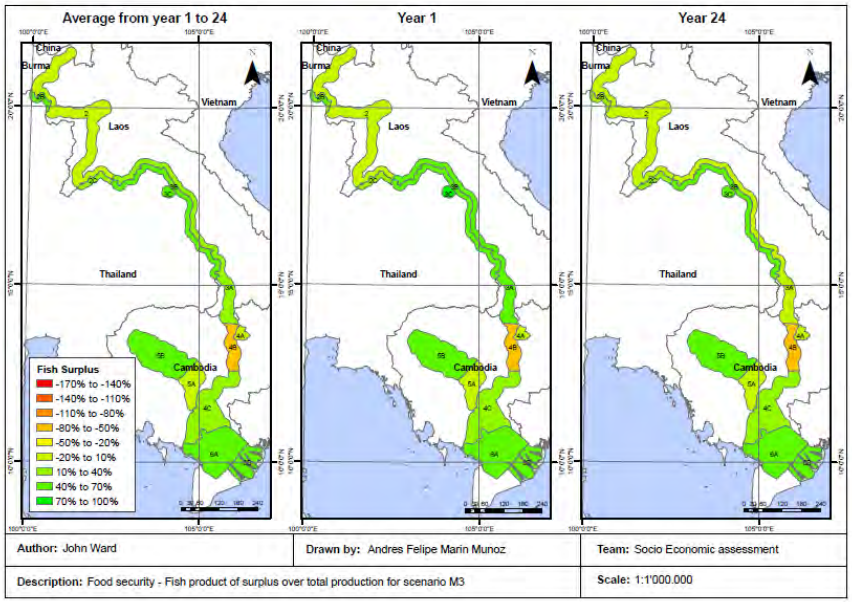
- The declines in fish surpluses were estimated at 27% (M2) to 30% (M3 and M3CC) in the freshwater zone and 32% (M2) to 43% (M3CC) in the saline zone.

The spatial representation of fish surplus of the main development scenarios after meeting food security needs for each of the Corridor zones is illustrated in Figure 8. The maps represent the mean value (%) of years 1-24, year1 and year24.

Figure 8 Fish surplus to meet food security needs: M1, M2, M3 and M3CC (% surplus to total production)







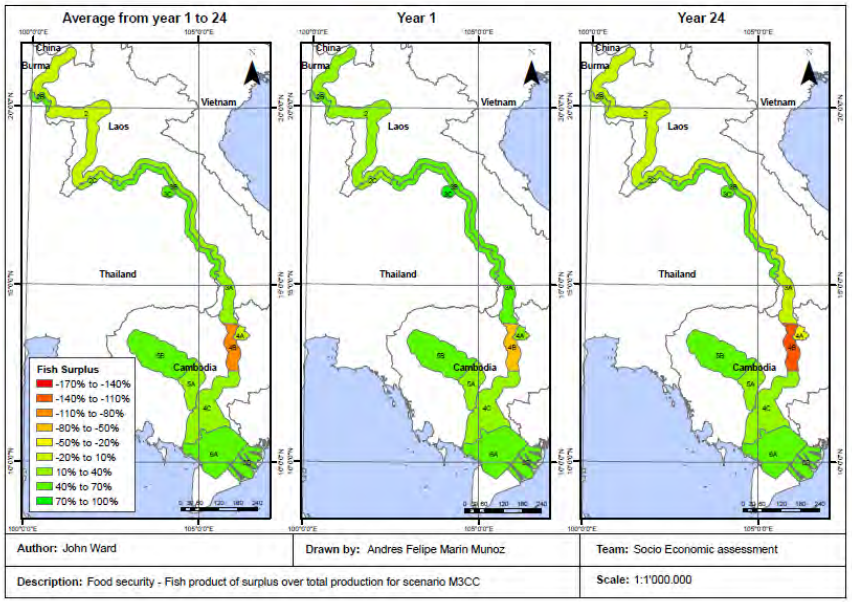


Figure 9 Fish surplus after meeting food security: M1-M3CC by corridor zones

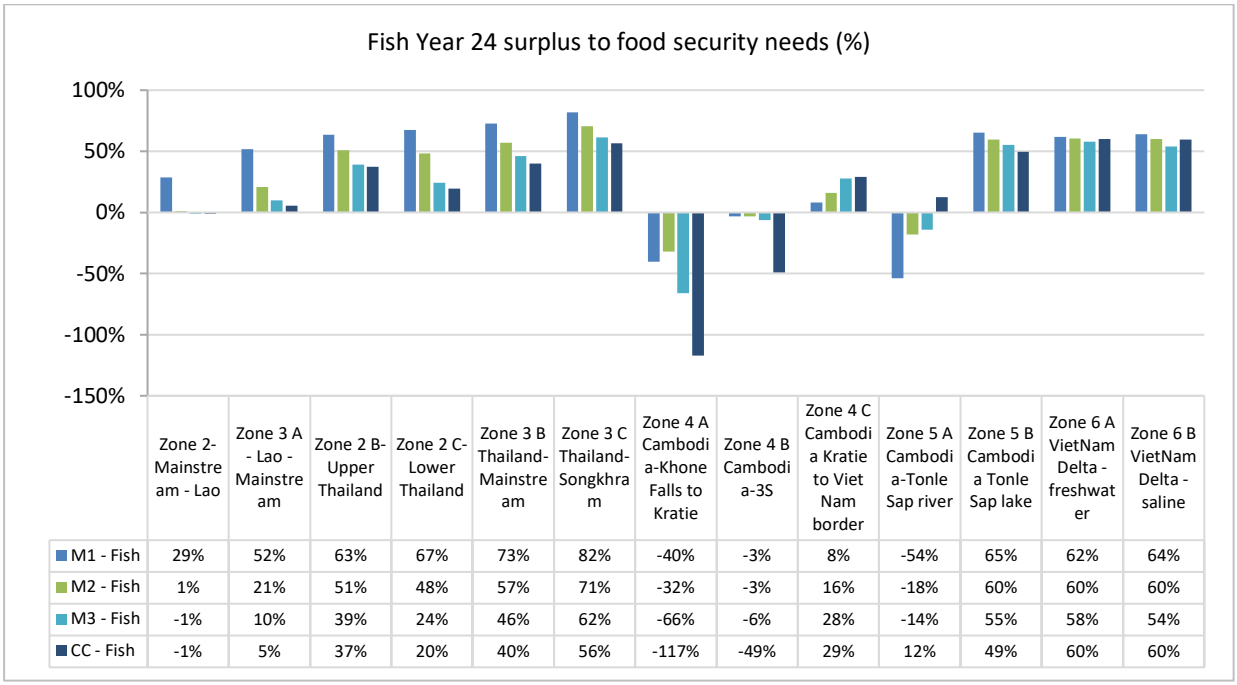


Table 13 Corridor fish production and surplus (mean years 1-24)

Fish	Mean annual production ('000 tonnes)				Mean annual surplus ('000 tonnes)			
SIMVA zones	M1	M2	M3	CC	M1	M2	M3	CC
Zone 2-Mainstream - Lao	36.9	24.2	13.2	12.1	12.8	1.7	-0.1	1.2
Zone 3 A - Lao - Mainstream	105.5	71.4	53.9	50.0	57.5	23.2	7.5	8.8
Zone 2 B-Upper Thailand	10.8	8.3	6.6	6.5	7.1	4.5	2.8	2.7
Zone 2 C-Lower Thailand	12.2	8.7	5.6	5.3	8.2	4.6	1.6	1.2
Zone 3 B Thailand-Mainstream	112.2	78.9	61.9	58.1	78.2	45.0	27.8	23.9
Zone 3 C Thailand-Songkhram	22.0	14.9	11.3	10.5	18.0	10.9	7.2	6.4
Zone 4 A Cambodia-Khone Falls	19.7	16.5	12.3	12.4	-8.5	-10.1	-9.7	-10.1
Zone 4 B Cambodia-3S	4.5	3.7	2.7	2.8	1.4	-0.3	-0.4	-0.4
Zone 4 C Cambodia Kratie to	127.4	102.5	130.9	131.7	5.7	10.3	43.8	44.7
Zone 5 A Cambodia-Tonle Sap	172.4	138.7	111.5	116.9	13.7	6.6	5.8	12.1
Zone 5 B Cambodia Tonle Sap	181.6	154.7	131.0	119.2	127.1	100.3	76.7	64.6
Zone 6 A Viet Nam Delta -	1180.8	1116.6	1074.3	1135.2	762.2	699.0	654.9	715.4
Zone 6 B Viet Nam Delta -	497.7	430.1	385.6	449.7	325.2	258.0	213.9	276.7
Total	2483.7	2169.4	2000.7	2110.2	1408.5	1153.6	1031.9	1147.5

Main findings for changes in rice production surpluses after food security needs met.

Cambodia: Rice

- Khone Falls to Kratie: The M2 rice production declines by 11% and increases by 40% (M3) and 51% (M3CC).
- 3S: rice production declines across all scenarios;
- Kratie to Viet Nam Border: increases from 7% (M2) to 55% (M3CC);

- Tonle Sap River: declines from 61% (M2) to 150% (M3CC) compared to the M1 year 24 surplus;
- Tonle Sap Lake: stable production for M2 and M3, 4% increase estimated for scenario M3CC.

Lao PDR: Rice

- Upper Mainstream: substantial increases of up to 1083% (M3CC) due to rainfed and irrigation rice expansion
- Lower Mainstream: surpluses increase by up to 195% (M3CC).

Thailand: Rice

- Upper mainstream: rice production surplus to food security needs increase by 12% (M2), 29% (M3) and 18% (M3CC) due to mainly irrigation expansion;
- Lower Mainstream: rice production surplus to food security needs increase by 99% (M2), 143% (M3) and 133% (M3CC) due to mainly irrigation expansion;
- Mainstream: rice production surplus to food security needs increase by 49% (M2), 72% (M3) and 62% (M3CC);
- Songkhram: rice production surplus to food security needs declines by 4% (M2), 5% (M3) and 15% (M3CC);

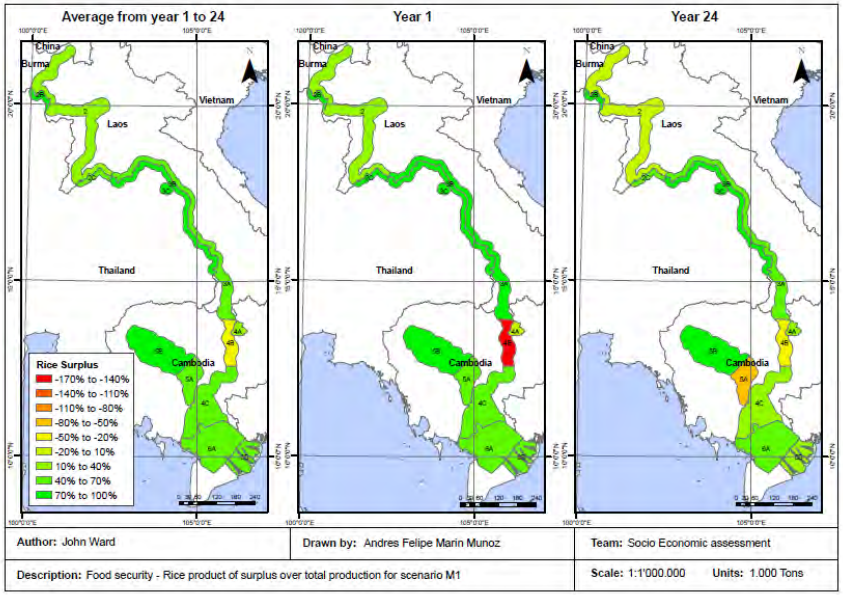
Viet Nam: Rice

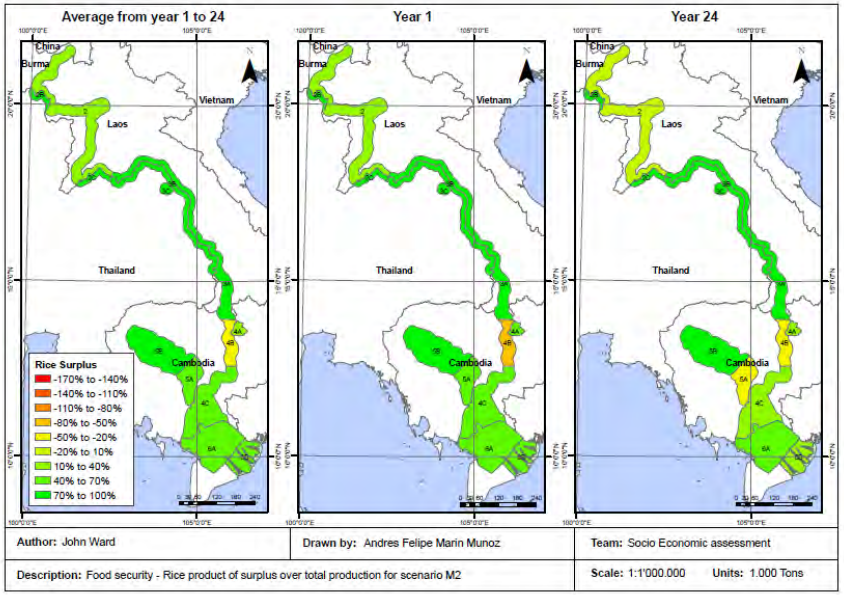
- Rice surpluses in the freshwater zone of the Viet Nam delta declined by 5% in M3 and 1% in M3CC; increased surpluses were predicted for the M3 (1%) and M3CC (16%) in the saline zone.

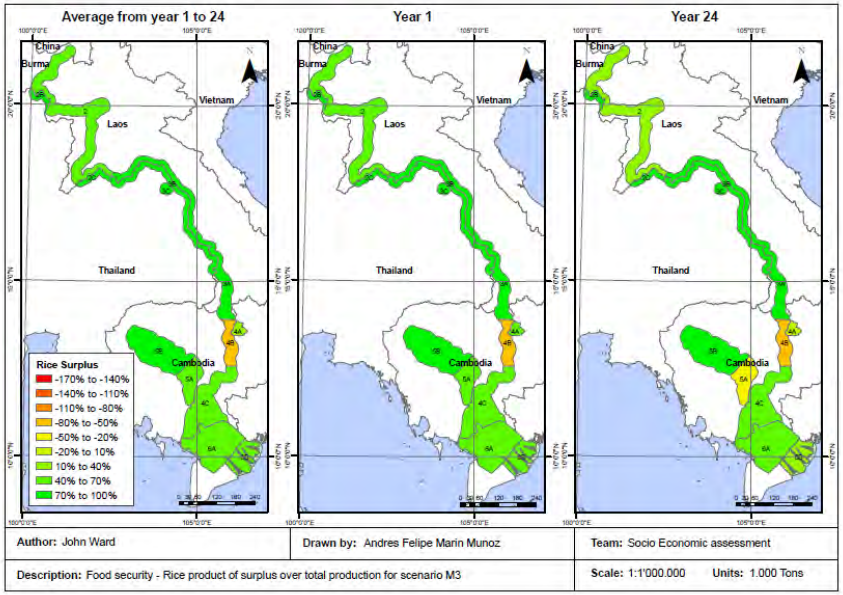
The spatial representation of the main development scenarios of rice surplus after meeting food security needs for each of the Corridor zones is illustrated in Figure 10. The maps represent the mean value (%) of years 1-24, year1 and year24.

The spatial representation of the development sub-scenarios of fish and rice surplus after meeting food security needs for each of the Corridor zones can be found in the Annex (. The maps represent the mean value (%) of years 1-24, year1 and year24 and the production (‘000 tonnes) for the same time periods.

Figure 10 Rice surplus to meet food security needs: M1, M2, M3 and M3CC (% surplus to total production)







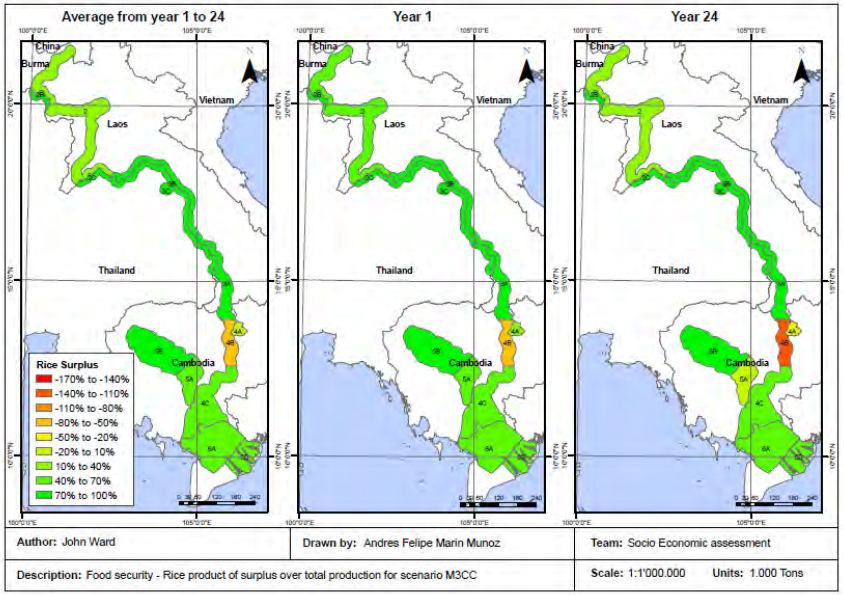
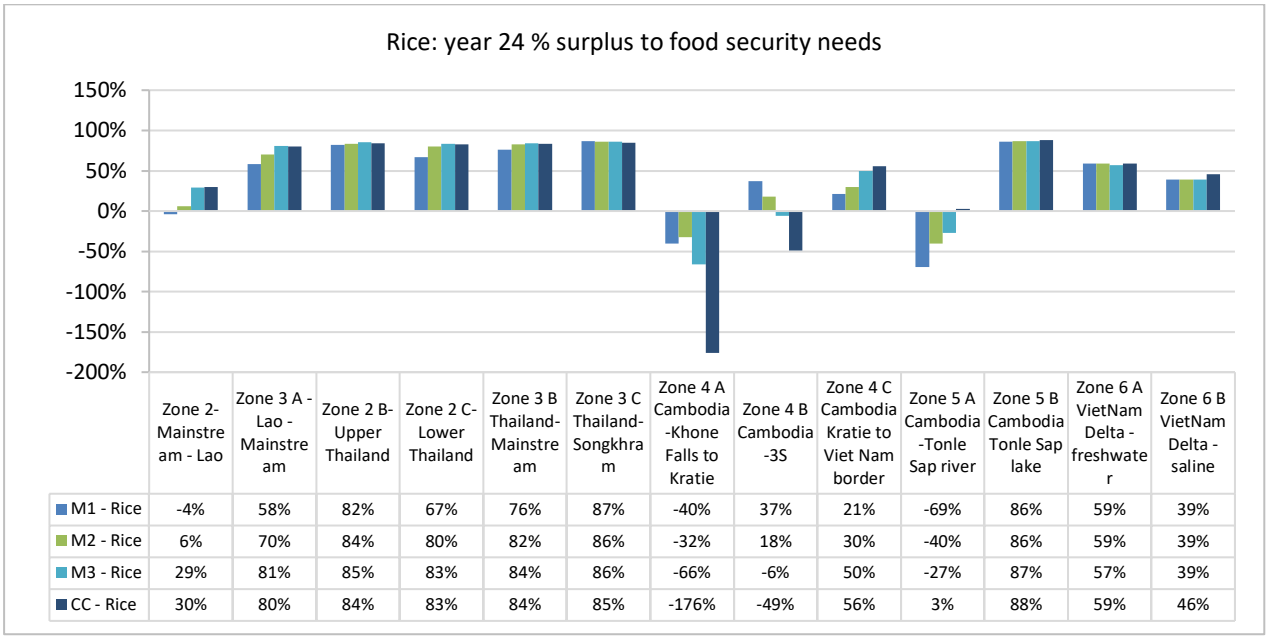


Figure 11 Rice production surplus to food security: M1-M3CC by corridor zones



	Zone 2-Mainstream - Lao	Zone 3 A - Lao - Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia -Khone Falls to Kratie	Zone 4 B Cambodia -3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia -Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta - freshwater	Zone 6 B VietNam Delta - saline
M1 - Rice	-4%	58%	82%	67%	76%	87%	-40%	37%	21%	-69%	86%	59%	39%
M2 - Rice	6%	70%	84%	80%	82%	86%	-32%	18%	30%	-40%	86%	59%	39%
M3 - Rice	29%	81%	85%	83%	84%	86%	-66%	-6%	50%	-27%	87%	57%	39%
CC - Rice	30%	80%	84%	83%	84%	85%	-176%	-49%	56%	3%	88%	59%	46%

Table 14 Corridor rice production and surplus (year 1-24)

Rice	Mean annual production ('000 tonnes)				Mean annual surplus ('000 tonnes)			
SIMVA zones	M1	M2	M3	CC	M1	M2	M3	CC
Zone 2-Mainstream - Lao	98.1	110.6	144.7	133.6	17.7	30.3	62.8	51.3
Zone 3 A - Lao - Mainstream	468.7	624.0	961.3	929.7	309.0	463.3	800.6	768.2
Zone 2 B-Upper Thailand	67.5	74.2	83.0	75.5	56.2	62.8	71.6	64.2
Zone 2 C-Lower Thailand	36.0	60.0	70.5	68.5	24.7	48.6	59.2	57.2
Zone 3 B Thailand-Mainstream	425.7	552.5	617.5	593.4	330.4	457.4	522.1	497.8
Zone 3 C Thailand-Songkhram	78.6	76.2	75.1	73.6	67.3	64.9	63.7	62.2
Zone 4 A Cambodia-Khone Falls	6.5	6.7	6.1	5.8	-2.7	-2.8	-4.0	-4.1
Zone 4 B Cambodia-3S	0.7	0.7	0.8	0.7	0.1	0.3	0.2	0.0
Zone 4 C Cambodia Kratie to	1304.7	1411.4	1838.2	2047.1	555.5	654.6	1075.7	1286.1
Zone 5 A Cambodia-Tonle Sap	404.8	452.3	479.4	535.5	179.9	220.5	242.5	298.9
Zone 5 B Cambodia Tonle Sap	1309.9	1340.8	1349.4	1476.7	1152.5	1183.6	1192.6	1319.0
Zone 6 A Viet Nam Delta -	3932.2	3853.1	3753.0	3830.6	2555.3	2479.6	2373.8	2449.9
Zone 6 B Viet Nam Delta -	1169.6	1168.0	1167.0	1192.2	602.2	601.9	602.3	623.2
Total	9303.1	9730.6	10545.9	10962.8	5848.1	6265.1	7063.0	7474.0

Table 15 % change in surplus available to meet food security, between development scenarios M1, M2, M3 and M3CC; year 24 by corridor zone

	Rice			Fish		
Corridor Zone	M1-M2	M1-M3	M1-M3CC	M1-M2	M1-M3	M1-M3CC
Zone 2 - Mainstream - Lao	70%	253%	189%	-91%	-101%	-92%
Zone 3 A - Lao - Mainstream	50%	159%	149%	-54%	-84%	-85%
Zone 2 B - Upper Thailand	12%	28%	14%	-33%	-68%	-73%
Zone 2 C - Lower Thailand	97%	140%	131%	-47%	-83%	-90%
Zone 3 B - Thailand - Mainstream	38%	58%	51%	-39%	-62%	-69%
Zone 3 C - Thailand - Songkhram	-4%	-5%	-8%	-36%	-57%	-63%
Zone 4 A - Cambodia - Khone Falls to	1%	1%	1%	-22%	-25%	-24%
Zone 4 B - Cambodia - 3S	1%	1%	1%	-1%	-44%	-45%
Zone 4 C - Cambodia - Kratie to Viet	4%	31%	27%	21%	38%	32%
Zone 5 A - Cambodia - Tonle Sap river	13%	21%	22%	-53%	-36%	32%
Zone 5 B - Cambodia - Tonle Sap lake	0%	0%	0%	-20%	-39%	-48%
Zone 6 A - Viet Nam - Mekong Delta -	0%	-4%	-5%	-11%	-12%	-13%
Zone 6 B - Viet Nam - Mekong Delta -	0%	0%	-4%	-27%	-30%	-29%
Overall change	6%	16%	13%	-32%	-46%	-44%

7.2 Annual variance in rice and fish production

Comparing the values and state of the social and economic assessment indicators at the end of the 24-year projection horizon across the water development scenarios is a primary objective of the Council Study. The results of the Modelling team and BioRA indicate the corridor zones are subject to substantial annual variation in flows, sediment and nutrient flux in response to the development scenario conditions. Changes in flows and nutrient partially affects annual fish production and biomass and the potential yields for rice production.

The following section discusses the annual variance of fish and rice production for each of the corridor zones in response to the conditions and factors associated with the four main development scenarios. The corridor zones were collated into country level graphics for ease of interpretation.

Spatial representation of the mean (years 1-24), year1 1nd year 24 of fish and rice production for ('000 tonnes) for the main development scenarios and sub-scenarios can be found in the Annex (Section 9.4).

Cambodia

Fish:

Inter annual declines in fish surpluses were estimated to be greater than 100% for the Khone falls to Kratie zone and greater than 50% for the 3s zone. Substantial declines in fish production and associated surpluses were estimated to occur in years 3, 13 and 19 across all the corridor zones located in Cambodia. Negative surpluses imply that there is insufficient production within the zone to meet the food security needs for the population estimated for a specific year. Surpluses from adjacent zones, when available, were assumed to be available to compensate for production deficits, partially contingent on the capacity of communities within the zone having sufficient resources to purchase imported fish and rice produce.

The substantial fish deficits estimated for all the corridor zones, across all scenarios suggests acute food shortages for Cambodian communities for years 3, 13 and 19. The fish deficits are more acute in the M3 and M3CC scenarios.

Rice:

Similar variance and acute deficits were estimated for rice production, albeit offset by increased and less variable rice production assumed to occur in the proposed irrigated rice expansion in the Kratie to the Viet Nam Border zone. Note that Khone Falls and 3S zones have been omitted in Figure 13: rice production is relatively limited compared to the other Cambodian corridor zones.

Figure 12 Fish surplus to food security: annual variance, Cambodian corridor zones

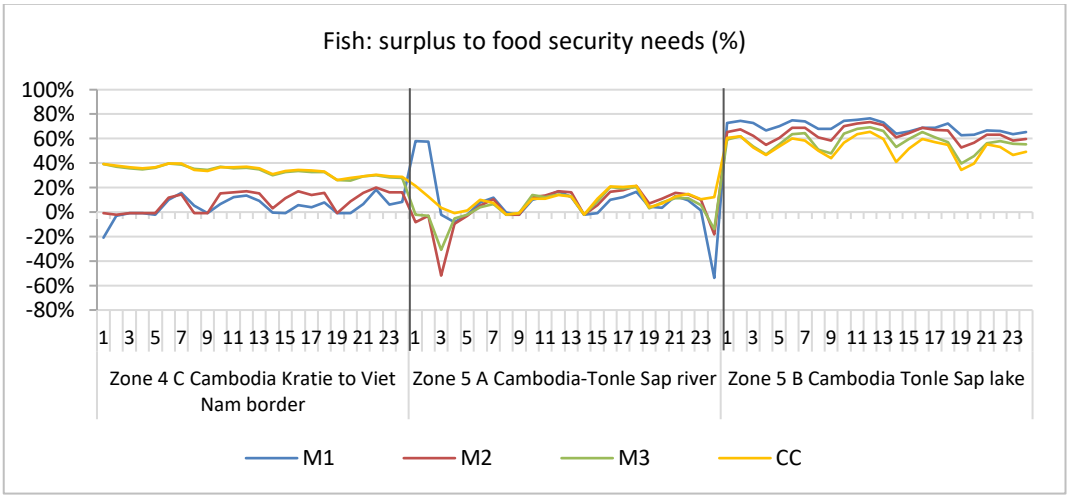


Figure 13 Rice surplus to food security: annual variance, Cambodian corridor zones

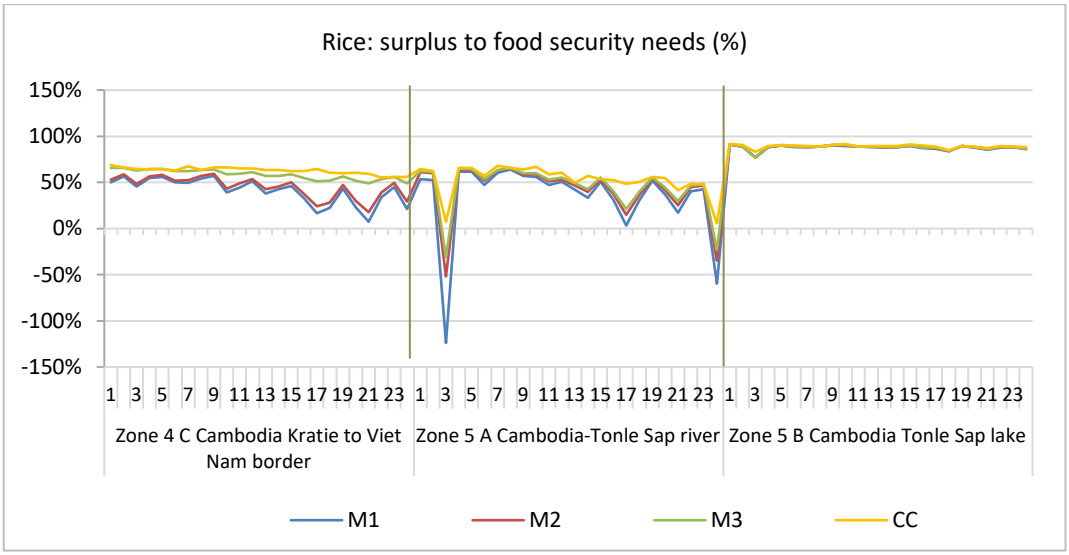


Table 16 %fish and rice production surplus to food security needs: by sub-scenarios (mean years1-24, *Year 24*)

	Zone 4 C Kratie to Viet Nam				Zone 5 A -Tonle Sap river				Zone 5 B Tonle Sap lake			
	Fish		Rice		Fish		Rice		Fish		Rice	
Scenario	Mean 1-24	Yr 24	Mean 1-24	Yr 24	Mean 1-24	Yr 24	Mean 1-24	Yr 24	Mean 1-24	Yr 24	Mean 1-24	Yr 24
M3	34%	*28%*	58%	*49%*	5%	*-14%*	*45%*	*-23%*	57%	*55%*	88%	*87%*
CC	34%	*29%*	63%	*56%*	10%	*12%*	*53%*	*6%*	53%	*49%*	89%	*88%*
C2	34%	*29%*	57%	*42%*	14%	*-20%*	*47%*	*-31%*	58%	*54%*	88%	*86%*
C3	32%	*25%*	57%	*43%*	5%	*-27%*	*47%*	*-32%*	32%	*24%*	88%	*86%*
A1	35%	*29%*	39%	*22%*	4%	*-54%*	*38%*	*-71%*	53%	*50%*	88%	*86%*
A2	34%	*29%*	57%	*42%*	6%	*-16%*	*47%*	*-31%*	53%	*54%*	88%	*86%*
I1	38%	*33%*	57%	*42%*	8%	*-14%*	*47%*	*-31%*	56%	*57%*	88%	*86%*
I2	35%	*30%*	57%	*43%*	8%	*-15%*	*47%*	*-32%*	55%	*56%*	88%	*86%*
F1	34%	*29%*	58%	*49%*	12%	*13%*	*50%*	*-4%*	55%	*55%*	88%	*87%*
F2	34%	*29%*	59%	*50%*	9%	*6%*	*48%*	*-7%*	60%	*60%*	88%	*87%*
F3	34%	*29%*	58%	*49%*	26%	*19%*	*46%*	*-10%*	60%	*61%*	88%	*87%*
H1a	33%	*36%*	59%	*51%*	43%	*42%*	*47%*	*-7%*	68%	*68%*	88%	*87%*
H1b	27%	*27%*	58%	*50%*	32%	*33%*	*48%*	*-6%*	60%	*62%*	88%	*87%*
H3	36%	*30%*	58%	*50%*	27%	*25%*	*47%*	*-8%*	57%	*59%*	88%	*87%*

Lao PDR

Fish:

Fish surpluses are estimated to approach 0% by year 9 of the M2 and year 15 of the M3CC scenarios. Surpluses are estimated at zero from year 1 of the M3 scenario in Zone 2 and year 15 in Zone 3A, exposing communities in the Lao PDR corridor zones to increased vulnerability to shocks that have consequences on food security. Potential protein deficiencies resulting from depleted fish catch are offset by increased livestock production, although the capacity of particularly urban populations to purchase meat and fish is dependent on access to additional paid employment and remains speculative.

Rice:

Rice production and irrigation expansion is estimated to increase across the Lao PDR zones: inter-annual variance is less in the M2-M3CC scenarios mainly due to the increased predictability of irrigated rice paddi. There is a minor increase in rice surplus due to climate change related effects in the upper mainstream zone and no detectable difference between the M3 and M3CC scenarios in Zone 3A mainstream.

Figure 14 Fish surplus to food security: annual variance, Lao PDR corridor zones

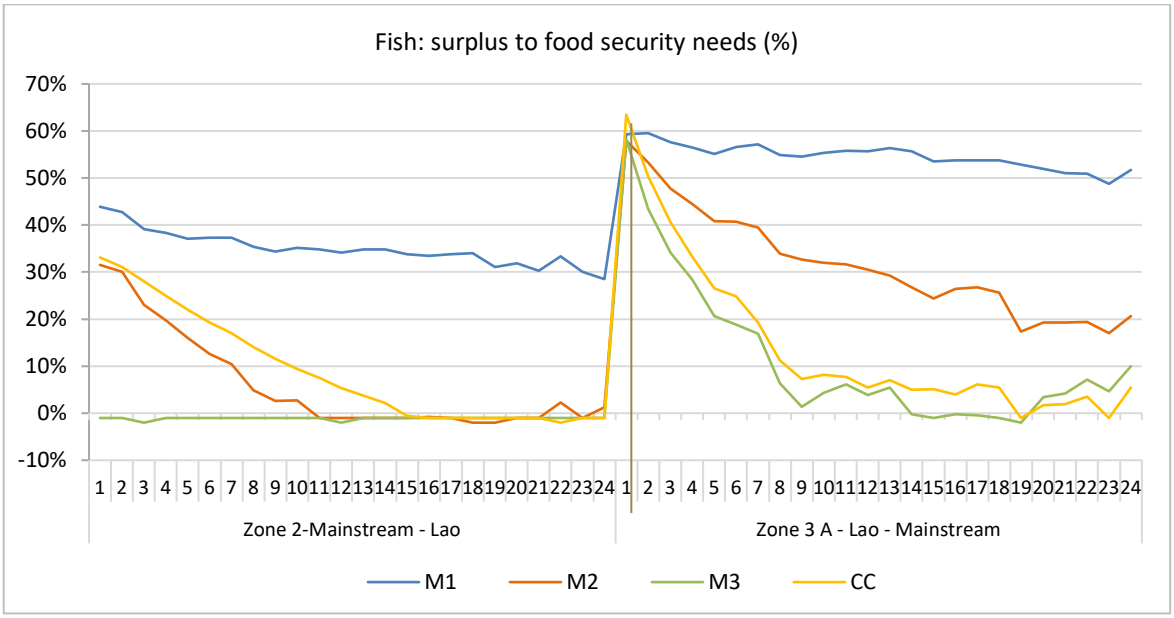


Figure 15 Rice surplus to food security: annual variance, Lao PDR corridor zones

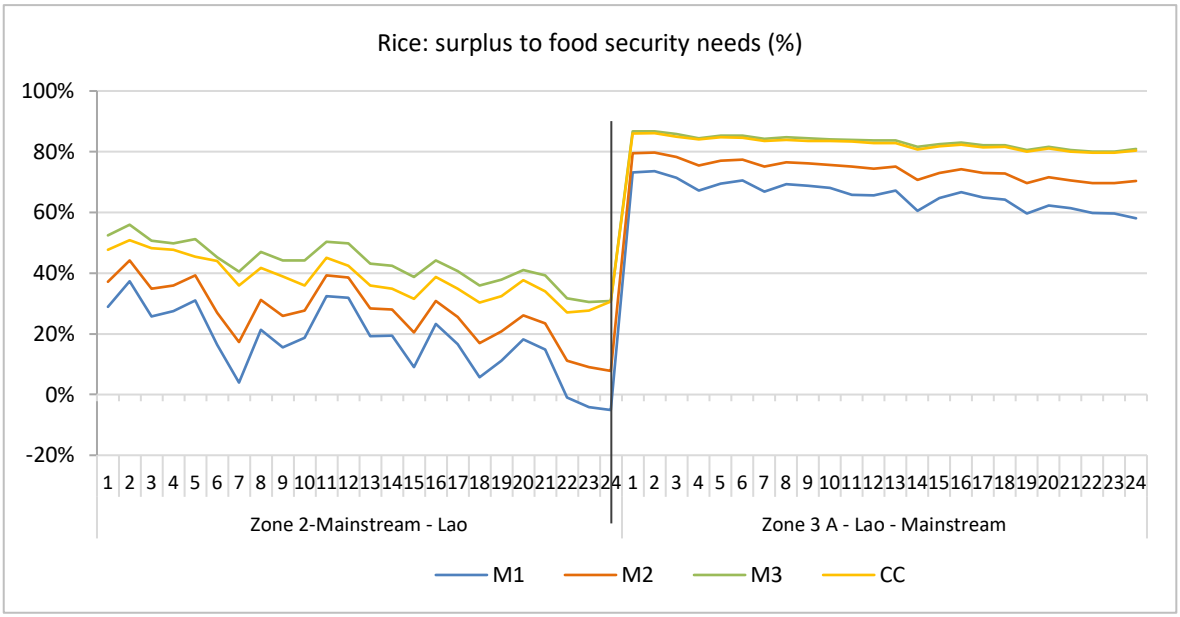


Table 17 % fish and rice production surplus to food security needs: by sub-scenarios (mean years1-24, *Year 24*)

	Zone 2-Mainstream – Lao PDR				Zone 3A-Mainstream - Lao PDR			
	Fish		Rice		Fish		Rice	
Scenario	Mean 1-24	Yr 24	Mean 1-24	Yr 24	Mean 1-24	Yr 24	Mean 1-24	Yr 24
M3	-1%	*-1%*	43%	*31%*	11%	*10%*	83%	*81%*
CC	9%	*1%*	38%	*31%*	14%	*5%*	83%	*80%*
C2	18%	*-1%*	38%	*30%*	20%	*5%*	82%	*80%*
C3	8%	*23%*	36%	*27%*	12%	*6%*	82%	*80%*
A1	33%	*17%*	14%	*-10%*	33%	*23%*	64%	*59%*
A2	31%	*22%*	42%	*30%*	30%	*21%*	83%	*81%*
I1	35%	*19%*	43%	*30%*	32%	*21%*	83%	*81%*
I2	32%	*19%*	43%	*30%*	31%	*20%*	83%	*81%*
F1	33%	*18%*	38%	*31%*	31%	*19%*	82%	*80%*
F2	32%	*19%*	37%	*30%*	30%	*18%*	82%	*80%*
F3	32%	*74%*	37%	*30%*	30%	*18%*	82%	*80%*
H1a	76%	*68%*	38%	*31%*	64%	*62%*	83%	*80%*
H1b	72%	*24%*	38%	*31%*	54%	*48%*	83%	*81%*
H3	36%	*-1%*	37%	*30%*	32%	*22%*	82%	*80%*

Thailand:

Rice:

Rice production in Zone 2C and 3B increases with the proposed M2 and M3 expansion of paddi and conversion of rainfed areas to irrigated land. The oberved varaince of rice production in Zone 3C is a function of climate related effects on rainfed rice cultivation. There is limited irrigation in the Zone across all development scenarios. The M3CC scenario introduces decreases in the surplus rice available after meeting food security needs acorss all Zones.

Fish:

The declines in estimated fish surpluses have similar trajectories as the Lao PDR Zones although surpluses do not approach zero within the 24-year CS time horizon. Minimal population increases compared to Lao PDR and Cambodia coupled with reativey high rates of work migration to major Thai cities limits the overall demand for fish as a protein source in the corridor zoness. The dietary composition of Thai households has trended toward increasing meat products and additional food sources compared top Lao PDR and Cambodia. Viewed through the lens of food and nutritional security the fish losses estimated across the M2, M3 and M3CC development scenarios are unlikely to compromise current nutritional levels. The fish losses do however impose substantial stresses on fishing dependent households and subsistence fishers, currently estimated at approximately 27%-30% of total fish consumption (SIMVA 2015 and 2011).

Figure 16 Fish surplus to food security: annual variance, Thai corridor zones

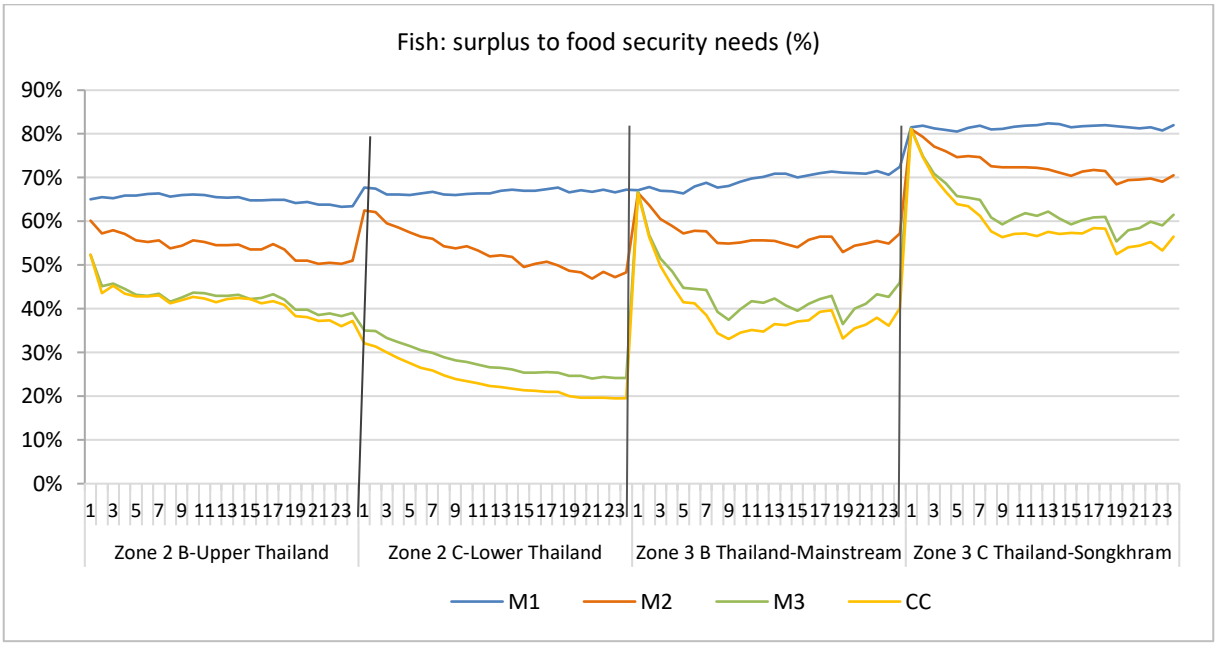


Figure 17 Rice surplus to food security: annual variance, Thai corridor zones

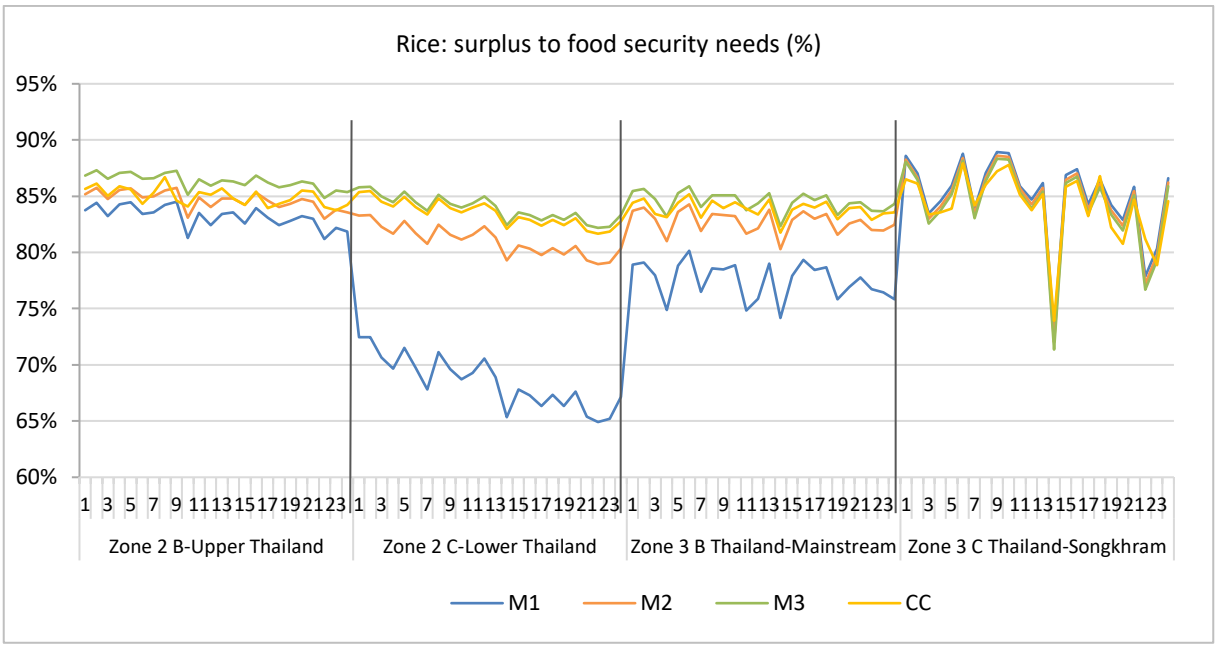


Table 18 % fish and rice production surplus to food security needs: by sub-scenarios (mean years 1-24; Year 24)

	Zone 2B Thailand				Zone 2C Thailand				Zone 3B Thailand				Zone 3C Thailand			
Scenario	Fish		Rice		Fish		Rice		Fish		Rice		Fish		Rice	
	Mean	*Y 24*	Mean	*Y 24*	Mean	*Y 24*	Mean	*Y 24*	Mean	*Y 24*	Mean	*Y 24*	Mean	*Y 24*	Mean	*Y 24*
M3	43%	*39%*	86%	*85%*	84%	*24%*	56%	*83%*	85%	*46%*	64%	*84%*	84%	*62%*	74%	*86%*
CC	42%	*37%*	85%	*84%*	83%	*20%*	54%	*83%*	84%	*40%*	62%	*84%*	84%	*56%*	72%	*85%*
C2	44%	*40%*	85%	*84%*	83%	*20%*	54%	*82%*	84%	*41%*	62%	*83%*	84%	*57%*	72%	*85%*
C3	41%	*36%*	84%	*84%*	83%	*12%*	50%	*83%*	84%	*34%*	59%	*83%*	82%	*50%*	69%	*83%*
A1	41%	*37%*	83%	*82%*	68%	*22%*	47%	*67%*	78%	*43%*	60%	*77%*	85%	*59%*	73%	*87%*
A2	42%	*37%*	86%	*85%*	84%	*19%*	53%	*83%*	84%	*42%*	62%	*84%*	84%	*58%*	72%	*86%*
I1	42%	*37%*	86%	*85%*	84%	*21%*	54%	*83%*	84%	*42%*	63%	*84%*	84%	*58%*	73%	*86%*
I2	41%	*37%*	86%	*85%*	84%	*19%*	53%	*83%*	84%	*42%*	63%	*84%*	84%	*58%*	72%	*86%*
F1	41%	*37%*	85%	*84%*	83%	*19%*	53%	*83%*	84%	*41%*	62%	*84%*	84%	*57%*	72%	*85%*
F2	42%	*37%*	85%	*84%*	83%	*19%*	53%	*83%*	84%	*40%*	62%	*84%*	84%	*56%*	72%	*85%*
F3	42%	*37%*	85%	*84%*	83%	*19%*	53%	*83%*	84%	*40%*	62%	*84%*	84%	*56%*	72%	*85%*
H1a	64%	*62%*	85%	*84%*	83%	*65%*	74%	*83%*	84%	*70%*	75%	*83%*	84%	*80%*	82%	*84%*
H1b	61%	*59%*	85%	*84%*	84%	*58%*	72%	*83%*	84%	*59%*	71%	*84%*	84%	*72%*	79%	*85%*
H3	41%	*37%*	85%	*84%*	83%	*22%*	55%	*83%*	84%	*43%*	63%	*84%*	84%	*58%*	73%	*85%*

Viet Nam

Rice:

Water, land and infrastructure limits on the potential for irrigation expansion combined with changing rice production to upland crops and cash crops implies that rice production is anticipated to decline across the 24-year CS time horizon for the M1 scenario. The attributes of the M2, M3 and M3CC scenarios have a relatively negligible effect on the expected yields in the freshwater Zone 6A and 3%-10% in the saline Zone 6B a likely affect of less irrigated paddi in the latter. There are relatively minor variations ascribed to the M3CC scenario compared to the M3 development scenario.

Fish:

Fish surpluses decline across the 24-year time horizon (a function of decreasing fish biomass and increasing population) across all development scenarios. The additional reductions observed for the M2, M3 and M3CC scenarios are approximately 5% (year 1) to 10% (year 24) in Zone 6A. Fish surpluses are subject to increasing variation in the 6B Zone, with up to 10% annual variance in the M1 sceanrio. The M2, M3 and M3CC scenarios consistently reduce fish surpluses by 12-15% compared to the M1 baseline and introduce similar inter annual variation.

Figure 18 Fish surplus to food security: annual variance, Viet Nam corridor zones

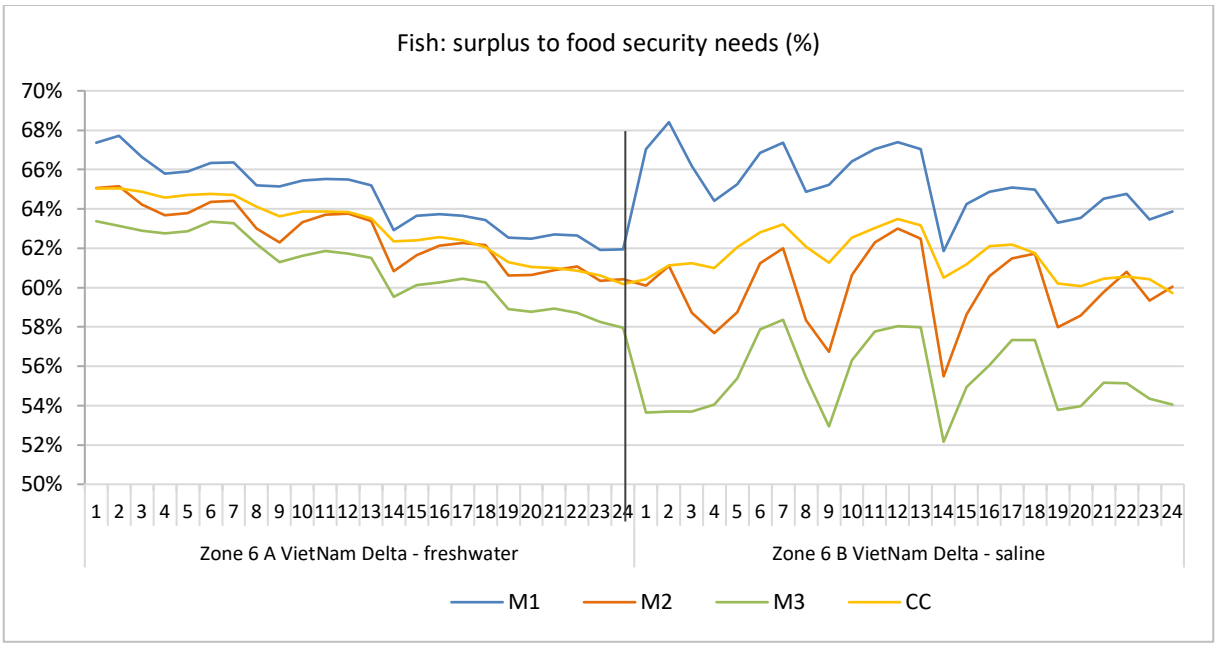


Figure 19 Rice surplus to food security: annual variance, Viet Nam corridor zones

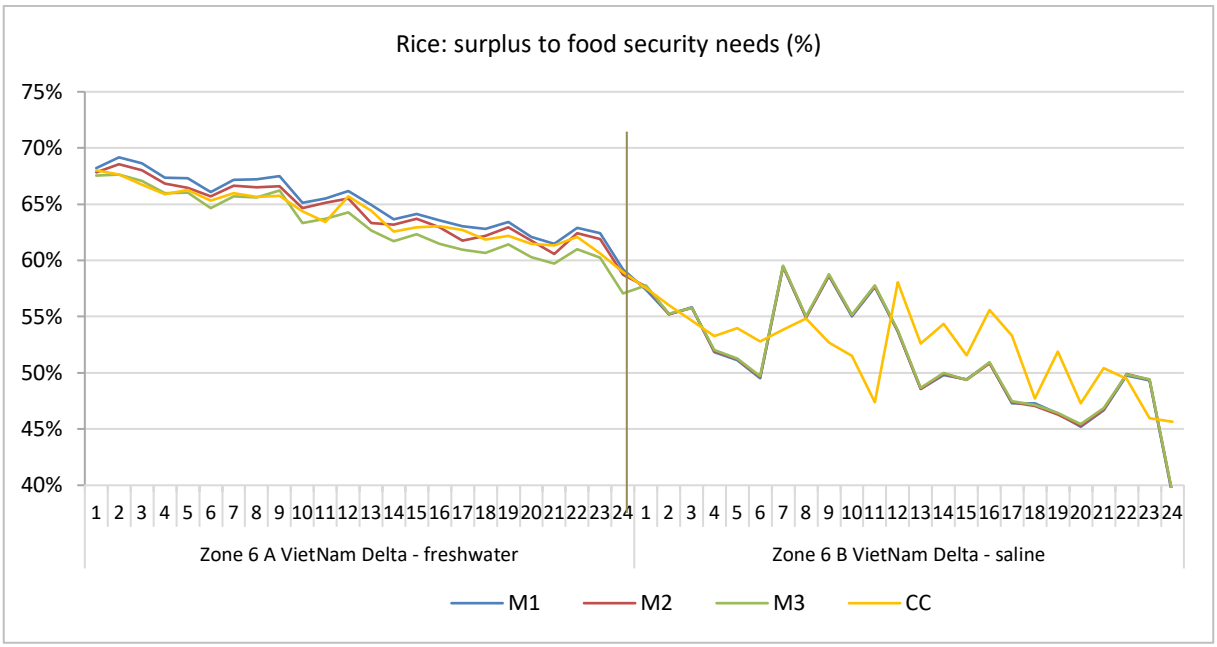


Table 19 % fish and rice production surplus to food security needs: by sub-scenarios (mean years1-24; *Year 24*)

	Zone 6 A Viet Nam Delta - freshwater				Zone 6 B Viet Nam Delta - saline			
Scenario	Fish		Rice		Fish		Rice	
	Mean 1-24	Year 24	Mean 1-24	Year 24	Mean 1-24	Year 24	Mean 1-24	Year 24
M3	*61%*	*62%*	63%	*59%*	55%	*64%*	51%	*39%*
CC	63%	*60%*	64%	*59%*	62%	*60%*	52%	*39%*
C2	64%	*58%*	62%	*57%*	63%	*54%*	51%	*39%*
C3	62%	*60%*	63%	*59%*	60%	*60%*	51%	*46%*
A1	63%	*61%*	63%	*51%*	62%	*61%*	51%	*38%*
A2	63%	*60%*	62%	*51%*	61%	*58%*	51%	*38%*
I1	63%	*60%*	62%	*52%*	62%	*60%*	51%	*39%*
I2	63%	*60%*	63%	*51%*	62%	*59%*	51%	*38%*
F1	63%	*60%*	60%	*51%*	62%	*60%*	53%	*38%*
F2	62%	*60%*	60%	*51%*	58%	*60%*	52%	*38%*
F3	63%	*60%*	60%	*53%*	60%	*60%*	53%	*45%*
H1a	66%	*59%*	60%	*54%*	68%	*57%*	52%	*44%*
H1b	64%	*60%*	58%	*53%*	65%	*58%*	52%	*45%*
H3	63%	*63%*	63%	*54%*	61%	*65%*	52%	*44%*

7.3 Subsistence production, consumption and food security

Chambers and Conway (1992 p.1) defined a sustainable livelihood as one comprising of "the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base". The assets referred to include tangible assets and resources as well as intangible assets such as claims and access (Krantz, 2001). Specifically, the five types of assets are: social, human, physical, financial and natural. Thus, a livelihood system encompasses such things as cash income, non-cash exchanges, self-produced items, property rights and social relations (Ellis, 1998), with the expected outcomes of improved and sustained human wellbeing.

The livelihoods system concept has largely evolved in a development context, to inform the twin goals of improving equity and prosperity of poor communities whilst maintaining or improving the environmental condition of the spaces they operate within (Chambers and Conway, 1992; Scoones, 1998). Importantly, use of the term 'livelihood' became popular in the development literature as a more encompassing alternative to singular terms such as income, subsistence and employment (Ellis, 2000). Cook and Gichuk, (2007) the World Bank (2009) and Ward and Kaczan (2014) contend that accounting for subsistence livelihoods and production and monetary equivalence is an important measure in substantial, non-market and hybrid agricultural economies such as the Lower Mekong Basin. Monetary poverty measures often fail to reflect the multiple dimensions of poverty and failure to at minimum account for subsistence production underestimates the productivity of traditional agricultural systems and contributions to national GDP calculations.

Total household income in hybrid agricultural economies can be disaggregated into three classes: farm, off-farm and subsistence income. Ward et al. (2016) and the EMRF (2012) programme assessed livelihoods in the Nam Xong Basin Lao PDR and LMB respectively including estimates of subsistence income. Subsistence income was estimated as the monetised value of farm production used by the

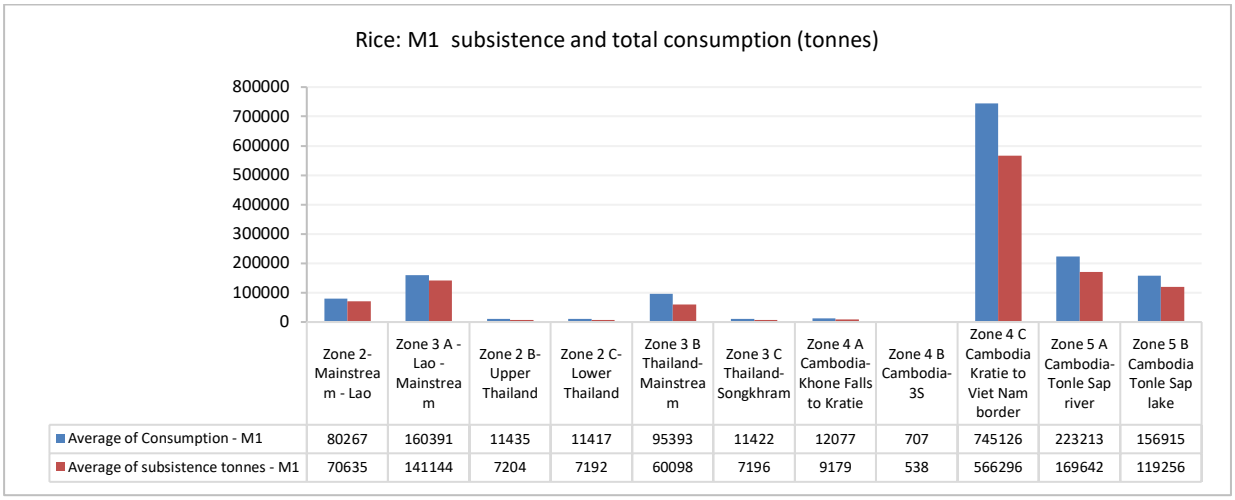
household for home consumption, calculated from the reported value of produce sold at market, or if no produce was sold by the respondent, from the mean of produce sold by adjacent households.

Median annual 2012-13 subsistence incomes were estimated at US$ 853 for the Tonle Sap; US$1738 in the Nam Ngum; US$2321 and US$ 641 in the Viet Nam delta.

The first step of accounting subsistence income is to derive the relative proportion of subsistence production. For example, of the 5950 respondents in the EMRF and Nam Xong surveys (2012 and 2016 respectively) 88% of Lao respondents reported growing rice for their own consumption; 76% in Cambodia; 63% in Thailand and 14% in Viet Nam. Forty nine percent of Lao PDR respondents in the SIMVA survey (2015) reported catching their own fish; 71% in Cambodia; 24% in Thailand and 62% in Viet Nam. Application of the field based subsistence proportions to the CS rice and fish production estimates are illustrated in Figure 20 and Figure 21. Viet Namese fish and rice production dominates total corridor production and have been omitted from the graphs to facilitate easier interpretation.

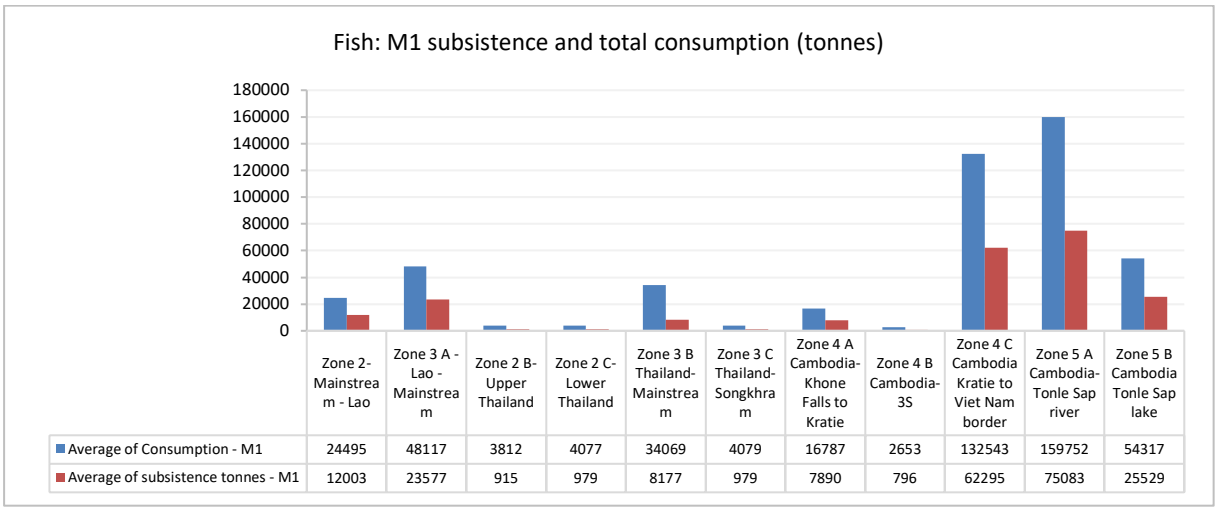
The estimated proportions of the value of corridor subsistence rice and fish production/consumption are 34% and 59% respectively (Table 21).

Figure 20 Rice consumption: corridor consumption and by consumption of own produce. M1 Year1



	Zone 2-Mainstream - Lao	Zone 3 A - Lao - Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake
Average of Consumption - M1	80267	160391	11435	11417	95393	11422	12077	707	745126	223213	156915
Average of subsistence tonnes - M1	70635	141144	7204	7192	60098	7196	9179	538	566296	169642	119256

Figure 21 Fish and OAA consumption: corridor consumption and by consumption of own produce. M1 Year1



	Zone 2-Mainstream - Lao	Zone 3 A - Lao - Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake
Average of Consumption - M1	24495	48117	3812	4077	34069	4079	16787	2653	132543	159752	54317
Average of subsistence tonnes - M1	12003	23577	915	979	8177	979	7890	796	62295	75083	25529

Table 20 Comparison of the M1 value of rice and fish and subsistence consumption

	Rice (US$)		Fish (US$)	
SIMVA Zone	M1 total	Subsistence	M1 total	Subsistence
	Mean (years 1-24) US$ '000			
Zone 2-Mainstream - Lao	191,462	124,660	141,659	69,413
Zone 3 A - Lao - Mainstream	437,236	373,853	424,833	208,168
Zone 2 B-Upper Thailand	46,755	39,172	62,178	14,923
Zone 2 C-Lower Thailand	24,965	44,990	71,413	17,139
Zone 3 B Thailand-Mainstream	294,833	441,196	700,311	168,075
Zone 3 C Thailand-Songkhram	54,457	86,815	137,802	33,072
Zone 4 A Cambodia-Khone Falls to Kratie	10,105	47,188	62,089	44,083
Zone 4 B Cambodia-3S	731	10,480	13,790	9,791
Zone 4 C Cambodia Kratie to Viet Nam border	1,770,421	329,478	433,524	307,802
Zone 5 A Cambodia-Tonle Sap river	474,188	420,073	552,727	392,436
Zone 5 B Cambodia Tonle Sap lake	1,480,909	428,674	564,045	400,472
Zone 6 A Viet Nam Delta - freshwater	4,189,152	763,449	5,453,209	3,380,990
Zone 6 B Viet Nam Delta - saline	878,830	198,418	1,417,272	878,709
Total	9,754,043	3,308,447	10,034,853	5,925,073

7.4 Undernourishment as a measure of food insecurity

The FAO measure of food deprivation and levels of food-nutritional security is referred to as the prevalence of undernourishment.[9] The measure is based on a comparison of usual food consumption expressed in terms of dietary energy (kcal/day/capita) with certain energy requirement norms. The part of the population with food consumption below the energy requirement norm is considered undernourished. The focus on dietary energy in assessing undernourishment focuses on maintain a sufficient minimum amount of dietary energy intake for body weight maintenance and work performance; and second, increased dietary energy, if derived from normal staple foods, brings with it more protein and other nutrients. The FAO calculations for undernourishment address and account for the average for groups of individuals of the same age, sex, body weight and physical activity. This means that even after taking into account the most influential factors such as age, sex, body weight and activity, differences exist in the energy requirement of individuals. FAO addresses variation through analysis of randomly sampled household consumption data and sophisticated statistical analysis.

A central assumption of undernourishment estimates for the corridor zones is changes in rice and food production translate directly to changes in nutritional security. Factors such as food affordability, access to safe water and sanitation, food distribution systems, gender differences, Gini coefficients, social norms and levels of household vulnerability. Accounting for these factors requires an expanded time series data set specific to the corridor and a dynamic modelling approach: both are currently limited in the portfolio of MRC datasets and modelling capacity.

As a first step to derive corridor level proportions of undernourished people, the FAO estimates of the % of the population undernourished the four LMB countries were regressed with national rice and fish

[9] http://www.fao.org/docrep/005/Y4249E/y4249e06.htm

production (tonnes) from 2007-2014[10]. Second a scaling factor to calibrate corridor rice and fish production with national production was estimated. Details of the scaling factors and corridor coefficients are presented in the Appendices, Section 9.1. Third undernourishment levels (% of population) were calculated for the corridor zones at year 24 for all the main and sub-scenarios[11]. The percent values were converted to the number of affected people and households using the zone population estimates and the median household size (SIMVA 2015).

The number of corridor zone households and the % of the zone population are reported in Table 22 and Table 23. The number of undernourished households are substantially lower in Thailand (M1: 9%) compared to Lao PDR, Cambodia and Viet Nam (M1: 23%, 18% and 18% respectively). The number of undernourished households increase in the M2 scenario by 3.5% in the Lao PDR zones and 2-3% in Thailand and 6% in Lao PDR in the M3 scenario. The number of undernourished households decline in the M3 scenario in Zone 3A (Lao PDR) and decline or are unchanged in Thailand.

The % change in undernourished households are less in Cambodia and Viet Nam compared to Lao PDR across the main scenarios. Lao PDR and the Viet Nam delta are the most sensitive to the changes in production associated with the C2 and C3 climate change scenarios.

Overall the proportional changes across the scenarios are greatest in Lao PDR.

Table 21 Number and % of total population undernourished: Lao PDR and Thai corridor zones

	Zone 2- Lao		Zone 3 A - Lao		Zone 2 B Thailand		Zone 2 C- Thailand		Zone 3 B Thailand		Zone 3 C Thailand	
	Undernourished											
Development Scenario	H/holds	%	H/holds	%	H/holds	%	H/holds	%	H/holds	%	H/holds	%
M1	28,305	23.0%	49,919	22.5%	2,319	9.2%	2,003	8.9%	15,422	9.8%	1,841	8.8%
M2	34,031	27.6%	57,749	26.0%	2,720	10.8%	1,693	7.5%	16,829	10.7%	2,617	12.5%
M3	35,806	29.1%	55,947	25.2%	2,796	11.1%	1,647	7.3%	16,874	10.7%	2,900	13.8%
CC	36,215	29.4%	57,910	26.1%	3,027	12.0%	1,820	8.1%	18,437	11.7%	3,138	14.9%
C2	36,185	29.4%	58,121	26.2%	2,967	11.8%	1,858	8.2%	18,889	12.0%	3,094	14.7%
C3	37,106	30.1%	59,415	26.8%	3,098	12.3%	1,911	8.5%	19,278	12.2%	3,357	16.0%
A1	38,324	31.1%	65,021	29.3%	3,322	13.2%	3,352	14.9%	22,449	14.2%	2,877	13.7%
A2	36,258	29.4%	57,073	25.7%	2,838	11.3%	1,713	7.6%	17,522	11.1%	2,979	14.2%
I1	36,098	29.3%	57,044	25.7%	2,837	11.3%	1,683	7.5%	17,491	11.1%	2,976	14.2%
I2	36,204	29.4%	57,052	25.7%	2,838	11.3%	1,706	7.6%	17,511	11.1%	2,977	14.2%
F1	36,196	29.4%	57,726	26.0%	3,027	12.0%	1,817	8.1%	18,344	11.6%	3,125	14.9%
F2	36,214	29.4%	57,910	26.1%	3,027	12.0%	1,820	8.1%	18,437	11.7%	3,138	14.9%
F3	36,214	29.4%	57,943	26.1%	3,027	12.0%	1,820	8.1%	18,454	11.7%	3,140	14.9%
H1a	27,210	22.1%	44,876	20.2%	2,127	8.5%	633	2.8%	12,197	7.7%	2,250	10.7%
H1b	29,744	24.1%	50,715	22.9%	2,297	9.1%	907	4.0%	15,154	9.6%	2,697	12.8%
H3	35,924	0.292	57,351	25.9%	3,027	12.0%	1,781	7.9%	18,171	11.5%	3,097	14.7%

[10] R^2 values were > 0.61, F values were significant (p<0.001) and the t values of rice and fish coefficients were significant (p<0.05).

[11] Adjusted Adjusted R^2 values were > 0.62, VIF were <5.1 F values were significant (p<0.05), and the t values of rice and fish coefficients significant (p<0.05).

Table 22 Number and % of total population undernourished: Cambodia and Viet Nam corridor zones

	Zone 4 A Cambodia		Zone 4 B Cambodia		Zone 4 C Cambodia		Zone 5 A Cambodia		Zone 5 B Cambodia		Zone 6 A VietNam Delta		Zone 6 B VietNam Delta	
	Undernourished													
Development Scenario	H/holds	%	H/holds	%	H/holds	%	H/holds	%	H/holds	%	H/holds	%	H/holds	%
M1	4,222	17.7%	335	18.2%	203,651	18.7%	67,699	17.9%	44643	18.0%	324353	16.0%	155775	17.8%
M2	4,351	18.3%	347	18.9%	208,811	19.2%	70,461	18.6%	46253	18.7%	329360	16.3%	155788	17.8%
M3	4,650	19.5%	366	19.9%	201,652	18.6%	74,098	19.6%	47259	19.1%	340375	16.8%	156004	17.9%
CC	4,698	19.7%	369	20.1%	200,342	18.4%	72,780	19.2%	48160	19.4%	325541	16.1%	138643	15.9%
C2	4,701	19.7%	368	20.1%	201,973	18.6%	73,544	19.4%	47553	19.2%	384814	19.0%	157643	18.0%
C3	4,710	19.8%	371	20.2%	203,718	18.7%	75,282	19.9%	50965	20.6%	384814	19.0%	157643	18.0%
A1	4,648	19.5%	366	19.9%	202,413	18.6%	73,024	19.3%	48191	19.4%	377014	18.6%	157643	18.0%
A2	4,652	19.5%	367	20.0%	201,447	18.5%	73,245	19.3%	47413	19.1%	384814	19.0%	157643	18.0%
I1	4,649	19.5%	365	19.9%	199,404	18.3%	73,462	19.4%	46859	18.9%	384814	19.0%	157643	18.0%
I2	4,648	19.5%	366	20.0%	201,443	18.5%	73,642	19.4%	46974	18.9%	384814	19.0%	157643	18.0%
F1	4,699	19.7%	369	20.1%	200,773	18.5%	71,380	18.8%	47127	19.0%	367903	18.2%	140839	16.1%
F2	4,699	19.7%	369	20.1%	200,734	18.5%	73,842	19.5%	46187	18.6%	366777	18.1%	142551	16.3%
F3	4,699	19.7%	369	20.1%	200,903	18.5%	72,174	19.0%	45958	18.5%	370169	18.3%	140976	16.1%
H1a	4,306	18.1%	338	18.4%	196,432	18.1%	66,493	17.5%	43589	17.6%	366777	18.1%	142551	16.3%
H1b	4,390	18.4%	348	18.9%	202,081	18.6%	68,988	18.2%	45604	18.4%	384725	19.0%	143317	16.4%
H3	4,718	19.8%	368	20.1%	200,341	18.4%	72,109	19.0%	46376	19%	347823	17.2%	143133	16%

The analysis of undernourished households allowed an estimation of the change in fish and rice production and the corresponding change in the number household defined as undernourished[12].

A reduction in the M1, M2 and M3CC fish production of 3800 tonnes corresponds to additional 1000 households defined as undernourished: 1000 households are affected with a change of 3300 tonnes of fish production in the M3 scenario. The substantial reduction in fish catch and surplus in the Lao PDR corridor zones, described in the food security section, are a possible factor explaining the higher levels of sensitivity of undernourished households to changes in rice and fish availability.

An increase of 12500 tonnes of rice production corresponds to 1000 less households defined as undernourished, the M1, M2, M3 and M3CC development scenarios.

The estimated effects of changing fish and rice production (mean value over 24-years) for each development scenario and the corresponding effects on the levels of undernourishment at Corridor zone are illustrated in Figure 22 (Lao PDR), Figure 23 (Thailand), Figure 24 (Cambodia) and Figure 25 (Viet Nam). The estimated number of undernourished households represents the combined effect of scenario specific production levels of fish and rice.

The sub-scenarios had a relatively minor effect on undernourishment levels, except H1a and A1. Sub-scenarios A1 and H1a indicate specific changes to rice and mainstream dams (and corresponding fish catch) while holding all other development investments constant. In A1, rice production approximates M1 production and all other development investments correspond with M3. The H1a scenario holds all investments constant for M3, except mainstream dams, which revert to M1 levels, and approximate fish production. The changes in A1 rice and H1A fish production and the corresponding change in the number of undernourished households compared to M3 values are summarized in Table 24. For example a reduction of 50,526 tonnes of rice and an increase of 24,208 tonnes of fish correspond to an increase of 12,331 undernourished households and a decrease 8,771 respectively in Lao PDR zone 2.

[12] R^2 values > 0.63, F and *t* values significant (p<0.001, p,0.05).

Table 23 Changes in rice, fish and undernourished households in sun scenarios A1 and H1A compared to M3.

	M3 (mean 24 years)			Scenario A1		Scenario H1A	
	Rice (tonnes, mean 24 years)	Fish (tonnes, mean 24 years)	Number undernourished HHs	Rice (tonnes): change from M3	Number undernourished HHs	Fish (tonnes): change from M3	Number undernourished HHs
Zone 2- Lao PDR	139,791	12,993	35,806	-50526	12331	24208	-8771
Zone 3 A - Lao PDR	993,786	54,992	55,947	-530304	44843	49861	-11872
Zone 2 B Thailand	84,725	6,778	2,796	-16121	512	4089	-622
Zone 2 C- Thailand	74,088	5,827	1,647	-36950	1655	6748	-821
Zone 3 B Thailand	617,274	64,066	16,874	-194008	5422	48670	-4244
Zone 3 C Thailand	88,157	11,557	2,900	4278	-21	10345	-572
Zone 4 A Cambodia	7,633	13,295	4,650	-35	13	7782	-631
Zone 4 B Cambodia	775	2,967	366	-48	7	1813	-48
Zone 4 C Cambodia	1,725,381	139,889	201,652	-595094	38152	17872	-7849
Zone 5 A Cambodia	222,752	118,286	74,098	-75297	4837	75596	-11608
Zone 5 B Cambodia	1,358,374	141,075	47,259	-78048	972	56859	-5627
Zone 6 A VietNam Delta	3,574,789	1,109,790	340,375	-383538	36674	129054	-10770
Zone 6 B VietNam Delta	1,031,259	414,347	156,004	-12236	1641	135862	-12024

Figure 22 Undernourishment in Lao PDR Corridor zones by mean rice and fish production across development scenarios

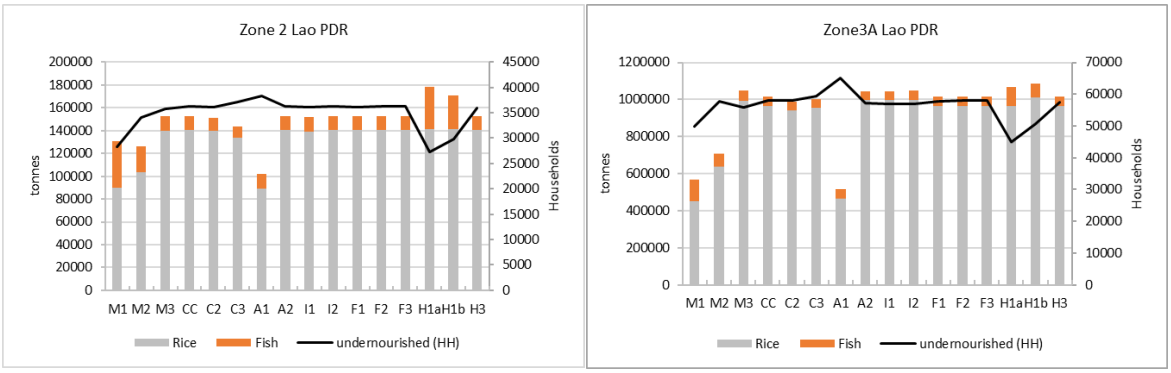


Figure 23 Undernourishment in Thai Corridor zones by rice and fish production across development scenarios

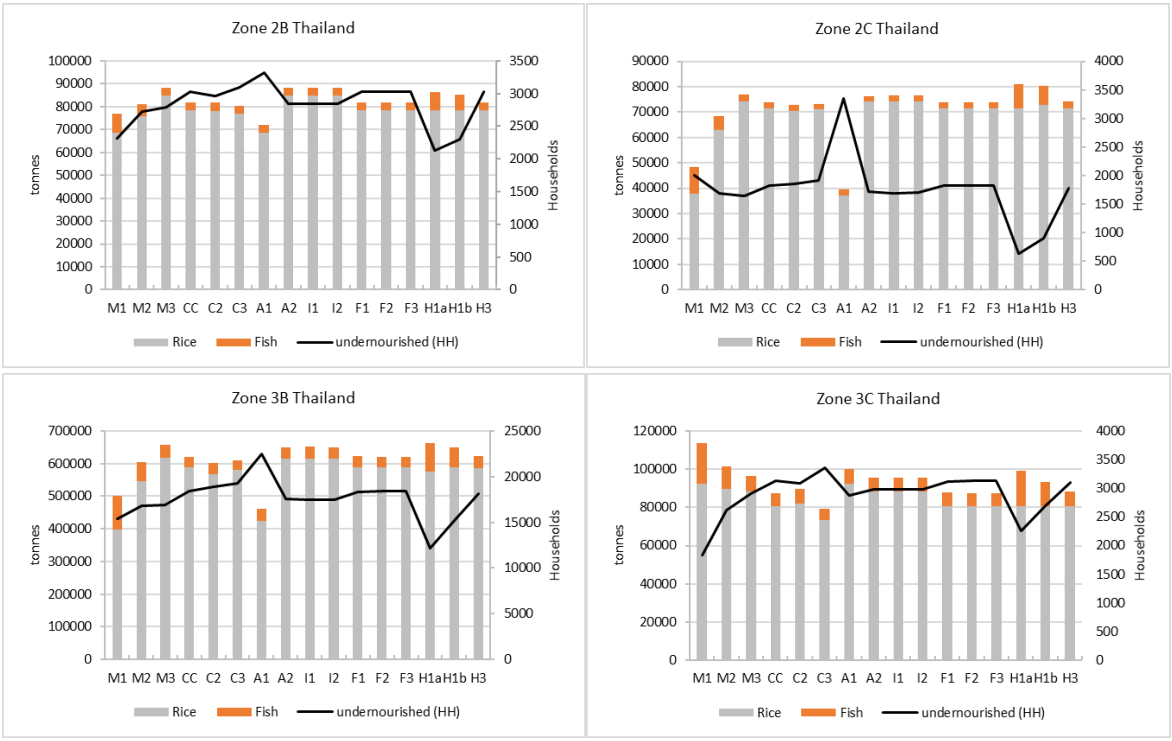


Figure 24 Undernourishment in Cambodian Corridor zones by rice and fish production across development scenarios

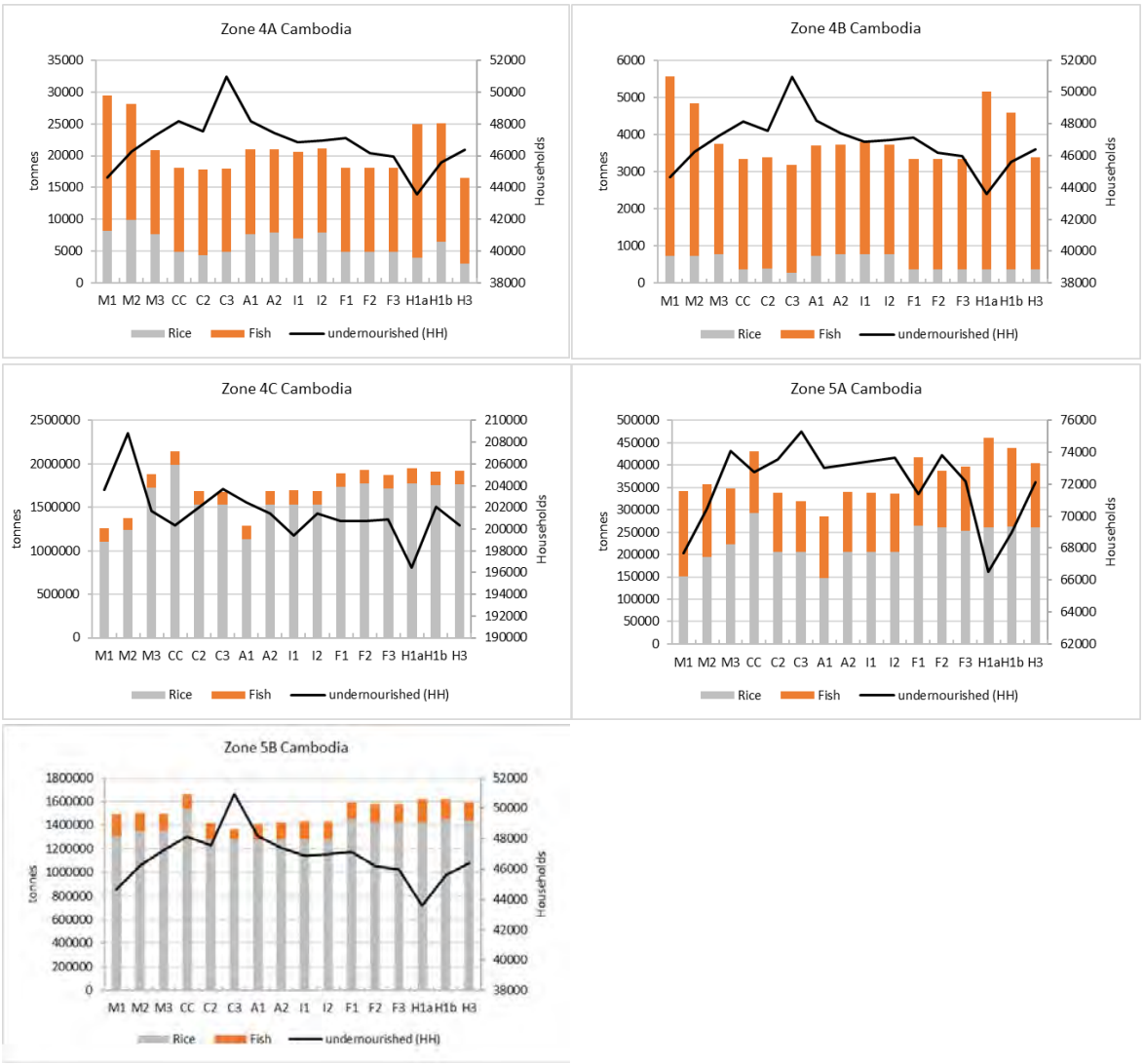
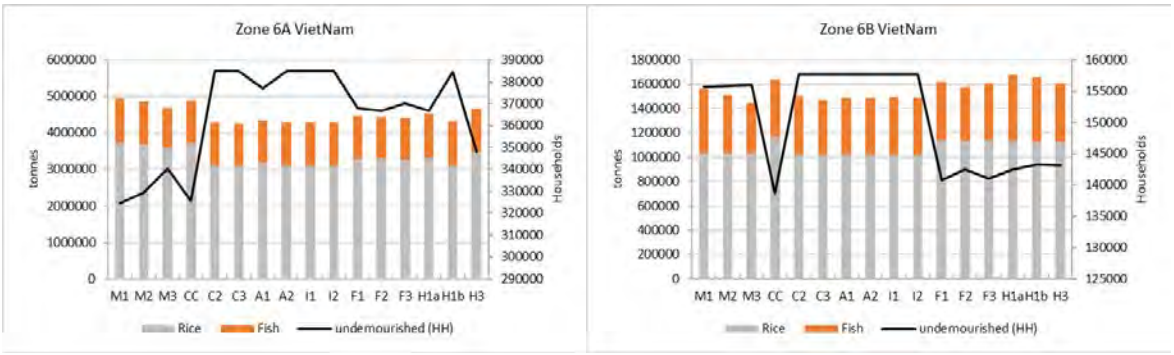
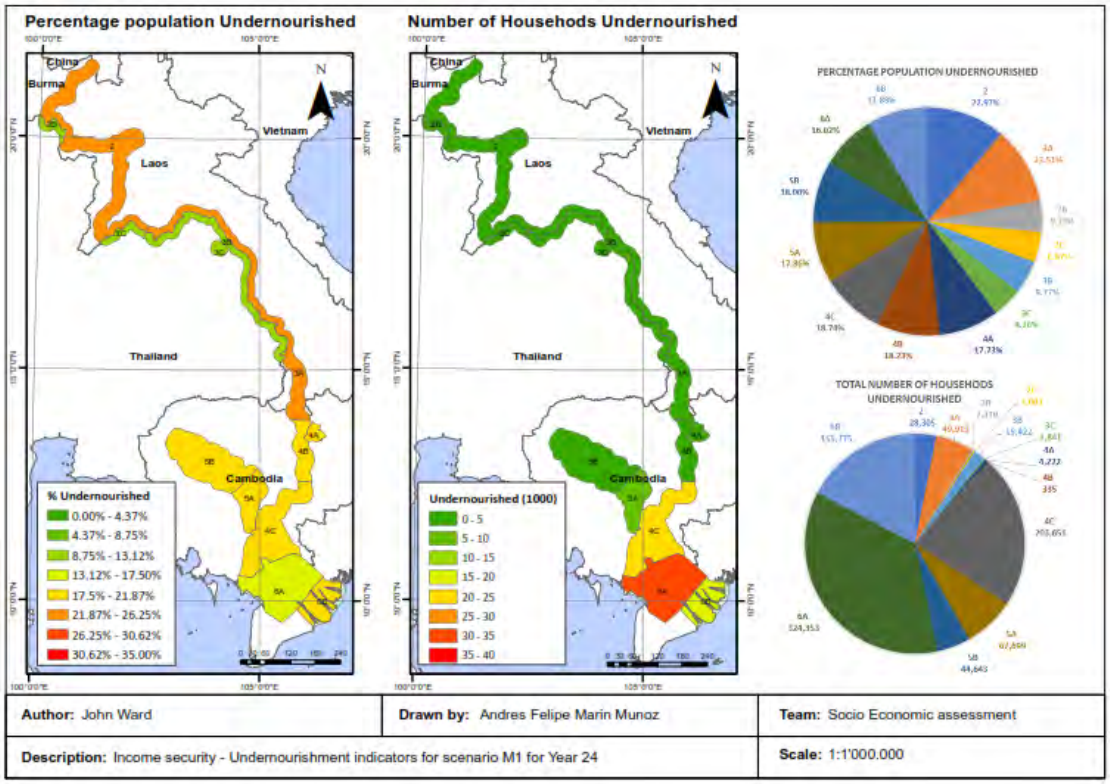


Figure 25 Undernourishment in Viet Nam delta Corridor zones by rice and fish production across development scenarios



The GIS representation of Figure 26 represents the percent and number of undernourished households for M1, M2 and M3. GIS maps of the sub-scenarios can be found in Annex 9.5.

Figure 26 M1, M2, M3, M3CC: % of population and number of households undernourished



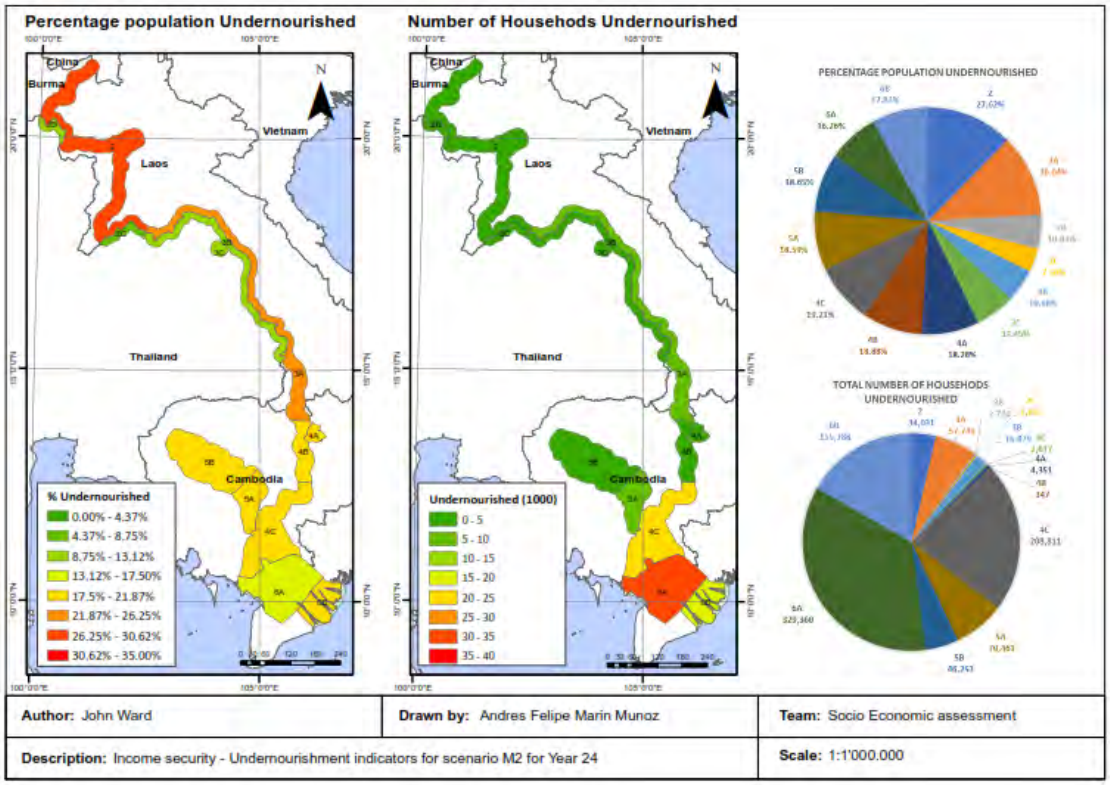
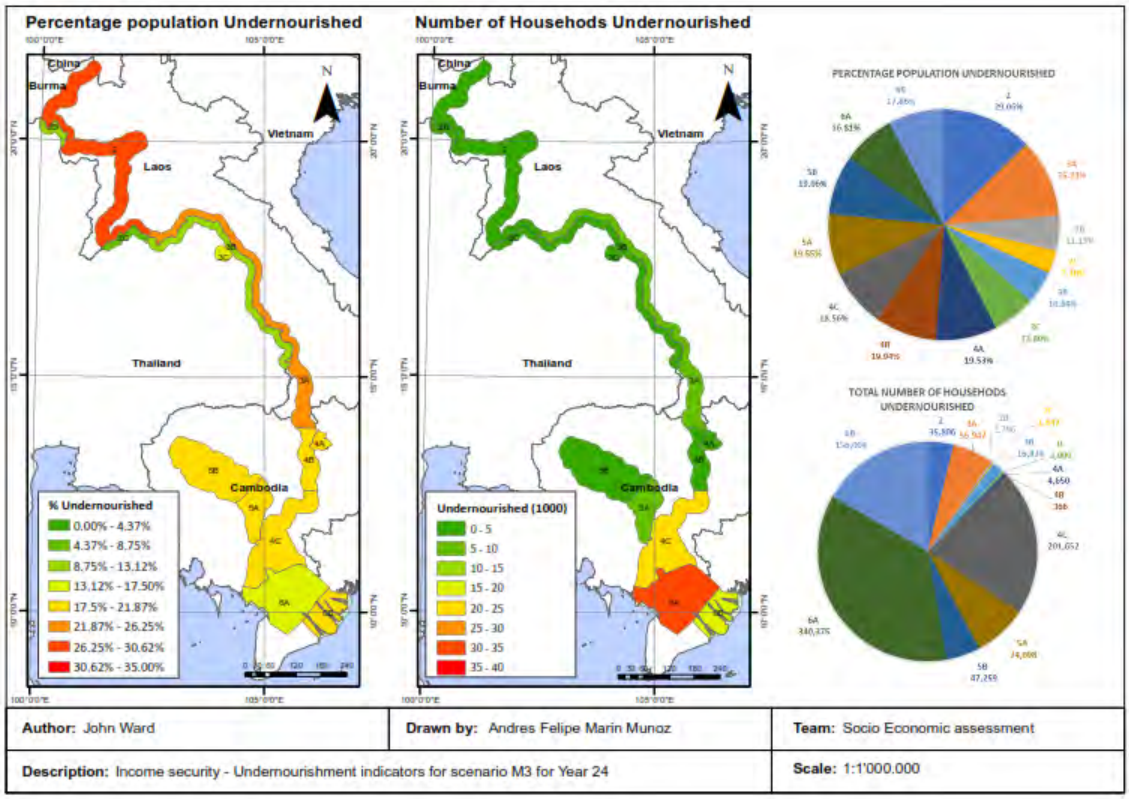
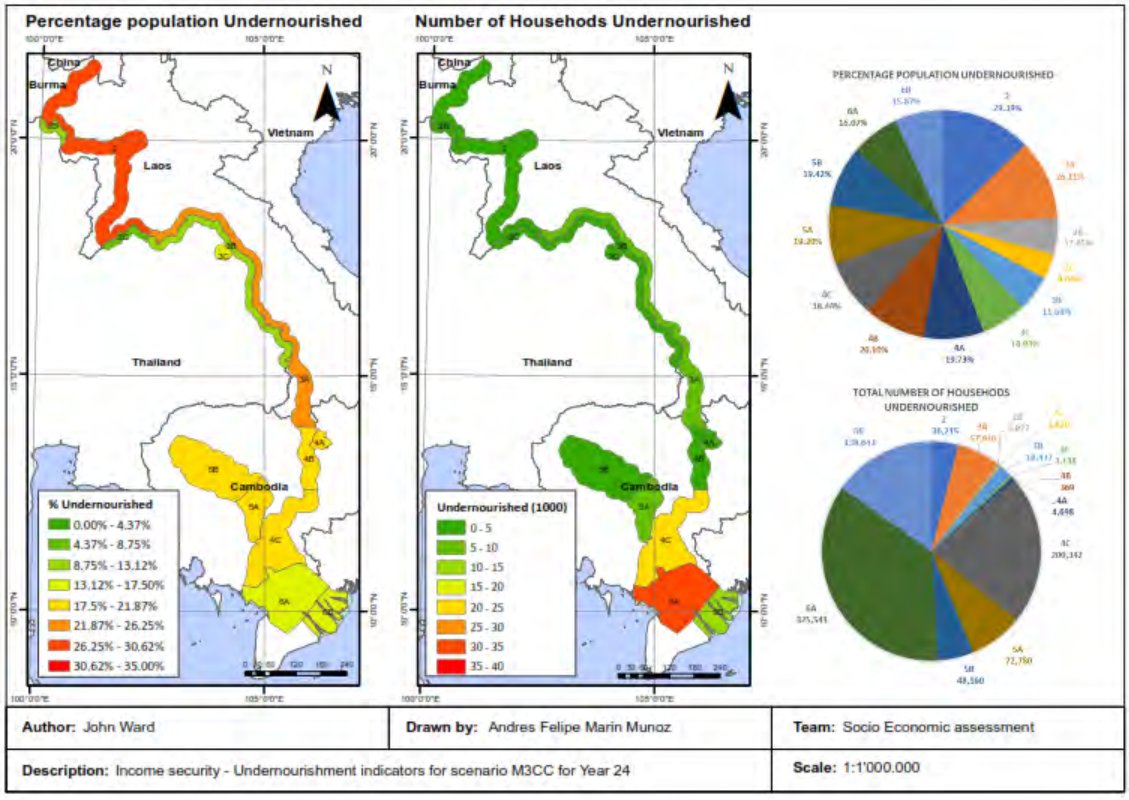


Table 26 (cont'd)





7.5 Poverty levels across the corridor

Poverty levels are dependent on multiple, interdependent factors, both monetary and non-monetary[13], including i*nter alia*, education, access to safe water, electrification, nutritional status, health, household income, gender, sanitation, entitlements, institutional settings, child morbidity and asset ownership. Conducting the poverty analysis for the Council Study required two critical factors; first the data needed to be specific to the corridor zones, or could be reliably interpolated from recognized national and international datasets; and second the metrics needed to have a direct relationship to the Discipline and Thematic Team analysis to detect differences between the Development scenarios. The two primary CS outputs that enable a poverty linkage to the development scenarios are rice and fish production, in turn the foundation for estimating sectoral employment and median incomes. Estimates of rural poverty at national poverty lines for Cambodia are 20.8%; Lao PDR 28.6%; Thailand 16.7% and 22.1% in Viet Nam (WDI 2017). The 2012 National poverty lines were $358/month (Cambodia); $288 (Lao PDR); $612 (Thailand) and $396 (Viet Nam).

Corridor level poverty was estimated as the 25th percentile of aggregate individual income combining males and females, derived from the SIMVA (2011) and EMRF (2012) surveys (see corridor level incomes Section 7.10.2). The percent of people below the 25th percentile by sector approximate the national average and are reported in Table 25. The proportions below the poverty line were multiplied by the sector employment numbers across all zones and development scenarios (see the Sector Employment Section (7.10).

Table 24 Estimated poverty levels for the corridor, by sector, aggregated to country level

		Agriculture	Secondary	Tertiary
Cambodia	Below poverty line	28.0%	26.0%	13.3%
Lao	Below poverty line	29.1%	17.9%	11.1%
Thailand	Below poverty line	15.6%	10.9%	14.1%
Viet Nam	Below poverty line	18.0%	22.0%	22.0%

The percent of people below the poverty line for each corridor zone across all development scenarios are reported in

The cells highlighted in red across zone row reflect the highest % of poverty; m green highlight represents the lowest. The M1 All other scenarios represent year24 of the projection horizon. **Graphic A** compares the main scenarios only. **Graphic B** compares the sub-scenarios with M3. The first observation is there are modest changes (0.1%-1.9%) in poverty levels across the main scenarios for all corridor zones. Second, the Vietnamese zones vary by less than 0.4%across all scenarios. The low poverty associated with C3 is the exception, primarily due to the increase in the generalist fish guild biomass.

Graphic A: The M1 scenario corresponds to the lowest levels of poverty for all zones except 3C Thailand, 5B Cambodia and 6B Viet Nam. The latter are characterized by less than 0.2% difference across the scenarios. The M3CC scenario corresponds to the lowest level of poverty for the 4A Cambodia zone. The highest levels of poverty M3 or M3CC scenarios.

Graphic B: The M3 and M3 scenarios correspond to the highest levels of poverty for the majority of corridor zones when compared across the sub-scenarios. The A1 is generally associated with the lowest poverty levels. H3 has the lowest estimated poverty for zone 4A Cambodia.

[13] Alkire, S. and Robles, G. (2016) "Multidimensional Poverty Index Winter 2016: Brief methodological note and results." Oxford Poverty and Human Development Initiative, University of Oxford, *OPHI Briefing* 44.

Table 25 Comparison of % change in poverty levels by main scenarios

	M1(y1)-M1(yr24)	M1-M2	M1-M3	M1-M3CC
Zone 2-Lao	-2.9%	0.3%	1.7%	-1.8%
Zone 3 A-Lao	-2.5%	1.0%	3.7%	-3.3%
Zone 2 B-Thailand	-0.1%	0.1%	0.3%	-0.1%
Zone 2 C-Thailand	-0.1%	0.5%	0.7%	-0.6%
Zone 3 B Thailand	-0.5%	0.7%	0.8%	-0.7%
Zone 3 C Thailand	-0.2%	-0.1%	-0.1%	0.2%
Zone 4 A Cambodia	1.0%	0.9%	-0.4%	2.0%
Zone 4 B Cambodia	-3.3%	1.8%	2.0%	-0.6%
Zone 4 C Cambodia	-1.8%	0.3%	1.5%	-2.3%
Zone 5 A Cambodia	-2.8%	0.2%	0.4%	-0.7%
Zone 5 B Cambodia	-1.1%	0.0%	0.0%	-0.1%
Zone 6 A Viet Nam	0.6%	0.0%	0.1%	0.0%
Zone 6 B Viet Nam	0.8%	0.0%	0.0%	0.1%

Table 26 Poverty levels (%) of corridor zones by development scenario

A	Percent population below the poverty line.				
	M1 yr1	M1 24	M2	M3	M3CC
Zone 2-Lao	21.7%	18.8%	19.1%	20.6%	20.6%
Zone 3 A-Lao	21.2%	18.7%	19.7%	22.4%	22.0%
Zone 2 B-Thailand	13.6%	13.5%	13.6%	13.8%	13.6%
Zone 2 C-Thailand	14.5%	14.4%	14.8%	15.0%	15.0%
Zone 3 B Thailand	14.2%	13.7%	14.3%	14.5%	14.4%
Zone 3 C Thailand	14.1%	13.9%	13.8%	13.8%	13.6%
Zone 4 A Cambodia	24.0%	25.1%	25.9%	24.7%	23.1%
Zone 4 B Cambodia	25.2%	21.9%	23.7%	23.8%	22.5%
Zone 4 C Cambodia	23.5%	21.6%	21.9%	23.2%	23.9%
Zone 5 A Cambodia	23.5%	20.7%	20.9%	21.1%	21.5%
Zone 5 B Cambodia	23.0%	21.9%	21.9%	21.9%	22.1%
Zone 6 A VietNam	19.4%	19.9%	20.0%	20.0%	20.0%
Zone 6 B VietNam	19.0%	19.8%	19.9%	19.9%	19.7%

Table 27 (cont'd)

B Percent population below the poverty line.

M3	M3CC	C2	C3	A1	A2	Irr1	Irr2	F1	F2	F3	H1a	H1b	H3
20.6%	20.6%	20.5%	23.1%	18.2%	20.6%	20.5%	20.6%	20.6%	20.6%	20.6%	21.1%	21.0%	20.6%
22.4%	22.0%	21.8%	26.2%	18.3%	22.2%	22.2%	22.2%	22.0%	22.0%	22.0%	22.0%	22.5%	22.2%
13.8%	13.6%	13.6%	13.8%	13.4%	13.7%	13.7%	13.7%	13.6%	13.6%	13.6%	13.6%	13.7%	13.7%
15.0%	15.0%	14.9%	15.2%	14.3%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
14.5%	14.4%	14.4%	14.5%	14.1%	14.5%	14.5%	14.5%	14.4%	14.4%	14.4%	14.4%	14.4%	14.4%
13.8%	13.6%	13.7%	13.7%	13.8%	13.7%	13.7%	13.7%	13.6%	13.6%	13.6%	13.6%	13.7%	13.7%
24.7%	23.1%	22.8%	24.3%	24.6%	24.7%	24.3%	24.7%	23.1%	23.1%	23.1%	22.6%	24.0%	22.2%
23.8%	22.5%	22.6%	24.8%	23.6%	23.7%	23.7%	23.7%	22.5%	22.5%	22.5%	22.5%	22.6%	22.6%
23.2%	23.9%	22.8%	25.6%	21.7%	22.8%	22.8%	22.8%	23.3%	23.4%	23.3%	23.4%	23.3%	23.3%
21.1%	21.5%	20.9%	24.0%	20.6%	20.9%	21.0%	20.9%	21.3%	21.3%	21.3%	21.3%	21.4%	21.3%
21.9%	22.1%	21.7%	22.7%	21.7%	21.7%	21.8%	21.8%	22.0%	21.9%	22.0%	22.0%	22.1%	22.0%
20.0%	20.0%	20.3%	19.5%	20.2%	20.3%	20.3%	20.3%	20.2%	20.2%	20.2%	20.2%	20.3%	20.1%
19.9%	19.7%	19.9%	19.2%	19.9%	19.9%	19.9%	19.9%	19.7%	19.7%	19.7%	19.7%	19.7%	19.7%

The incidence of women in the primary sector having incomes below national poverty lines is significantly higher ($Chi^2 = 22.7$, $p<0.05$) than males except Lao PDR, varying by 12% in Cambodia, 4.6% in Thailand and 17% in Viet Nam (Table 28). Aspirations of gender equity are generally not reflected in the Council Study assessment and indicate a need for sustained efforts to correct the imbalance. The number of female respondents in the secondary sector were less than 2% of the sample and viewed

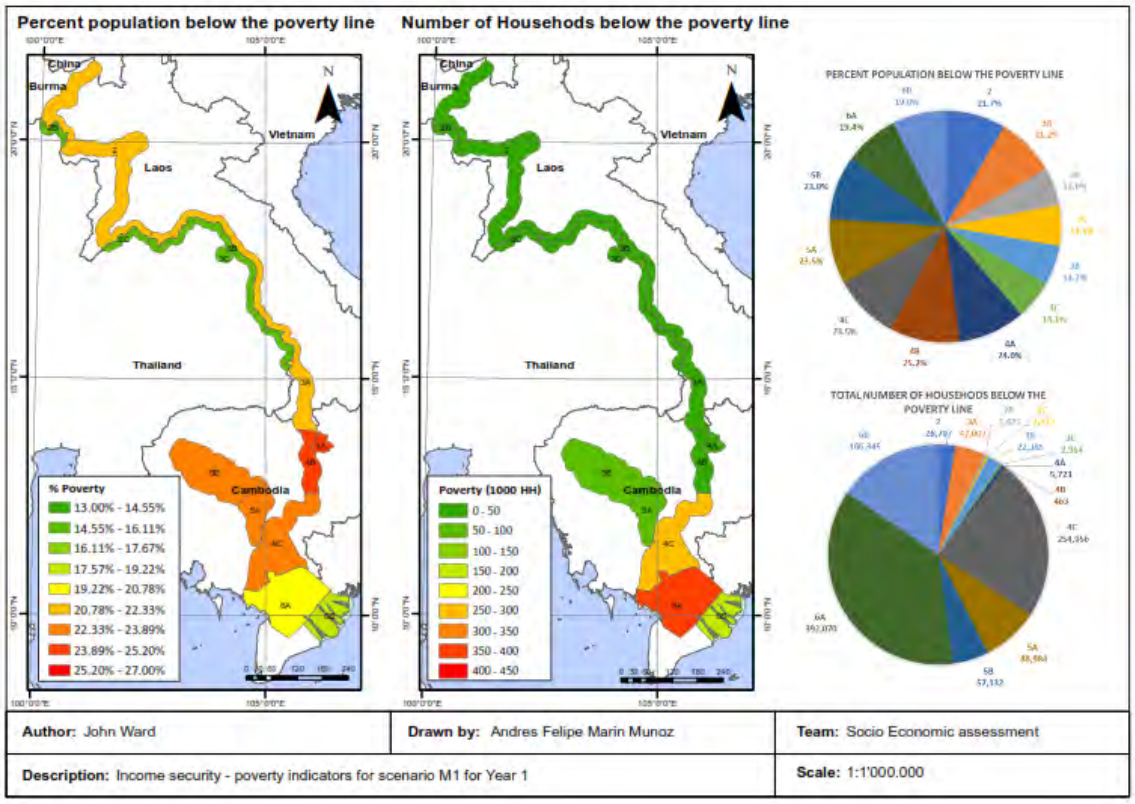
Notably the MRC Social impact and vulnerability assessments (SIMVA) did not treat gender as a specific survey dimension and data class. A central recommendation of the social and economic assessment is the future investigation of the status of gender equity in the corridor and the vulnerability and opportunities for women be undertaken by the MRC to correct this important omission.

Table 27 Corridor poverty levels by gender, sector and country

		Agriculture		Secondary		Tertiary	
Country	Status	male	female	male	female	male	female
Cambodia	Below poverty line	25.6%	37.1%	29.0%	0.0%	14.2%	9.6%
Lao PDR	Below poverty line	29.4%	25.9%	8.7%	0.0%	9.0%	35.7%
Thailand	Below poverty line	14.3%	19.9%	33.3%	0.0%	12.7%	19.0%
Viet Nam	Below poverty line	17.1%	34.0%	53.6%	60.0%	32.4%	69.2%

The GIS representation of Figure 27 represents the percent and number of households under the poverty line for M1, M2 and M3. GIS maps of the sub-scenarios can be found in Annex 9.6.

Figure 27 M1, M2 and M3: percent and number of households below poverty lines



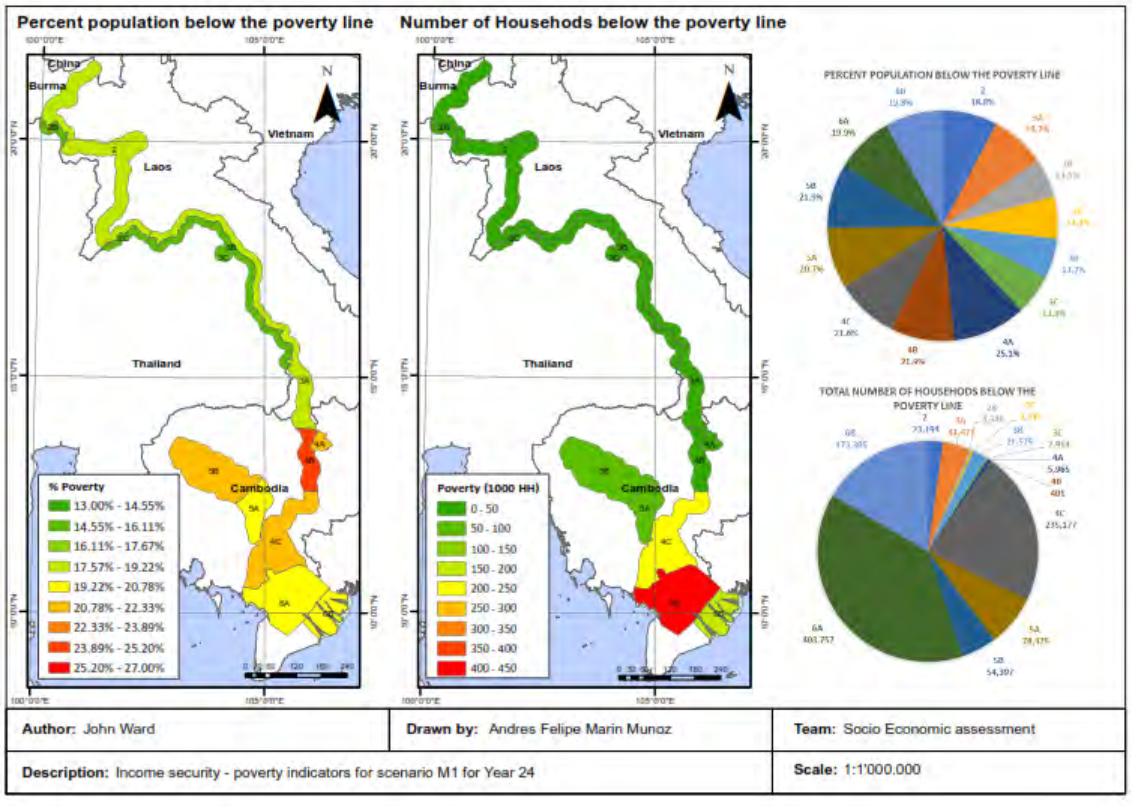
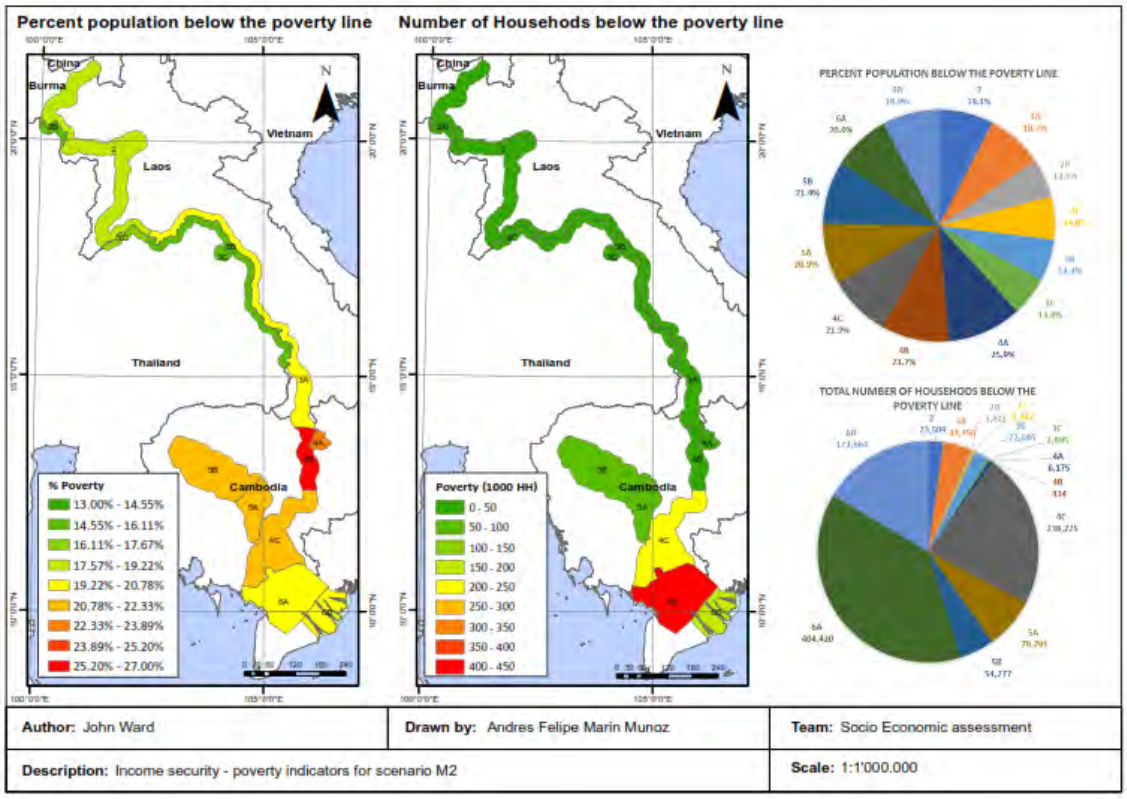
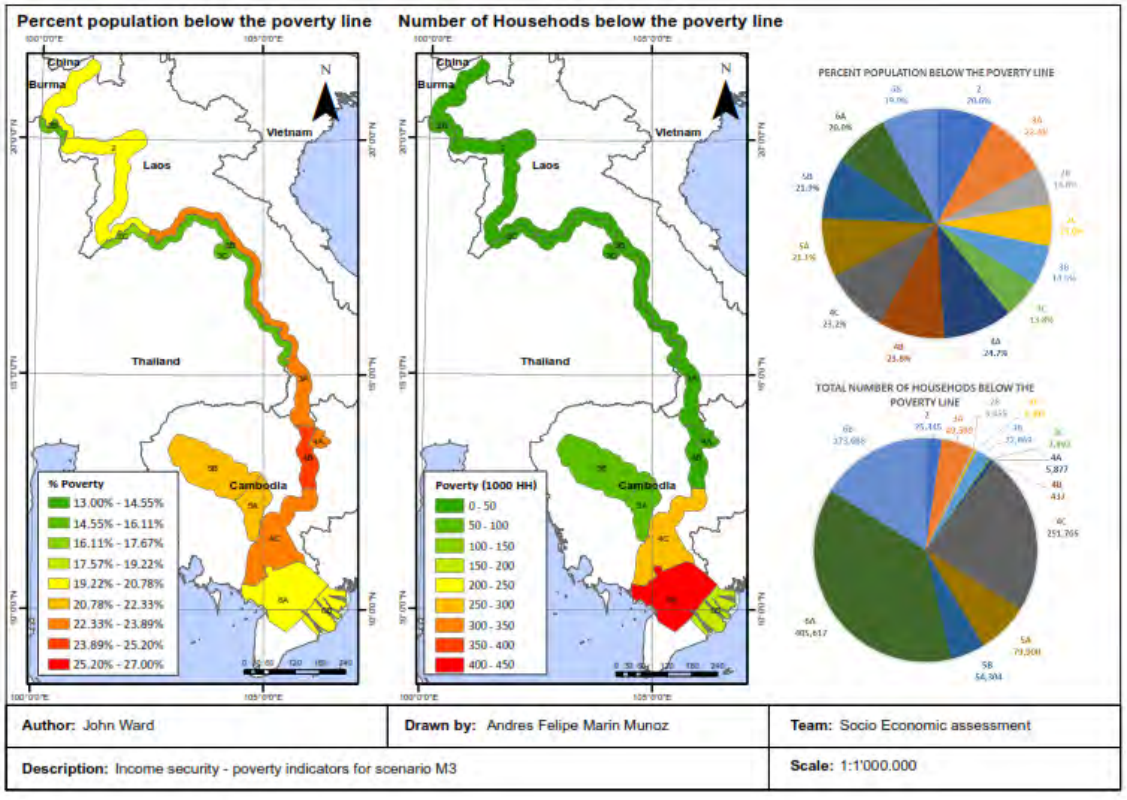


Figure 27 (cont'd)





7.6 Water security: floods and drought

The Council Water Security Assessment Indicator is comprised of four sub-indicators:

1. The % of households with access to safe water;
2. The % of households whose primary domestic water sources runs dry (drought);
3. The % of household reporting water shortages that resulted in crop damage (drought);
4. The % of HHs reporting water excess that resulted in crop damage (floods).

Periodic flooding of low-lying areas near rivers is a common occurrence in most natural river systems. The Mekong River has some of the most extensive floodplains in the world, comprising large parts of Cambodia and the Mekong Delta in Viet Nam. The Songkhram River in Northeast Thailand has a large floodplain where natural flooding occurs every year. As floodplains are increasingly appropriated as farmland, and human habitation, the exposure, losses and damages from flooding is likely to increase. Changes in river flows due to human activity such as deforestation, water regulation, hydropower and climate change create new situations where flooding becomes a risk to humans and assets. Adaptations to the periodic cycle of floods and seasonal variation in the Lower Mekong Basin are a central feature of rural livelihoods and livelihood activities. The thresholds and capacities of adaptations at household, community and corridor are also exceeded by major flooding and drought that cause loss of life, health risks, loss of agricultural land and livestock, damage to infrastructure and assets crucial for sustaining rural livelihoods.

The SIMVA 2014 (MRC 2015) identifies four dimensions of drought: meteorological or fluvial drought, i.e., low rainfall; agricultural drought accounting for water needs of crops during different growing stages; hydrological drought referring to persistently low water volumes in streams, rivers and reservoirs; and socioeconomic drought that occurs when the demand for water exceeds the supply. e

The effects of the 24 cycle of floods and drought influencing cropping patterns and food production, changes in irrigation and the subsequent changes in modelled agricultural production are included in the socio-economic assessment Food Security indicator. The variation in corridor rice yields and area under cultivation were modelled by the IWRM team as a function of rainfall variation, including droughts and floods, over the Council Study 24-year projection horizon. Variations in rice production and associated surplus (after nutritional requirements have been met) are therefore accounted for in the food security tool.

The focus of the social and economic assessment was the rural populations in the 13 corridor zones. The detailed impacts and effects of floods on both urban and to a lesser degree rural populations and centres is reported in the Council Study Flood and Flood Plain management (FFPM) Theme Report (2017). In addition to the FFPM report an additional section describing the overall effects of urban flooding in the Lower Mekong Basin has been included in Appendix 11.10 of the Social and Economic Assessment.

Exposure of corridor households to floods

The SIMVA 2014 survey elicited information on the flood situation of corridor villages based on historical exposure and impact at the household level (Table 29). The results indicate high levels of exposure and damages, although exposure was not uniformly distributed. In 77% of the villages in Cambodia 49% of the households had experienced damages; in Thailand 68% of villages with an average of 31% of the households, and in Viet Nam 13% of the villages with an average of 32% of the households had losses or damages. One percent of the Lao PDR villages reported households had had losses from flooding. 39% of the all the sample households had experienced flooding in the last three years and 80% of those had experienced damages or lost assets.

Multiple sources of flooding were reported and were not restricted to the Mekong mainstem. Rivers were reported by 45% of respondents as the main source of flooding: 17% from ineffective drainage; 9% from canal overtopping; and 12% from lakes. The average number of exposure days ranged from 26, ranging up to 45 days in Zone 6A, Viet Nam where monsoonal rains were reported as the source of the most serious floods.

Three percent of respondents overall reported hydropower reservoir releases as a source of serious flooding events was reported by only 3% of all households overall, ranging from 10-14% in the Cambodian 4A and 4C zones. This an important insight for the Council Study assessment and is consistent with the findings of the FFPM Thematic team who note that the characteristics of the investments in the +development scenarios will have a relatively effect on overall Mekong floods.

Table 28 Corridor exposure to floods in the past 3 years (SIMVA 2015)

	Villages with households that experienced losses or damages from any floods in the last 3 years		% HHs experienced damages from flooding in last 3 years
Sub-Zone	N	%	Mean % of HHs
Zone 4 A - Subzone Cambodia - Khone Falls to Kratie	20	90.91%	39.33%
Zone 4 B - Subzone Cambodia - 3S	3	75.00%	49.73%
Zone 4 C - Subzone Cambodia - Kratie to Viet Nam border	12	66.67%	52.60%
Zone 5 A - Subzone Cambodia - Tonle Sap river	15	68.18%	49.15%
Zone 5 B - Subzone Cambodia - Tonle Sap lake	18	81.82%	58.78%
All	***68***	***77.27%***	***49.45%***
Zone 2 A - Mainstream - Lao	1	2.27%	.
Zone 3 A - Subzone Lao - Mainstream	0	0.00%	.
All	***1***	***1.14%***	**.**
Zone 2 C - Subzone Lower Thailand	9	40.91%	24.74%
Zone 2 B - Subzone Upper Thailand	19	86.36%	22.83%
Zone 3 C - Subzone Thailand - Songkhram	18	81.82%	45.17%
Zone 3 B - Subzone Thailand - Mainstream	14	63.64%	26.64%
All	***60***	***68.18%***	***30.71%***
Zone 6 A - Subzone Viet Nam - Mekong Delta - freshwater	8	18.18%	30.16%
Zone 6 B - Subzone Viet Nam - Mekong Delta - saline	3	6.82%	34.10%
All	***11***	***12.50%***	***32.13%***
All	**140**	**39.77%**	**38.96%**

Source: SIMVA 2014 (MRC 2015)

The Food Security tool estimates the yearly time steps of the total rainfed and irrigated rice, by corridor zone and across scenarios, reported in Section 10.2. The Council Study 24-year projection horizon modelled the climatic and hydrological conditions of a year that represents the effects of the major 2000-2001 flood, presenting the possibility of estimating the effect on corridor rice production and, as a corollary, the number of people affected as a consequence of an extreme drought.

The 2000-2001 (flood) corridor rice production, number of people affected and monetary value were compared against 2003 (post flood year) across all corridor zones and the M1, M2 and M3 scenarios using the outputs of the food security tool (Appendix 10.2).

The number of people affected by the 2000-2001 flood with rice based livelihoods (and the % change) are detailed in Table 30. The 2000 flood was one of the most severe in recent time, followed by flooding

in 2001. For example, the 2000-2001 combined cropland loss in Cambodia was estimated at 585,741 ha (Council Study Flood and Flood Plain Development Theme Report).

Relying on the Council Study modelling estimates, the total corridor number of affected people with rice based livelihoods was estimated at 1,137,264 in the M1 development scenario, M2: 1,232,452 and M3: 818,887. The affected population represents M1: 4.8%, M2: 5.23% and M3: 3.5% of the total corridor population corresponding with 2000 and 2003.

The effects of flooding were not uniformly distributed across the corridor zones; the comparison of 2003 with 2001 reveals increases in rice based livelihoods for the Lao PDR zones for the 2001 flood period (that is a negative number in the Table) and the Thai mainstream zone. The majority of affected people with rice based livelihoods were located in the Kratie to the Viet Nam Border (634,412 people) and the Tonle Sap River (419,376 people). Compared to the 2001 flood, rice based livelihoods increased in 2003 by 50% and 105% in the Katie and Toney Sap River zones respectively.

The estimates for the M2 development scenario indicate a potential increase in the number of people affected in the two most impacted Cambodian zones and an increase in the Viet Nam Delta freshwater zone. The increase in affected livelihoods of the M2 scenario reflects the predicted expanded rice area in Cambodia.

The value of rice production losses in 2001 compared to 2003 were estimated at US$1.1 billion (M1); M2 by US$1.2 billion (M2) and US$0.828 billion (M3). Total M1, M2 and M3 corridor rice production comparing 2001nd 2003 is detailed in Table 30. Rice production for all the main development scenarios substantially in 2000-2001, primarily in the Cambodian and Viet Nam delta corridor zones. The M1 rice losses (milled equivalent) in 2001 were estimated to decline by 1,067,650 tonnes (-11%) compared to production in 2003; M2 by 1,152,886 tonnes (-11%): and M3 by 797,824 tonnes (-8%).

Table 29 Number (and %) of rice based livelihoods affected 2000 flood by corridor zone: M1, M2 and M3

	M1 (2001-2003)		M2 (2001-2003)		M3 (2001-2003)	
Corridor Zone	# affected	%	# affected	%	# affected	%
Zone 2-Mainstream - Lao	-4583	-4%	-3294	-2%	-3624	-2%
Zone 3 A-Lao-Mainstream	-24594	-11%	-23926	-8%	-24294	-5%
Zone 2 B-Upper Thailand	4	0%	-42	0%	-86	0%
Zone 2 C-Lower Thailand	352	2%	685	2%	828	2%
Zone 3 B Thailand-Mainstream	-17301	-11%	-15864	-8%	-17820	-8%
Zone 3 C Thailand-Songkhram	242	1%	235	1%	231	1%
Zone 4 A Cambodia-Khone Falls to	-10929	-43%	-11173	-44%	-5310	-27%
Zone 4 B Cambodia-3S	-1832	-75%	-1822	-75%	-1952	-75%
Zone 4 C Cambodia Kratie to Viet	634412	50%	667709	48%	317979	15%
Zone 5 A Cambodia-Tonle Sap river	419376	105%	418809	89%	414314	81%
Zone 5 B Cambodia Tonle Sap lake	49829	25%	46235	22%	45039	22%
Zone 6 A Viet Nam Delta-freshwater	91091	3%	157591	5%	95915	3%
Zone 6 B Viet Nam Delta-saline	1197	0%	-2691	0%	-2333	0%
Totals	1,137,264		1,232,452		818,887	

Table 30 Comparison of 2001-2003 corridor rice production: M1, M2 and M3 (,000 tonnes)

Zone	M1 2001	M1 2003	M2 2001	M2 2003	M3 2001	M3 2003
	tonnes ('000)					
Zone 2-Mainstream - Lao	96	93	107	105	138	136
Zone 3 A - Lao - Mainstream	454	405	592	544	899	850
Zone 2 B-Upper Thailand	48	48	53	53	59	59
Zone 2 C-Lower Thailand	24	25	40	41	47	48
Zone 3 B Thailand-Mainstream	307	274	388	359	434	400
Zone 3 C Thailand-Songkhram	52	52	50	50	49	50
Zone 4 A Cambodia-Khone Falls to	10	6	10	6	8	6
Zone 4 B Cambodia-3S	1	0	1	0	1	0
Zone 4 C Cambodia Kratie to Viet	966	1453	1063	1576	1679	1924
Zone 5 A Cambodia-Tonle Sap	251	516	297	561	324	586
Zone 5 B Cambodia Tonle Sap lake	1266	1585	1317	1613	1330	1618
Zone 6 A Viet Nam Delta -	4123	4239	3977	4177	3922	4045
Zone 6 B Viet Nam Delta - saline	811	812	811	809	811	810
Total	8409	9507	8705	9893	9702	10530

Exposure of corridor households to droughts

Thirty-seven per cent of all sample households had experienced drought in the last three years. Seventy three percent of Cambodia households reported drought exposure primarily in Sub-zone 4A: 46% in Thailand: 23% in Lao PDR and 6% of households in Viet Nam. Overall, 75% of households who had experienced drought reported losing assets.

Table 31 Corridor households reporting drought exposure during the previous 3 years

	HHs experienced drought in the last 3 years		HHs lost assets due to drought last 3 years	
Sub-Zone	*N* HHs	% of HH	*N* HHs	% affected HHs
Zone 4 A - Subzone Cambodia - Khone Falls to Kratie	337	95.7%	324	96.1%
Zone 4 B - Subzone Cambodia - 3S	49	76.6%	46	93.9%
Zone 4 C - Subzone Cambodia - Kratie to Viet Nam border	144	50.0%	103	71.5%
Zone 5 A - Subzone Cambodia - Tonle Sap river	279	79.3%	203	72.8%
Zone 5 B - Subzone Cambodia - Tonle Sap lake	225	63.9%	179	79.6%
All	***1,034***	***73.4%***	***855***	***82.7%***
Zone 2 A - Mainstream - Lao	168	23.9%	84	50.0%
Zone 3 A - Subzone Lao - Mainstream	160	22.7%	86	53.8%
All	***328***	***23.3%***	***170***	***51.8%***
Zone 2 B - Subzone Upper Thailand	182	51.7%	124	68.1%
Zone 2 C - Subzone Lower Thailand	177	50.3%	118	67.8%
Zone 3 B - Subzone Thailand - Mainstream	143	40.6%	112	78.3%
Zone 3 C - Subzone Thailand - Songkhram	152	43.2%	121	80.7%
All	***654***	***46.4%***	***475***	***73.2%***
Zone 6 A - Subzone Viet Nam - Mekong Delta - freshwater	41	5.8%	24	58.5%
Zone 6 B - Subzone Viet Nam - Mekong Delta - saline	40	5.7%	35	87.5%
All	***81***	***5.8%***	***59***	***72.8%***
All	**2,097**	**37.2%**	**1,559**	**74.5%**

Source SIMVA 2014

The Council Study 24-year projection horizon also modelled the climatic and hydrological conditions of a year that represents the effects of the intense 1995-96 El Niño, presenting the possibility of estimating the effect on corridor rice production and, as a corollary, the number of people affected as a consequence of an extreme drought. The recent 2015-16 El Niño was considered to be similar in intensity to the 1995-96 El Niño.

The 1993 (pre-El Niño) corridor rice production, number of people affected and monetary value were compared against the 1997 (El Niño) across all corridor zones and the M1, M2 and M3 scenarios using the outputs of the food security tool. The total working populations were held constant for the 1993 and 1997 years for all the corridor zones to compare the 1993 and 1997 changes in rice based livelihoods. The proportion of working population assigned to the primary sector is dependent on the level of rice production and the calculated levels of productivity, measured as the number of people required to produce one tonne of rice. Details of the method are described in the sector employment section of the report (Annex 10.3).

The number of people affected by the 1995-96 El Niño with rice based livelihoods (and % change) are detailed in Table 33. The effects of the El Niño were not uniformly distributed across the corridor zones; increases in rice based livelihoods were estimated for the Lao PDR zones and two in Thailand; rice based livelihood numbers decreased by -4%-26% in the Cambodian and Vietnamese zones, particularly the Kratie to Viet Nam border and Tonle Sap River zones.

The number of total people affected ranged from M1: 700,527; M2: 745,593 and M3: 587,288. The increase in the M2 scenario reflects the increase in some rainfed production and subsequent increase in the number of people with rice based livelihoods. The population estimated to be affected by the drought represents M1: 3.4%, M2: 3.3% and M3: 2.6% of the total corridor population corresponding with 2000 and 2003.

Table 32 Number (and %) of rice based livelihoods affected 1995-96 El Niño by corridor zone: M1, M2 and M3

	M1 (93-97)		M2 (93-97)		M3 (93-97)	
Corridor Zone	People affected	%	People affected	%	People affected	%
Zone 2-Mainstream - Lao	13160	11%	13393	10%	10044	6%
Zone 3 A-Lao-Mainstream	3109	2%	3879	1%	4011	1%
Zone 2 B-Upper Thailand	-702	-4%	-787	-4%	-853	-4%
Zone 2 C-Lower Thailand	310	1%	574	2%	705	2%
Zone 3 B Thailand-Mainstream	4580	3%	6793	3%	6018	3%
Zone 3 C Thailand-Songkhram	-3787	-18%	-3669	-18%	-3612	-18%
Zone 4 A Cambodia-Khone Falls to	-4484	-20%	-4438	-19%	-4446	-19%
Zone 4 B Cambodia-3S	-289	-13%	-287	-13%	-308	-13%
Zone 4 C Cambodia Kratie to Viet	-300289	-26%	-306331	-25%	-152951	-11%
Zone 5 A Cambodia-Tonle Sap river	-73104	-20%	-71190	-18%	-71400	-17%
Zone 5 B Cambodia Tonle Sap lake	-26353	-15%	-23164	-13%	-22201	-12%
Zone 6 A Viet Nam Delta-freshwater	-110614	-4%	-157079	-5%	-148105	-5%
Zone 6 B Viet Nam Delta-saline	-202063	-16%	-203286	-17%	-204190	-17%
Totals	-700527		-745593		-587288	

Total M1, M2 and M3 corridor rice production comparing 1993 and 1997 is illustrated in Table 34. Rice production for all the main development scenarios declined substantially, primarily in the Cambodian and Viet Nam delta corridor zones. Comparing 1993 to 1997, the M1 total rice production (milled

equivalent) was estimated to decline by 1,116,422 tonnes (11%); M2 by 1,150,991 tonnes (11%): and M3 by 913,844 tonnes (8%).

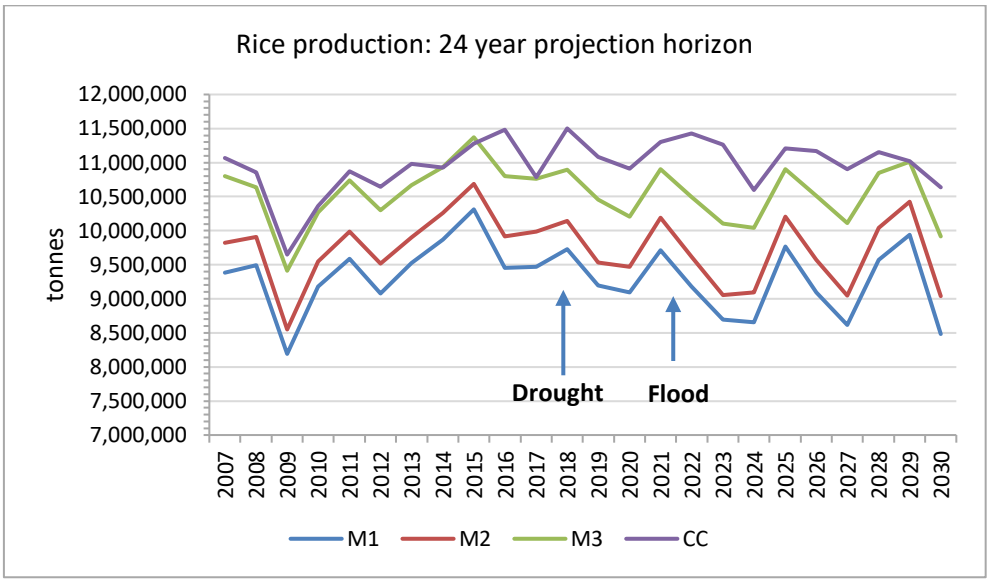
The M1 scenario has proportionately more rainfed production but less overall production compared to M2 and M3 and yields and the cultivation area vary substantially compared to irrigated cultivation. The M2 and M3 scenarios are characterized by increased rice expansion compared to M1, mainly in the conversion of rainfed to irrigated production and the development of new irrigation commands. The M2 scenario is characterized by proportionately more rainfed production compared to M3. The reduced declines estimated for the M3 scenario indicate an improved resilience of irrigated expansion.

The value of rice production declined by US$1.07 billion from 1993 compared to 1997; M2 by US$1.11 billion and in M3 by US$0.868 billion. Comparing the capital costs of infrastructure, operation and loss of ecosystem services to the benefits of the relative drought resilience of the M3 scenario would provide a more comprehensive economic assessment, however these data are not available at the spatial resolution of the corridor zones for 1993 and 1997.

Table 33 Comparison of 1993-1997 corridor rice production: M1, M2 and M3 (,000 tonnes)

	M1 1993	M1 1997	M2 1993	M2 1997	M3 1993	M3 1997
	Tonnes (,000)					
Zone 2-Mainstream - Lao	90	100	102	113	138	146
Zone 3 A-Lao-Mainstream	484	491	639	648	978	987
Zone 2 B-Upper Thailand	71	68	78	75	86	83
Zone 2 C-Lower Thailand	36	37	60	61	70	71
Zone 3 B Thailand-Mainstream	442	454	569	587	634	650
Zone 3 C Thailand-Songkhram	99	82	96	79	95	78
Zone 4 A Cambodia-Khone Falls to	5.7	4.6	5.7	4.6	5.8	4.6
Zone 4 B Cambodia-3S	1.0	0.8	1.0	0.8	1.0	0.9
Zone 4 C Cambodia Kratie to Viet Nam	1651	1216	1766	1323	2015	1793
Zone 5 A Cambodia-Tonle Sap river	496	395	540	443	567	469
Zone 5 B Cambodia Tonle Sap lake	1517	1294	1529	1333	1534	1346
Zone 6 A Viet Nam Delta-freshwater	4095	3946	3976	3764	3923	3723
Zone 6 B Viet Nam Delta-saline	1326	1109	1325	1106	1325	1105
Totals	10313	9197	10687	9536	11372	10458

Figure 28 24-year total corridor rice production estimated for the Council Study main development scenarios



The 1995-96 El Niño and 2000-2001 floods correspond to 2015-2017 and 2022-2024 of the projection horizon of the Council Study (Figure 28). The social and economic assessment of the 1995-96 drought and 2000-2001 flood estimated that a 10-11% decrease in rice production due to a major flood corresponds to 4.5-5% of the corridor population affected. An 11% decrease in rice production due to drought corresponds to 3.1-3.3% % affected.

The FFPM Report indicates the main scenarios are likely to have a relatively minor influence on flood levels due to high water volumes in the mainstem during flood periods. The undernourishment analysis does indicate that if for example the rice production decline modelled for 2027 and 2030 occur with a similar impact pattern, there is a high risk of a substantial increase in the level of increased undernourishment in Cambodia. Of note, there is also substantial reductions in fish biomass predicted for the same period.

7.6.1 Access to safe drinking water

Changes in access to and the diversity of drinking water sources due to the Development Scenarios are unlikely to be altered substantially, although water quality is a factor requiring additional consideration. Changes in the access to safe drinking water associated with the Development scenarios has been evaluated in consultation with the Domestic and Industrial Water Use Thematic team and the Flood Thematic Team and are reported in this section.

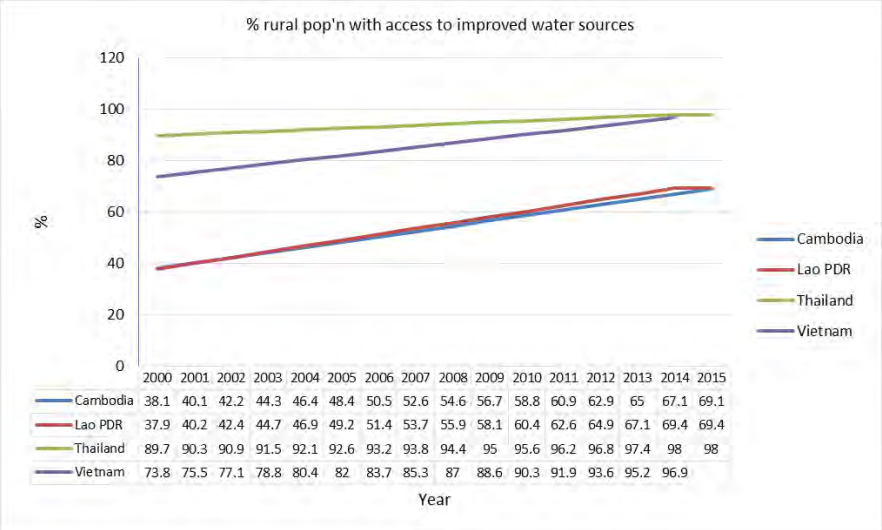
National level trends

The World Development Indicators (WDI 2017 indicate improvements in access to improved water sources (200-2015) for both urban and rural populations across all four LMB countries. Approximately 100% of urban populations located in Thailand, Viet Nam and Cambodia had access to improved water sources in 2015; access in Lao PDR has improved from 72% in 2000 to 86% in 2015. Similar rates of improvement are reported for rural populations: Thailand and Viet Nam are approaching 100% access; 70% of rural communities in Lao PDR and Cambodia had access to improved water sources in 2015.

These trends are anticipated to continue independently of the CS development scenarios.

The observed improvements are anticipated to continue in Lao PDR and Cambodia, albeit the rate of change in Lao PDR plateaued during 2014-2015. The time series (2000-2015) percent of rural and urban populations with access to improved water sources for the four LMB countries are illustrated in Figure 29 and Figure 30 respectively.

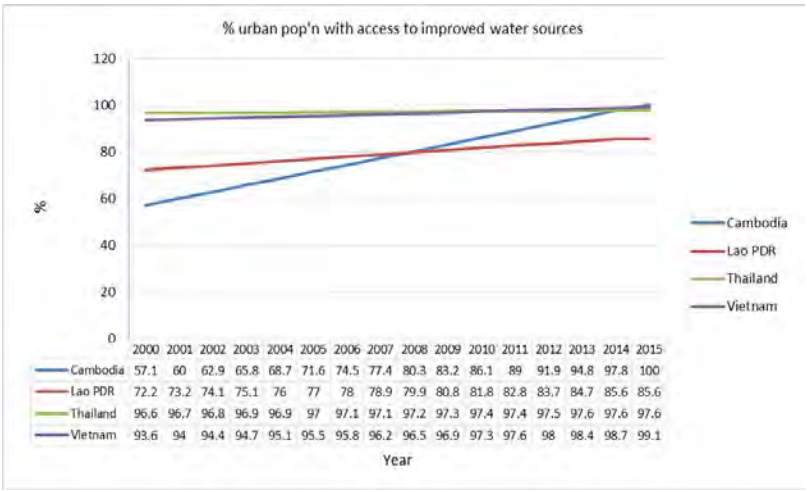
Figure 29 Access to improved water sources: rural population



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cambodia	38.1	40.1	42.2	44.3	46.4	48.4	50.5	52.6	54.6	56.7	58.8	60.9	62.9	65	67.1	69.1
Lao PDR	37.9	40.2	42.4	44.7	46.9	49.2	51.4	53.7	55.9	58.1	60.4	62.6	64.9	67.1	69.4	69.4
Thailand	89.7	90.3	90.9	91.5	92.1	92.6	93.2	93.8	94.4	95	95.6	96.2	96.8	97.4	98	98
Vietnam	73.8	75.5	77.1	78.8	80.4	82	83.7	85.3	87	88.6	90.3	91.9	93.6	95.2	96.9	

Source: WDI (2017)

Figure 30 Access to improved water sources: urban population

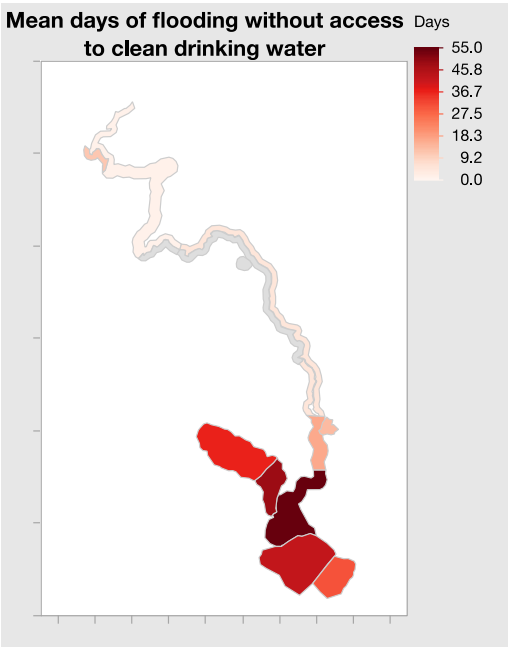


Source WDI (2017)

Corridor level access to safe drinking water

Ten per cent of flood affected households sampled in the SIMVA (2015) survey reported that they had experienced days without access to clean drinking water (Figure 31). 10% of the Sub-zone 4A Khone Falls to Kratie was reported the highest level of with 22% of flood affected households experiencing 17 days on average without access. In Sub-zone 4C Kratie to Viet Nam border 20% of the households experienced on average 55 days without access to clean drinking water. Households in the Tonle Sap River and lake zones, reported that 12-14% of the flood-affected households went for 37 to 49 days without access and in Viet Nam; in the freshwater zone 6A, 10% of the households did not have access for an average of 43 days; while 17% of the flood affected households in the saline area of the Mekong delta - zone 6B – did not have access to clean drinking water for 31 days in the last 12 months due to flooding.

Figure 31 Mean days of flooding without access to clean drinking water



Source: (SIMVA (2015)

Despite improvements in drinking water sources in the LMB Corridor, river water is still used for drinking water, especially in Cambodia and Lao PDR, with a mean percentage of 82% and 55% respectively of sampled households using river water as one of several drinking water sources (SIMVA 2015)[14].

SIMVA (2015) reports that water resources for agriculture relied mainly on rainwater, while Mekong water is the most important irrigation water source for 22% of the surveyed households. However, almost all irrigation with Mekong water is conducted in the Mekong Delta in Viet Nam, where irrigation density is approaching full capacity. Irrigation from the Mekong was used on a limited scale in Cambodia, Lao PDR and Thailand by 1-2% of the sampled households. The 2014 survey result on drought impacts indicates that development of irrigation potential in the LMB Corridor in Cambodia, Lao PDR and in Thailand is a relevant undertaking and additional irrigation modelled in the Development Scenarios is likely to occur in Lao PDR, Cambodia and Thailand.

7.6.2 LMB trends in water use and discharge

The Domestic and Industrial Water Use Theme of the Council Study has estimated the per capita domestic consumption and total water consumption for the LMB countries (Table 35). Total domestic water consumption was estimated to have been approximately 2 billion m^3 in 2007, of which approximately 49% was consumed in Thailand, 31% in Viet Nam, 12% in Cambodia and 8% in Lao PDR.

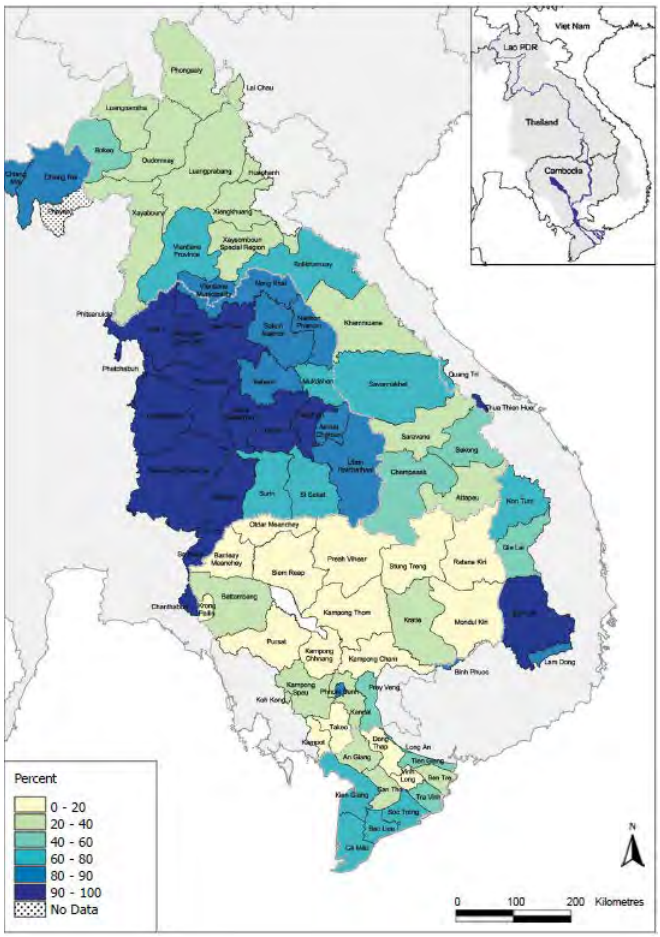
Table 34 LMB estimates of per capita domestic water consumption (l/c/d) and annual consumption (m^3/year) 2007-2040.

Country	2007		2015		2020		2040	
	(l/c/d)[a]	(m^3/year)	(l/c/d)	(m^3/year)	(l/c/d)	(m^3/year)	(l/c/d)	(m^3/year)
Cambodia	50	231	59	309	64	361	81	571
Lao PDR	75	163	87	217	94	255	118	406
Thailand	120	992	133	1,129	141	1,206	167	1,375
Viet Nam	80	630	93	794	99	890	121	1,218

Source: Domestic and Industrial Water Use Theme. [a] l/c/d litres per capita per day.

[14] SIMVA (2015) Social Impact Monitoring and vulnerability assessment. MRC, Vientiane

Figure 32 Map of community water access to improved water sources in the LMB



Source: MRC Social Atlas of the LMB (2003)

The quality of water supply varies widely across the LMB. In most provinces in Northeast Thailand, over 90 percent of the population has access to safe water. In the majority of Cambodian provinces, the proportion is less than 25 percent; in Lao PDR, it is between 25 and 50 percent.

Access to safe water may be more common in Lao PDR than in Cambodia because of greater numbers of people living in remote upland areas with access to unpolluted mountain streams. During the dry season in Cambodia, the number of households with access to safe water declines in both urban and rural areas.

The Mekong Delta, in Viet Nam, has many households that lack access to safe water. Throughout the delta, people rely on shallow wells and irrigation canals (often contaminated by pollutants or saltwater intrusion), streams and rainwater collection. In the northern part of the delta, acid-sulphate soils often contaminate ground and surface water.

In urban areas, piped water systems increase the availability of safe water. Access to safe water is much more common in Phnom Penh and Vientiane Municipality than in other areas of Cambodia and Lao PDR. Water supplies are also improving in secondary urban centres as a result of government and donor investments.

7.6.3 Industrial water use, discharge and water quality

The MRC Water Quality Technical Guideline for protection of human health is intended to maintain the ambient water quality of the Mekong mainstream for domestic purposes and primary human contact, with a specific focus on public health.

The water quality criteria are primarily based on the criteria selected by the Member Countries for their national water quality guidelines and water quality standards, guided by regional and international standards appropriate for the Mekong River Basin. Non-water disease vectors capable of transmitting infectious diseases, and the role of water from use from multiple sectors are not considered in the guidelines.

Table 35: Standards of the MRC Water Quality Guidelines

Parameters	Unit	Protection of Human Health	Protection of Aquatic Life
Temperature	°C	Natural	Natural
pH	-	6 - 9	6 -- 9
TSS	mg/L	-	-
TOTN	mg/L	5	-
TOTP	mg/L	-	-
BOD_5	mg/L	4	3
COD	mg/L	5	-
DO	mg/L	≥ 6	> 5

Source: MRC, 2012[15] cited in MRC Domestic and Industrial Water use CS Thematic report

The CS Domestic and Industrial Water use Thematic assessment of water quality notes that estimated and observed levels slightly exceed the recommended threshold of 5 mg/L level exceed (but are under an alternate recommended discharge level of 10 mg/L or industrial facilities (IFC 2017[16]). The Thematic recommends that the levels of the total nitrogen are acceptable contingent on Mekong flows remaining at present levels.

Total phosphorous levels exceed the MRC guidelines. Observed values measured from city outfalls located along the Mekong ranged from 10.37 mg/L to 18.67 mg/L. The MRC Water Quality Guidelines do not specify a recommended total phosphorous threshold for the protection of human health and aquatic life purposes. The IFC level is 2 mg/L for wastewater treatment. The Thematic Team recommends that domestic and industrial wastewater be adequately treated to lower the values of nutrients prior to discharge directly into the Mekong, into recharge sources or tributaries.

The SIMVA (2015) survey analyzed village and household level use of different drinking water sources. Multiple drinking water sources were common in the majority of sampled villages and households.

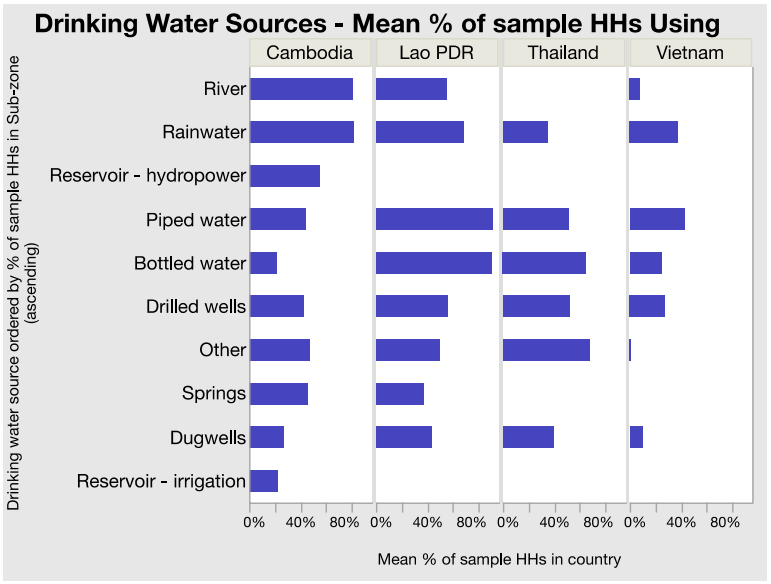
River water used for drinking water is most frequently found in Cambodia, with a mean percentage of 82% of village households using this as a source, and secondly in Lao PDR with a mean percentage of 55% accessing Mekong water for drinking purposes. It is notable that bottled water is a very common drinking water source in Lao PDR and Thailand. Though it is known that piped water, which is common in Lao PDR, is from rivers in some cases, the survey did not obtain data on the source of piped water supply. Figure 14 below shows the mean percentage of village households in the sample villages that use different drinking water sources.

In terms of inputs to MRC activities and policy, the finding that river water is extensively used for drinking water in Cambodia and Lao PDR points to the importance of water quality monitoring. Recommendations from SIMVA (2015) include developing an inventory of drinking water extraction sites from the Mekong would be a worthwhile exercise that could more precisely identify critical spots where potable water quality is most important.

[15] MRC. (2012). Water Quality Guidelines for the Protection of Human Health and for the Protection of Aquatic Life. Vientiane

[16] IFC (2017) EHS guidelines: environmental wastewater and ambient water quality. www.ifc.org/ehsguidelines

Figure 33 Drinking water sources in SIMVA sampled villages



Source: SIMVA (2015)

7.7 Health Security

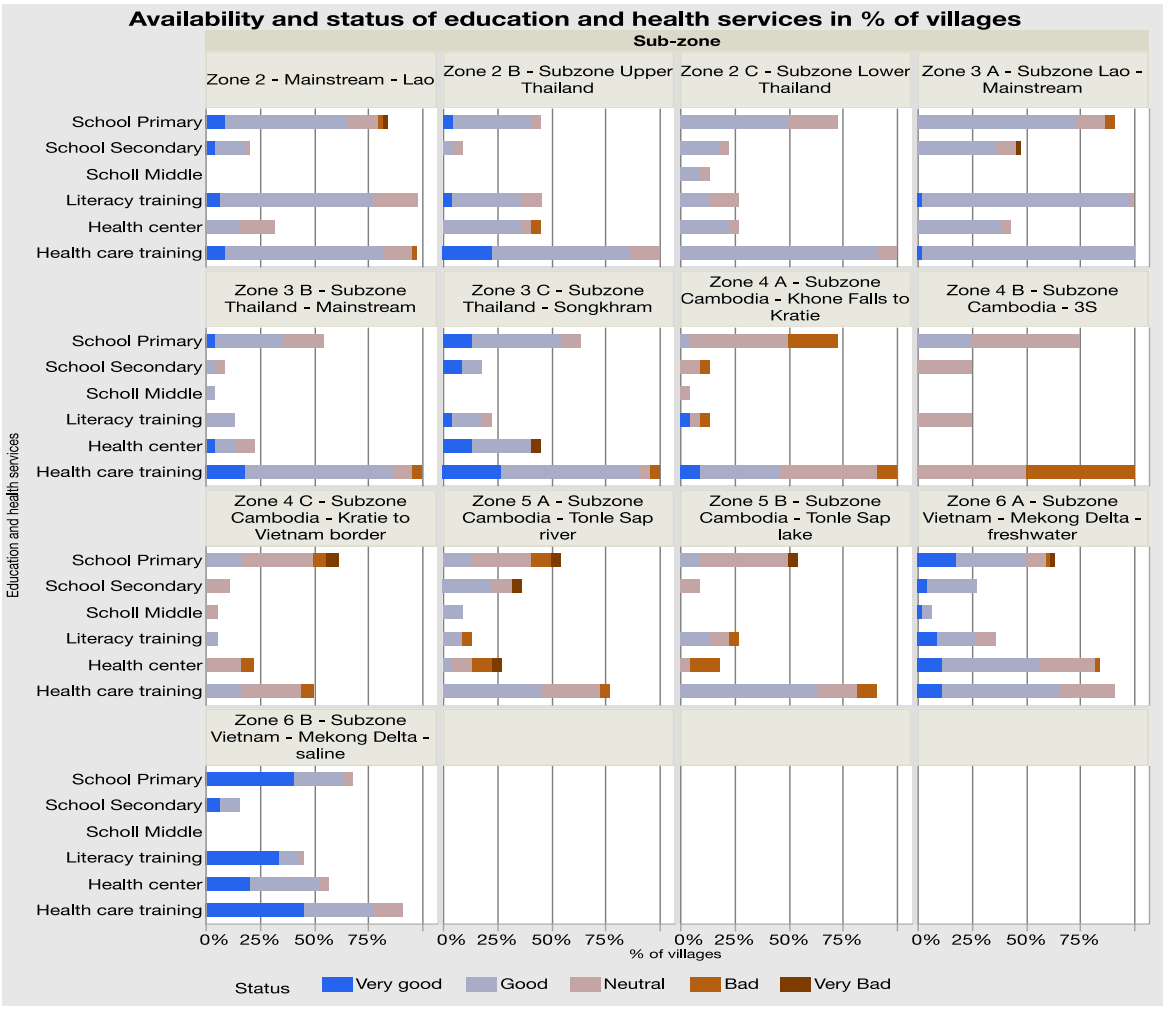
The Council Study health security indicator is comprised of three sub-indicators: access to health facilities, access to improved sanitation and access to safe drinking water; the latter is reported in the previous section.

7.7.1 Access to health facilities

The SIMVA (2015) survey team asked respondents their assessment and opinion of the functionality/quality of health services, infrastructure and facilities on a scale from: very good, good, neutral, bad, very bad. The distribution of all health and education services and the assessment of each across the 352 villages sampled as part of the SIMVA survey (2015) are detailed in Figure 34.

Respondents in the Sub-zones 3S Khone Falls to Kratie, and Sub-zone Kratie to Viet Nam border rated services lower compared to the other corridor zones. Cambodian respondents in all Sub-zones reported bad to very bad conditions. Generally, the respondents in Thailand and Viet Nam rated village services of a higher standard and adequate functionality. Respondents located in the saline Sub-zone in Viet Nam reported very good education and health services, due to improvements that have been made in the last 10 years. Villages in Thailand and Lao PDR report mainly good conditions of these services, with some cases of very good.

Figure 34 Respondent opinions and attitudes of the quality of health and education services



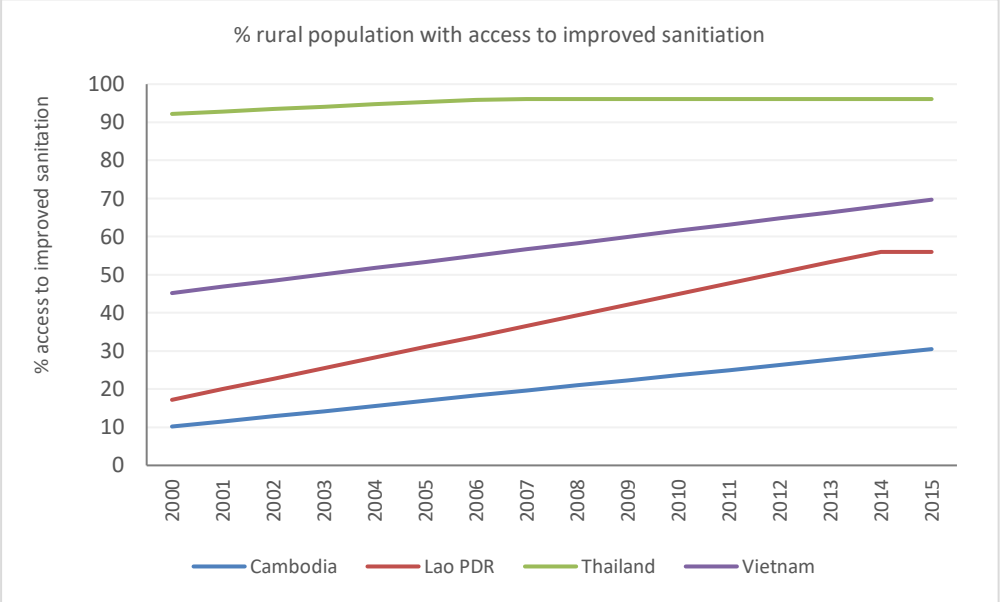
Source: SIMVA (2015)

7.7.2 Access to improved sanitation

The WDI time series assessments of rural and urban community access to improved sanitation in the four LM countries are illustrated in Figure 35. Urban access for all LMB countries has trended towards 100% in the period 2000-2015, ranging from 88% in Cambodia to 95% in Thailand. Rural access is characterised by similar increasing trajectory from 2000-2015 but is substantially lower than urban counterparts: 31% of rural Cambodian communities have access to improved sanitation; Lao PDR 56%; Viet Nam 70% and Thailand 96%.

SIMVA (2015) reports access to improved sanitation in Corridor communities as part of the composite resilience metric. The resilience metric focuses on the effects of floods and drought but does not include a baseline evaluation of household access prior to flooding. Flooding limited the access to sanitation for 18% of the flood-affected households in the LMB corridor (Figure 36). The average number of days without access to sanitation for flood affected households across the LMB corridor was 36: Cambodia reported 39 days; Viet Nam 24 days; Lao PDR and Thailand 4 and 7 days respectively (less than 10% of households reported flood effects).

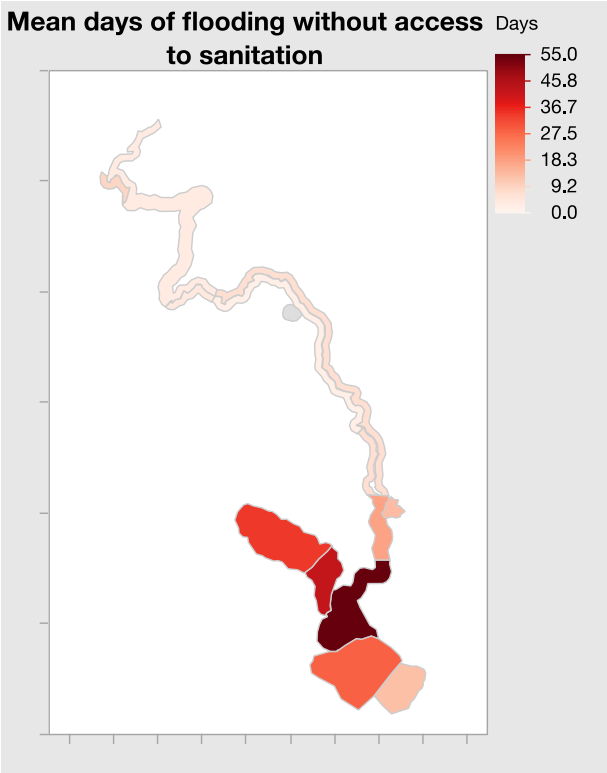
Figure 35 Access to improved sanitation: urban and rural populations in LMB countries



Source: WDI (2017)

Storage of food and drink and ensuring shelter and access to sanitation were reported by an average of 28% respondents as the most important measures to prevent or minimize the impacts from floods and droughts.

Figure 36 Mean days without access to sanitation due to flooding



Source: SIMVA (2015)

7.8 Energy security

Electricity as part of the rural energy mix is one of the most important factors for economic growth and human development. Energy access as a means for productive use is of key importance for rural communities to improve livelihoods and for the opportunities it creates. There are also strong linkages between rural poverty and electrification rates[17]. The indicators for CS Energy Security are the proportion of the rural population with access to electricity and rural electricity pricing. Electricity fees are charged as block tariffs in Lao PDR from 4c-12c/kWh. Tariffs in Cambodia are currently 9c-17c/kWh. As of 2014-2025 rural electrification in Thailand was 100%, 98.9% in Viet Nam, Thailand 58% in Cambodia (possibly as high as 68% EDC pers. comm.) and 68.1 % in Lao PDR. Available data are generally at national and provincial level and not specific to the corridor zones however.

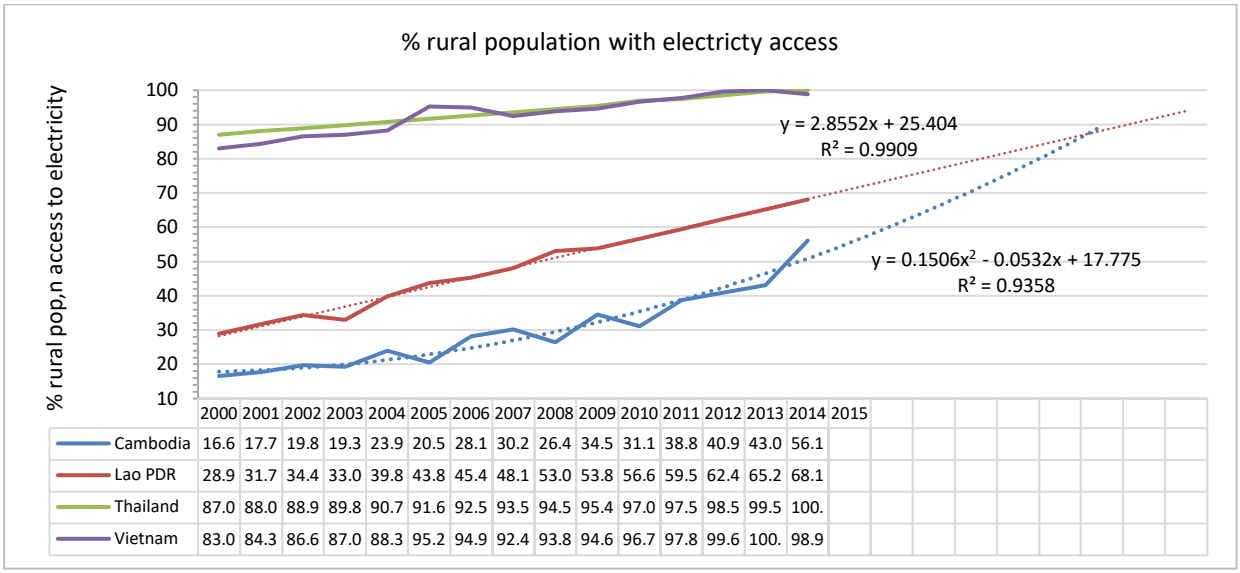
As Thailand and Viet Nam are at or close to 100% of electricity access, and therefore the development scenarios unlikely to have any effect on electrification levels, the social and economy assessment focused on the corridor zones in Cambodia and Lao PDR.

The Lao PDR Government Rural Electrification Master Plan[18] has set a national electrification target of 94% by 2020 and the Royal Government of Cambodia a target of 70% of all households by 2030[19]. Both Governments have specific Rural Electrification Departments and rural electrification enterprises and funds that focus on developing both grid and off-grid (renewable) supply. Electricite du Lao and Elecricite du Cambodge are state owned enterprises that promote primarily grid connections, including rural connection. Mini-hydro and pico-hydro[20], solar and biofuels are identified as part of the energy mix for rural communities in both Lao PDR and Cambodia and are expected to play an important role in achieving both national and rural electrification targets (ADB 2015)[21].

The mix of renewable and grid electrification, funding from sources such as the Global Environment Fund, the ADB and World Bank and ongoing institutional support are likely to have a far greater influence on rural electrification than the investments proposed in the CS development scenarios. The increasing national trends from 2000 to 2015 projected to 2024 indicate the rates of rural electrification are likely continue independently of the CS development scenarios.

[17] Alkire, S. and Robles, G. (2016) "Multidimensional Poverty Index Winter 2016: Brief methodological note and results." Oxford Poverty and Human Development Initiative, University of Oxford, *OPHI Briefing* 44.
[18] Under the updated Rural Electrification Master Plan (REMP) of 2010
[19] Ministry of Mines and Energy, RCG
[20] Liu, Maser and Esser (2013) estimate 60,000 pico hydro plants (<1.5KW) are in operation in Lao PDR. www.smallhydroworld.org/fileadmin/user_upload/pdf/WSHPDR_2013_Final_Report_updated_version.pdf.
[21] ADB (2015) Renewable energy developments and potential in the Greater Mekong Subregion. ADB, Manila. ISBN 978-92-9254-831-5

Figure 37National levels of rural electrification; projections to 2023



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cambodia	16.6	17.7	19.8	19.3	23.9	20.5	28.1	30.2	26.4	34.5	31.1	38.8	40.9	43.0	56.1	
Lao PDR	28.9	31.7	34.4	33.0	39.8	43.8	45.4	48.1	53.0	53.8	56.6	59.5	62.4	65.2	68.1	
Thailand	87.0	88.0	88.9	89.8	90.7	91.6	92.5	93.5	94.5	95.4	97.0	97.5	98.5	99.5	100.	
Vietnam	83.0	84.3	86.6	87.0	88.3	95.2	94.9	92.4	93.8	94.6	96.7	97.8	99.6	100.	98.9	

Source: WDI (2017)

7.9 Changes in the monetary value of agriculture and fisheries

The monetary value of agricultural and fisheries production was calculated from the production/surplus estimates derived from the social and economic assessment tool detailed in section of the report. The relative mean values (US$ year 1-24) of fish and rice for the corridor zones and the four main development scenarios are reported in Figure 38 and Figure 39 respectively. Additional estimates of the annual and mean value of livestock (cattle/buffalo, pigs, goats and poultry), other aquatic animals and specific fish guild prices and yields can be obtained from the social and economic spreadsheet tool. The reported fish values represent the aggregate of the white fish, grey, black, non-native and marine/estuarine guilds summarized by the BioRA team. The values of rice and fish production approximate an order of magnitude increase compared to the other corridor zones and are reported separately in Table 37 to facilitate ease of interpretation.

A primary Council Study focus is on the relative or ordinal comparison of the effects of the development scenarios. The comparative percent changes in the mean US$ value of fish and rice production across the four main development scenarios and corridor zones are reported in Table 38 and Table 39 respectively.

The results represent important insights for the respective CS Thematic teams to gain a better understanding of the economic consequences of the development scenarios.

Table 36 Estimated monetary value (USD '000) of fish and rice production: Viet Nam corridor zones by development scenarios

Fish production		Scenario (USD '000)			
SIMVA Zone		M1	M2	M3	CC
Zone 6 A Viet Nam Delta - freshwater		5,453,209	5,316,319	5,300,400	5,250,127
Zone 6 B Viet Nam Delta - saline		1,417,272	1,273,517	1,257,410	1,265,632
	Total	6,870,481	6,589,836	6,557,810	6,515,759
Rice production					
Zone 6 A Viet Nam Delta - freshwater		4,189,152	4,176,794	4,081,096	4,065,772
Zone 6 B Viet Nam Delta - saline		878,830	878,568	878,486	862,092
	Total	5,067,981	5,055,362	4,959,582	4,927,864

The mean fisheries value of the M2 and M3 scenario (year 1-24) declines by US$ 1.04 and US$1.57 billion (-25% and -38% respectively) compared to the M1 baseline. The highest proportion of the decline in value occurs between the M1 and M2 scenarios (US$ 1.05 billion); the additional decline from M2-M3 equals US$0.52 billion or a further decline of 21%. TheM1-M2 percent changes range from -3% (Viet Nam zone 6A) to -39% (Lao PDR zone 2). TheM1-M3 percent changes range from -3% (Viet Nam zone 6A) to -68% (Lao PDR zone 2 and Thailand zone 3C). The predicted effects of climate change introduce a further 2% reduction of the M3 scenario or US$ 0.134 billion.

The mean rice value of the M2 and M3 scenario (year 1-24) increases by US$ .34 and US$ 0.95 billion compared to the M1 baseline. The highest proportion of the increase in value occurs between the M2 and M3 scenarios (US$ 0.61 billion) or an additional mean increase of 10%. TheM1-M2 percent changes range from 0% (Viet Nam zone 6A and 6B; Cambodia 4B and 5B) to 66% (Thailand zone 3C). TheM1-M3 percent changes range from -5% (Thailand zone 3C) to 96% (Thailand zone 2C). The predicted effect of climate change introduces a -6% decline in value of the M3 scenario or US$ .135 billion.

Figure 38 Estimated monetary value (mean US$) of fish production: by corridor zone across development scenarios

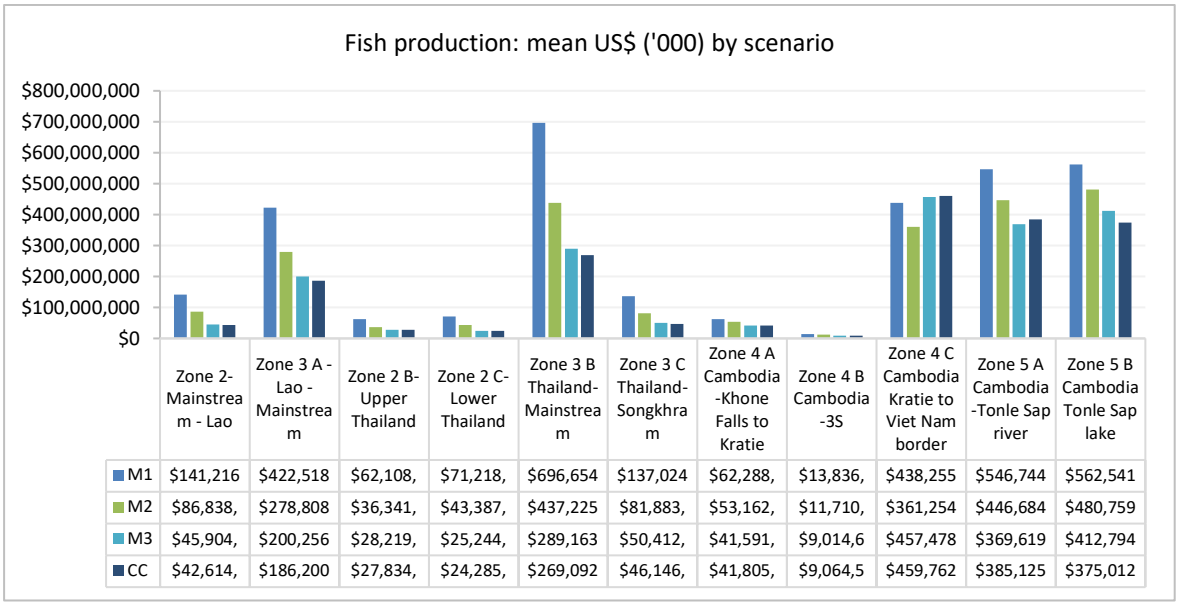


Table 37 Relative changes in the value (US$) of M1, M2, M3 and M3CC corridor fish production

Fish production	M1-M2		M1-M3		M3-M3CC		M2-M3	
SIMVA Zone	$'000	%	$'000	%	$'000	%	$'000	%
Zone 2-Mainstream - Lao	-54,378	-39%	-95,312	-67%	-3,290	-7%	-40,934	-47%
Zone 3 A - Lao - Mainstream	-143,710	-34%	-222,263	-53%	-14,056	-7%	-78,553	-28%
Zone 2 B-Upper Thailand	-25,767	-41%	-33,888	-55%	-385	-1%	-8,122	-22%
Zone 2 C-Lower Thailand	-27,831	-39%	-45,975	-65%	-959	-4%	-18,143	-42%
Zone 3 B Thailand-Mainstream	-259,429	-37%	-407,490	-58%	-20,071	-7%	-148,062	-34%
Zone 3 C Thailand-Songkhram	-55,141	-40%	-86,611	-63%	-4,266	-8%	-31,470	-38%
Zone 4 A Cambodia-Khone Falls to Kratie	-9,125	-15%	-20,696	-33%	214	1%	-11,571	-22%
Zone 4 B Cambodia-3S	-2,126	-15%	-4,822	-35%	50	1%	-2,696	-23%
Zone 4 C Cambodia Kratie to Viet Nam border	-77,002	-18%	19,223	4%	2,284	0%	96,224	27%
Zone 5 A Cambodia-Tonle Sap river	-100,060	-18%	-177,125	-32%	15,506	4%	-77,065	-17%
Zone 5 B Cambodia Tonle Sap lake	-81,782	-15%	-149,746	-27%	-37,783	-9%	-67,964	-14%
Zone 6 A Viet Nam Delta - freshwater	-102,828	-2%	-170,567	-3%	97,470	2%	-67,739	-1%
Zone 6 B Viet Nam Delta - saline	-108,712	-8%	-176,644	-13%	99,795	8%	-67,933	-5%
Total	-1,047,892	-25%	-1,571,918	-38%	134,509	-2%	-524,026	-21%

Figure 39 Estimated monetary value (mean US$) of rice production: by corridor zone across development scenarios

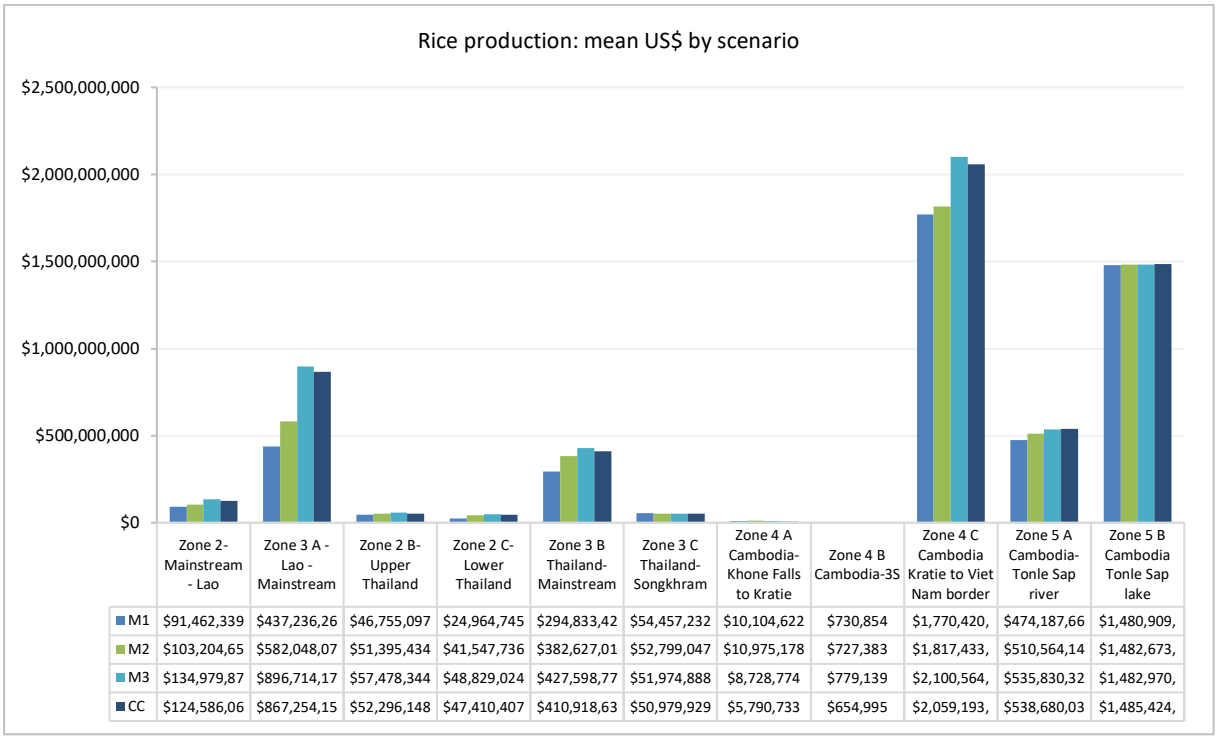


Table 38 Relative changes in the value (US$) of M1, M2, M3 and M3CC corridor rice production

Rice production	M1-M2		M1-M3		M3-M3CC		M2-M3	
SIMVA Zone	$'000	%	$'000	%	$'000	%	$'000	%
Zone 2-Mainstream - Lao	11,742	13%	43,518	48%	-10,394	-8%	31,775	31%
Zone 3 A - Lao - Mainstream	144,812	33%	459,478	105%	-29,460	-3%	314,666	54%
Zone 2 B-Upper Thailand	4,640	10%	10,723	23%	-5,182	-9%	6,083	12%
Zone 2 C-Lower Thailand	16,583	66%	23,864	96%	-1,419	-3%	7,281	18%
Zone 3 B Thailand-Mainstream	87,794	30%	132,765	45%	-16,680	-4%	44,972	12%
Zone 3 C Thailand-Songkhram	-1,658	-3%	-2,482	-5%	-995	-2%	-824	-2%
Zone 4 A Cambodia-Khone Falls to Kratie	871	9%	-1,376	-14%	-2,938	-34%	-2,246	-20%
Zone 4 B Cambodia-3S	-3	0%	48	7%	-124	-16%	52	7%
Zone 4 C Cambodia Kratie to Viet Nam border	47,013	3%	330,144	19%	-41,371	-2%	283,130	16%
Zone 5 A Cambodia-Tonle Sap river	36,376	8%	61,643	13%	2,850	1%	25,266	5%
Zone 5 B Cambodia Tonle Sap lake	1,764	0%	2,061	0%	2,454	0%	297	0%
Zone 6 A Viet Nam Delta - freshwater	-12,357	0%	-108,056	-3%	-15,324	0%	-95,699	-2%
Zone 6 B Viet Nam Delta - saline	-262	0%	-344	0%	-16,394	-2%	-82	0%
Total	337,314	13%	951,986	26%	-134,977	-6%	614,672	10%

Development Sub Scenarios

The monetary value of fish and rice production (US$ million) of the M3 main development scenario compared to the Council Study sub-scenarios are detailed in Table 40 and Table 41. The dollar value of fish production ranges from US$8.27 billion (sub-scenario M3CC) to US$ 10.23 billion (sub-scenario H1a). The mean value across the sub-scenarios is US$ 8.75 billion, the range is US$ 1.96 billion and the standard deviation is US$ US$ 0.51 billion.

The dollar value of rice production ranges from US$8.92 billion (sub-scenario A1) to US$ 10.57 billion (sub-scenario M3CC). The mean value across the sub-scenarios is US$ 9.91 billion, the range is US$ 1.65 billion and the standard deviation is US$ US$ 0.35 billion.

Table 39 Fish value (US$ million) by SIMVA Zone across development scenarios

	Scenario (US$ Million: Fish production)													
SIMVA Zone	**M3**	**M3CC**	**C2**	**C3**	**A1**	**A2**	**I1**	**I2**	**F1**	**F2**	**F3**	**H1a**	**H1b**	**H3**
Zone 2-Mainstream - Lao	45.9	42.6	43.4	38.4	44.5	42.1	44.0	42.6	42.8	42.6	42.7	127.5	106.2	44.9
Zone 3 A - Lao - Mainstream	200.3	186.2	189.9	170.2	195.5	187.7	190.9	188.2	189.0	186.2	186.9	376.0	294.5	191.9
Zone 2 B-Upper Thailand	28.2	27.8	28.5	27.6	27.8	27.8	27.9	27.8	27.8	27.8	27.8	57.9	50.2	27.8
Zone 2 C-Lower Thailand	25.2	24.3	24.5	23.1	24.8	24.1	24.7	24.3	24.3	24.3	24.3	64.3	53.1	24.9
Zone 3 B Thailand-Mainstream	289.2	269.1	273.2	245.3	282.3	270.8	276.8	271.3	272.4	269.2	271.6	613.7	467.2	277.9
Zone 3 C Thailand-Songkhram	50.4	46.1	47.0	41.1	48.9	46.5	47.8	46.6	46.8	46.2	46.7	119.4	88.3	48.0
Zone 4 A Cambodia-Khone Falls to Kratie	41.6	41.8	41.9	40.4	42.0	41.3	42.4	41.6	41.7	41.7	41.6	60.8	53.4	42.8
Zone 4 B Cambodia-3S	9.0	9.1	9.1	8.7	9.1	8.9	9.2	9.0	9.0	9.0	9.0	13.5	11.8	9.3
Zone 4 C Cambodia Kratie to Viet Nam border	457.5	459.8	460.3	443.1	462.9	461.2	487.4	461.2	462.4	460.3	460.2	449.0	412.8	470.3
Zone 5 A Cambodia-Tonle Sap river	369.6	385.1	380.8	343.9	392.0	380.4	376.0	370.8	424.5	365.8	409.7	537.1	456.6	406.3
Zone 5 B Cambodia Tonle Sap lake	412.8	375.0	416.1	264.5	369.7	377.2	399.5	390.8	387.6	428.5	434.5	532.4	430.1	407.6
Zone 6 A Viet Nam Delta - freshwater	5273.7	5371.2	5394.1	5335.2	5369.9	5364.5	5370.6	5369.7	5367.6	5317.0	5343.2	5502.8	5428.0	5352.0
Zone 6 B Viet Nam Delta - saline	1231.6	1331.4	1355.4	1293.4	1441.1	1324.3	1330.7	1329.8	1327.6	1298.3	1327.5	1784.9	1666.5	1310.6
Grand Total	8435.1	8569.6	8664.4	8274.9	8710.6	8557.0	8627.9	8573.6	8623.4	8516.9	8625.6	10239.2	9518.6	8614.3

Table 40 Rice value (US$ million) by SIMVA Zone across development scenarios

	Scenario (US$ Million: Rice production)													
SIMVA Zone	**M3**	**M3CC**	**C2**	**C3**	**A1**	**A2**	**I1**	**I2**	**F1**	**F2**	**F3**	**H1a**	**H1b**	**H3**
Zone 2-Mainstream - Lao	135.0	124.6	125.3	119.8	90.8	136.0	135.8	136.0	124.6	124.6	124.6	125.0	125.1	124.0
Zone 3 A - Lao - Mainstream	896.7	867.3	855.9	857.0	429.5	895.6	895.6	895.6	867.3	867.3	867.3	867.5	905.1	867.1
Zone 2 B-Upper Thailand	57.5	52.3	52.5	50.7	46.7	57.5	57.5	57.5	52.3	52.3	52.3	52.3	52.3	52.2
Zone 2 C-Lower Thailand	48.8	47.4	46.8	47.2	24.5	48.8	48.8	48.8	47.4	47.4	47.4	47.4	48.3	47.4
Zone 3 B Thailand-Mainstream	427.6	410.9	402.1	400.8	301.6	425.2	425.3	425.2	410.9	410.9	410.9	408.6	411.0	410.1
Zone 3 C Thailand-Songkhram	52.0	51.0	50.3	46.0	54.5	52.0	52.0	52.0	51.0	51.0	51.0	51.0	51.0	51.1
Zone 4 A Cambodia-Khone Falls to Kratie	6.1	5.8	5.8	5.1	8.5	8.5	8.4	8.5	5.8	5.8	5.8	5.5	7.6	5.0
Zone 4 B Cambodia-3S	0.8	0.7	0.7	0.5	0.7	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
Zone 4 C Cambodia Kratie to Viet Nam border	1849.1	2059.2	1800.8	1800.8	1300.2	1800.8	1800.8	1800.8	1832.8	1852.4	1810.3	1852.4	1834.2	1831.0
Zone 5 A Cambodia-Tonle Sap river	482.3	538.7	491.9	491.9	432.3	491.9	491.9	491.9	502.4	487.3	482.9	487.3	496.2	493.2
Zone 5 B Cambodia Tonle Sap lake	1357.4	1485.4	1374.3	1374.3	1374.3	1374.3	1374.3	1374.3	1400.4	1371.4	1375.0	1371.4	1397.9	1391.4
Zone 6 A Viet Nam Delta - freshwater	3983.4	4065.8	3910.6	3910.6	4013.9	3910.6	3910.6	3910.6	3704.1	3697.4	3688.8	3697.4	3568.3	3921.7
Zone 6 B Viet Nam Delta - saline	843.8	862.1	842.7	842.7	842.7	842.7	842.7	842.7	871.0	861.3	870.3	861.3	857.3	851.9
Grand Total	10140.5	10571.1	9959.6	9947.3	8920.1	10044.6	10044.4	10044.6	9870.7	9829.6	9787.1	9827.7	9755.0	10046.8

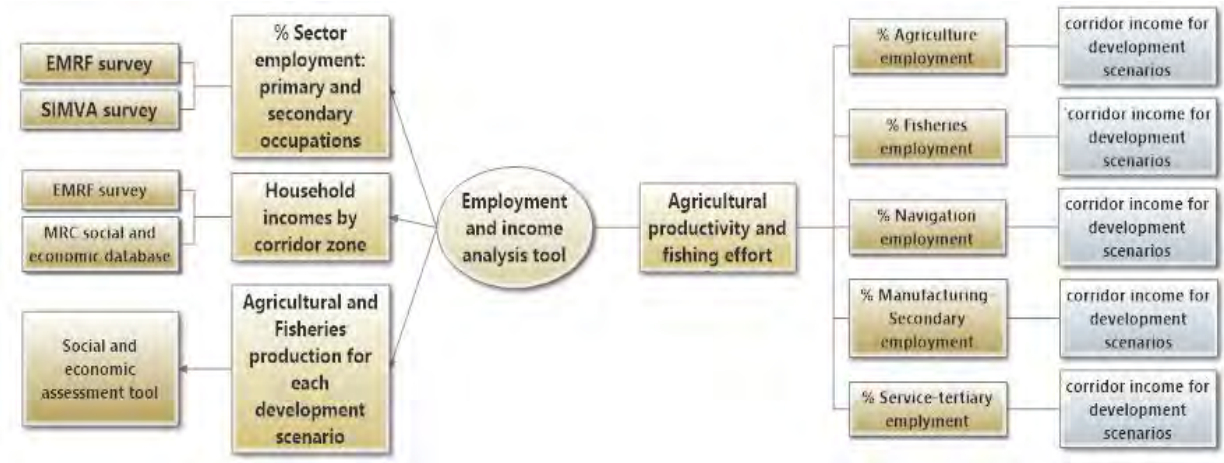
7.10 Employment in the Council Study sectors

Changes in the structure and composition of employment in the LMB corridor associated with the Development scenarios was identified as one of the main social and economic sub-assessment indicators. The primary variables assessed are the estimated number of fulltime employment (FTE) and the relative employment contribution of the CS sectors to communities residing in the LMB corridor. The Employment indicator has clear linkages to the Income Security indicator, particularly the diversity of household income sources and the proportion of income derived from the Agricultural fisheries and navigation sectors.

Historical employment (expressed as full-time equivalent (FTE) jobs in MRC sectors) was derived from the SIMVA and EMRF surveys for the CS corridors referenced against international employment databases (see section 11.8). The data sets enabled estimates of the proportions of primary and secondary livelihood occupations referenced against the levels of agricultural production and a determination of labour requirements (that is productivity measured as the number of people required to produce one tonne of rice or catch one tonne of fish) for each corridor zone.

The primary sector is defined as agricultural and fishing employment. The secondary sector refers to manufacturing, construction and industries that produce a finished good. Tertiary sector refers to service related activities. Agricultural production and fish catch estimates were derived from the CS Social and Economic Assessment tool used to calculate levels of food security and subsequent production surpluses available for sale or consumption. from which can be determined. An employment and income spreadsheet tool was developed to connect the food security and the agricultural-fisheries analysis with sectoral employment estimates and inform the macro-economic assessment of the Council Study (details of the tool can be found in Appendix 10.3). A schematic of the model logic is illustrated in Figure 40.

Figure 40 Schematic of the employment and income tool



The BioRA (fish biomass) and IWRM (rice yields and production area) are the primary data inputs to the social and economic assessment, establishing the functional relationships between the employment indicators describing the corridor zones and the CS main development scenarios and sub-scenarios. The fish and rice production therefore establish the foundation data to estimate the relative proportions of primary employment (rice and fish production) sufficient to produce agricultural and fish production estimates. Agricultural employment changes across the development scenarios, hence primary sector employment also changes. Secondary and tertiary employment numbers were calculated as the residual number of working population after agriculture and fishing

employment estimates were subtracted from the working population. The employment estimates are therefore biased towards the primary sector in order to meet priority food and nutritional security.

The employment and subsequent income estimates rely on six sequenced methodological steps:

Step one establishes the relative proportions of existing sectoral employment from the SIMVA 2011 and EMRF 2012 survey data, apportioned to agriculture, fishing, navigation, secondary and tertiary sectors. The majority of survey respondents indicated they have at least two livelihood occupations, mostly involved in agriculture. Sector employment proportions for each corridor zone were calculated by using scaling factors of 0.2 for fishing (the majority of respondents indicated they were part time fishers) and 0.62-0.71 for agriculture, applied to the raw primary and secondary scores to address livelihood diversity. The scaling factor implies that farmers spend 70% of their labour on farm and 30% off farm. Secondary occupations were scaled down by a factor of 0.3 to calculate Full time employment (FTE) equivalence. Final employment estimates for each corridor were estimated by applying the FTE sector proportions to the zone population estimates for years one and 24 (see Section 5.2). The proportion of the population in work for each zone were derived from the ADB national estimates (ADB 2017, national statistics available online). Unemployment is factored into the ASDB estimates.

Step 2: rice and fish production estimates for each development scenario by corridor zone were imported from the social and economic assessment tool.

Step 3: productivity levels for rice production and fishing effort were estimated for each corridor zone for years 1 and 24 of the CS time horizon. Productivity was measured as the number of people required to produce one tonne of rice and catch one tonne of fish. Productivity was assumed constant across all development scenarios and for years 1 and 24. Productivity was calculated as the number of people stating their primary or secondary occupation was agriculture divided by the volume of either rice or fish production. Several options for productivity levels were and can be investigated using the developed employment tool. The output estimates the number of people involved in agriculture or fishing for a given production level estimated for each development scenario

Step 4: The agriculture and fishing employment levels were imported into the employment calculator specific for each development scenario for the working population levels estimated for years 1 and 24. Secondary and tertiary employment numbers were calculated as the residual number of the working population after agriculture and fishing employment estimates were subtracted.

Step 5: median incomes for each sector were estimated from the SIMVA and EMRF datasets and referenced against International employment and income data.

Step 6: Employment numbers and associated incomes were estimated for each sector by corridor zone and development scenario (years 1 and 24). The incomes were further scaled up to national level by aggregating the respective zones located in each of the four member countries for the macro-economic assessment.

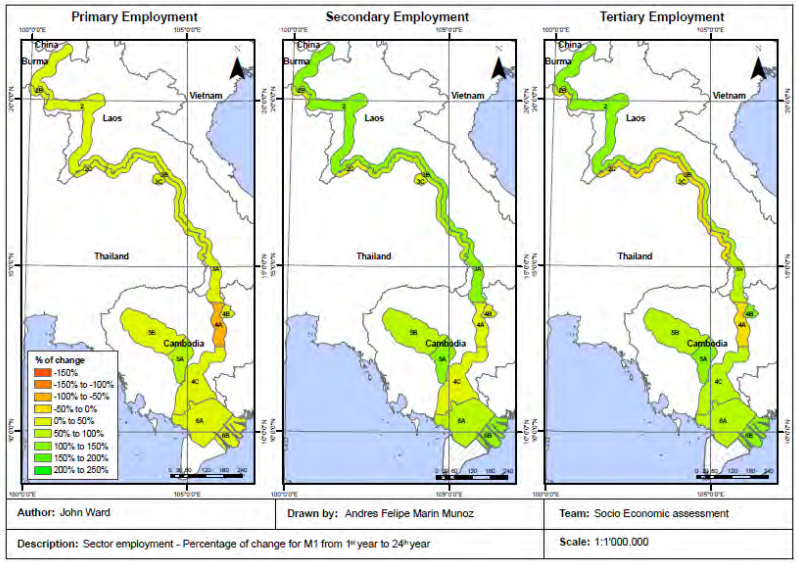
The employment estimates for the primary, secondary, tertiary and navigation sectors across the 13 SIMVA zones the M1 (years 1 and 24), M2 (year 24) and M3 (year 24) development scenarios are detailed in Figure 42. The M1 year 1 compared to year 24 is intended as a reference control to indicate the modelled changes in sectoral employment levels due to the estimated population growth for each corridor zone.

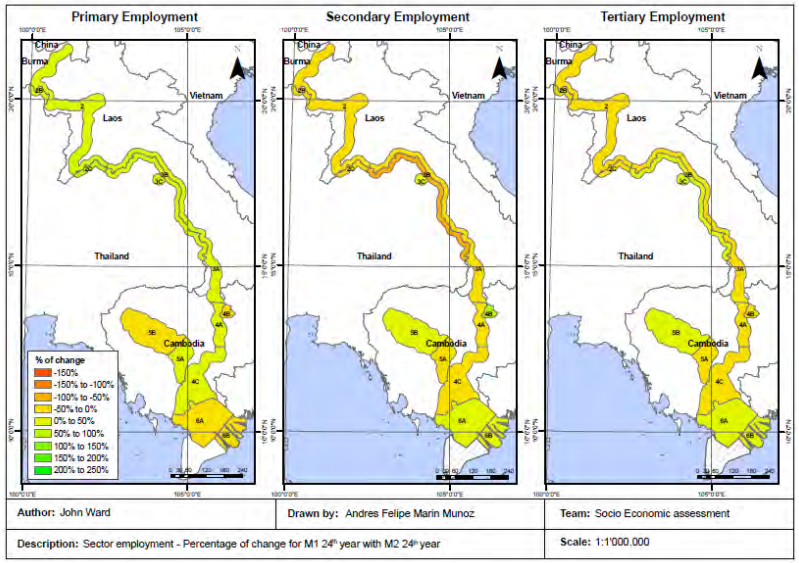
Sectoral employment estimates for the M3CC, C2, C3 and ALU1 sub scenarios are illustrated in Figure 43. The ALU2, Irr1, Irr2 and F1 sub scenario employment estimates are detailed in Figure 44 and the

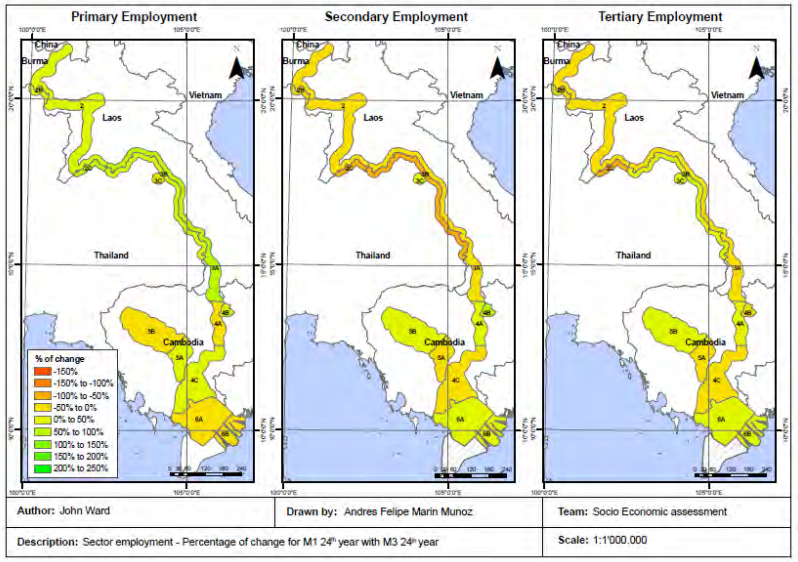
F2, F3, H1a and H1b hydropower sub scenario employment for the four CS sectors are illustrated in Figure 45.

The spatial representation of the main development scenarios sector employment for each of the Corridor zones is illustrated in Figure 41. The maps represent the changes in mean value (%) of years 1-24, year1 and year 24 compared to the M1 pre-development scenario.

Figure 41 Sector employment by zone across M1, M2, M3 and M3CC (% change)







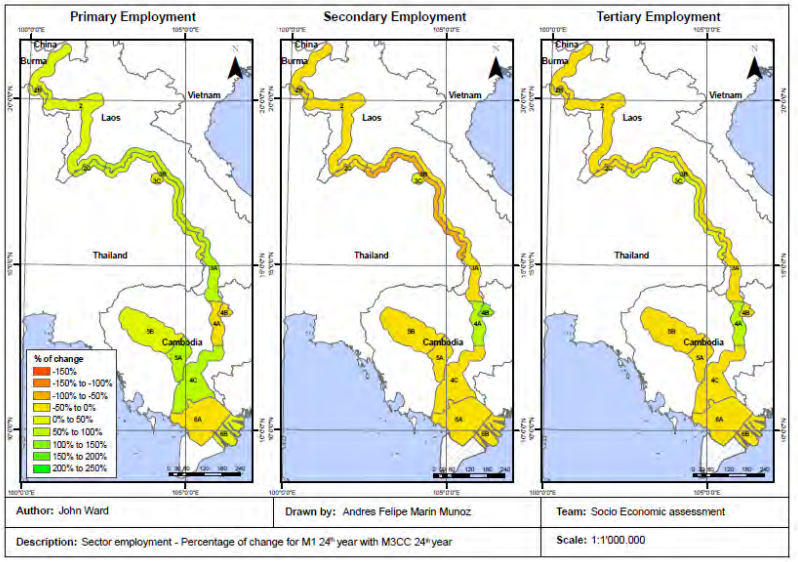
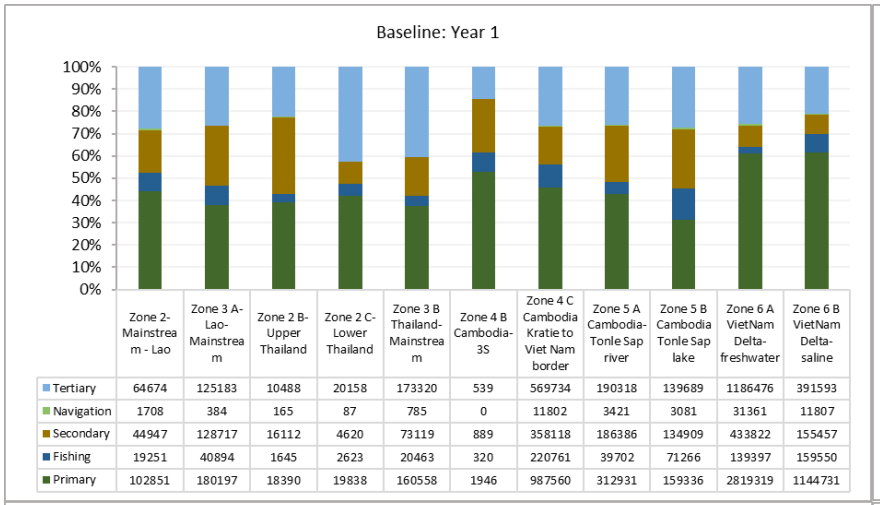
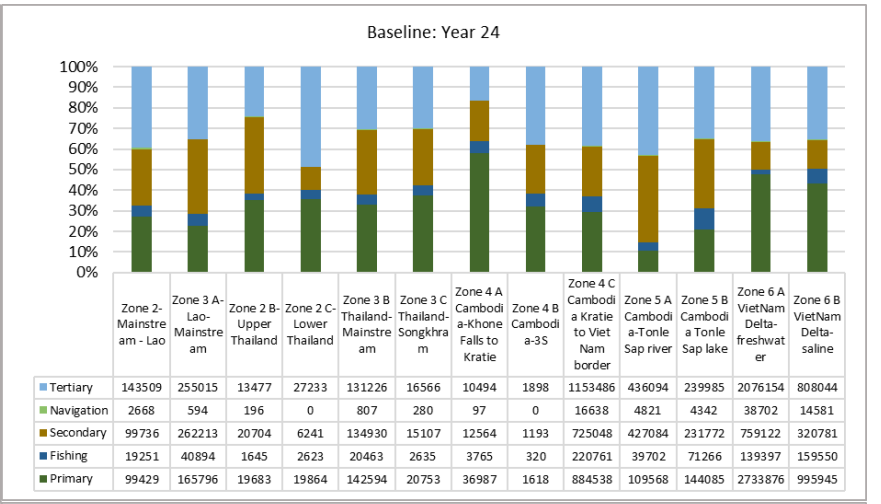


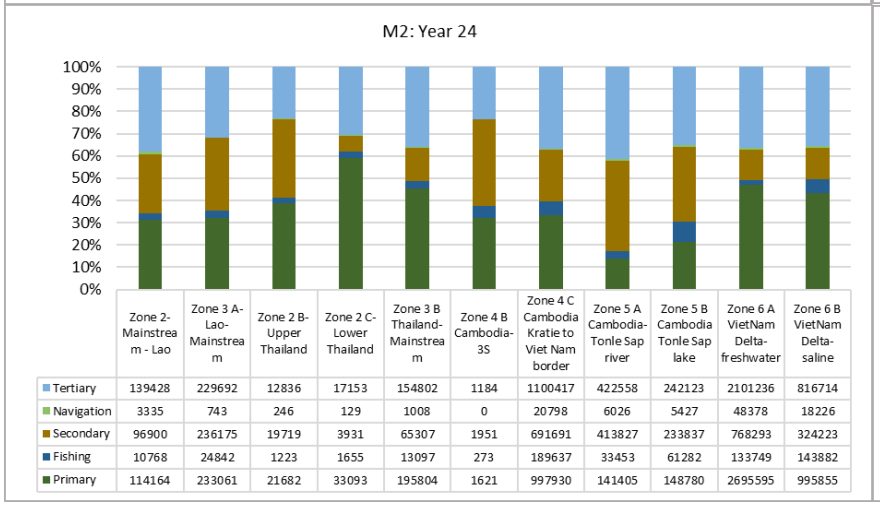
Figure 42 Sector employment by corridor zone: M1 year 1, and year 24; M2 and M3 year 24



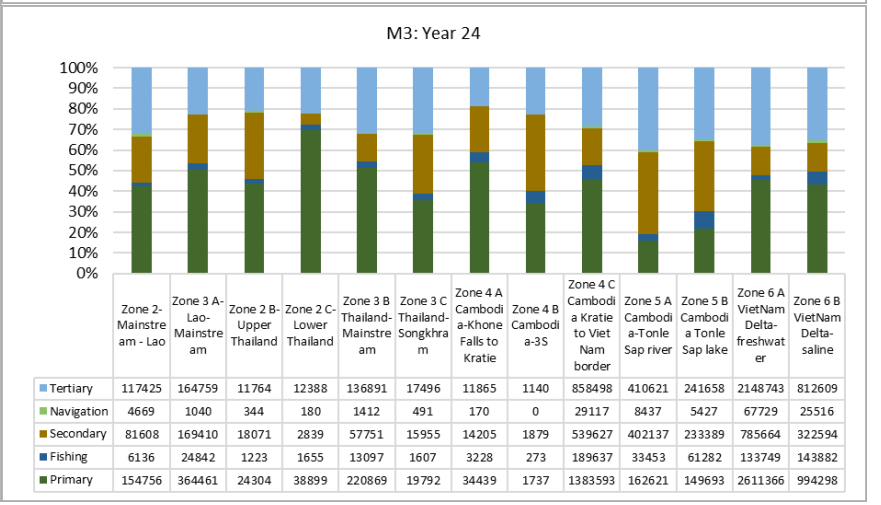
	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	64674	125183	10488	20158	173320	539	569734	190318	139689	1186476	391593
Navigation	1708	384	165	87	785	0	11802	3421	3081	31361	11807
Secondary	44947	128717	16112	4620	73119	889	358118	186386	134909	433822	155457
Fishing	19251	40894	1645	2623	20463	320	220761	39702	71266	139397	159550
Primary	102851	180197	18390	19838	160558	1946	987560	312931	159336	2819319	1144731



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	143509	255015	13477	27233	131226	16566	10494	1898	1153486	436094	239985	2076154	808044
Navigation	2668	594	196	0	807	280	97	0	16638	4821	4342	38702	14581
Secondary	99736	262213	20704	6241	134930	15107	12564	1193	725048	427084	231772	759122	320781
Fishing	19251	40894	1645	2623	20463	2635	3765	320	220761	39702	71266	139397	159550
Primary	99429	165796	19683	19864	142594	20753	36987	1618	884538	109568	144085	2733876	995945



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	139428	229692	12836	17153	154802	1184	1100417	422558	242123	2101236	816714
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	96900	236175	19719	3931	65307	1951	691691	413827	233837	768293	324223
Fishing	10768	24842	1223	1655	13097	273	189637	33453	61282	133749	143882
Primary	114164	233061	21682	33093	195804	1621	997930	141405	148780	2695595	995855



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	117425	164759	11764	12388	136891	17496	11865	1140	858498	410621	241658	2148743	812609
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	81608	169410	18071	2839	57751	15955	14205	1879	539627	402137	233389	785664	322594
Fishing	6136	24842	1223	1655	13097	1607	3228	273	189637	33453	61282	133749	143882
Primary	154756	364461	24304	38899	220869	19792	34439	1737	1383593	162621	149693	2611366	994298

Figure 43 Sector employment by corridor zone: M3CC, C2, C3 and ALU1, year 24

M3CC: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	118022	173883	12618	13983	147236	1514	712624	388752	237788	2079953	728653
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	82023	178791	19384	3204	62115	2495	447935	380720	229651	760511	289264
Fishing	5537	16834	950	1058	9423	196	225145	27817	48990	133612	143504
Primary	155675	354261	22508	37587	210237	824	1593970	213953	169593	2724796	1119253

C2: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	117938	178509	12610	14408	152162	18469	18904	1491	933017	419755	252287	2397675	821325
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	81965	183548	19371	3302	64193	16842	22632	2457	586468	411082	243653	876683	326054
Fishing	5650	16834	950	1058	9423	1094	2351	196	225145	27817	48990	133612	143504
Primary	154373	344580	22431	37013	202830	18445	19849	884	1226726	150178	141092	2271552	982501

C3: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	123165	176531	12802	14220	149351	1600	945231	423436	260560	2413811	831877
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	85598	181514	19667	3259	63007	2636	594145	414688	251643	882583	330243
Fishing	4788	14791	933	973	8485	193	213572	22941	32727	130927	136054
Primary	147708	350933	22057	37381	208167	600	1226726	150178	141092	2271552	982501

A1: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	150579	265603	13701	28726	188956	17331	12355	1211	1136824	443705	260560	2355969	826658
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	104649	273100	21048	6583	79716	15804	14792	1996	714575	434537	251643	861433	328171
Fishing	5876	14791	933	973	8485	963	2308	193	213572	22941	32727	130927	136054
Primary	98821	169977	19680	19499	151450	20753	34282	1630	906384	107650	141092	2331193	982501

Figure 44 Sector employment by corridor zone: ALU2, Irr1, Irr2 and F1 year 24

A2: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	117922	168186	11905	12919	140185	1169	937430	421208	249519	2412456	828201
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	81954	172933	18288	2961	59141	1927	589242	412505	240980	882087	328783
Fishing	5467	17385	951	1050	9676	195	226276	27352	54431	132778	141189
Primary	155916	365265	24315	38902	220009	1737	1226726	150178	141092	2271552	982501

Irr1: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	117942	168134	11866	12878	139786	17746	13493	1169	932322	419990	249519	2398286	822982
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	81967	172879	18229	2951	58972	16183	16153	1927	586031	411312	240980	876906	326712
Fishing	5773	17385	951	1050	9676	1129	2333	195	226276	27352	54431	132778	141189
Primary	154243	365074	24315	38902	220173	19792	31758	1737	1226726	150178	141092	2271552	982501

Irr2: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	202206	339206	20749	42224	279991	-679	1620458	452007	311732	3452814	1205319
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	140529	348780	31875	9676	118121	-1120	1018573	442668	301064	1262483	478494
Fishing	5539	17416	951	1058	9690	196	226297	26493	57114	133106	142098
Primary	12984	18366	1885	2874	21208	6632	114346	90075	16113	850471	454763

F1: Year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	201372	339218	20711	42176	279923	26881	693	-683	1615226	443010	311950	3438305	1199640
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	139950	348793	31816	9665	118093	24513	830	-1125	1015285	433857	301275	1257177	476239
Fishing	5563	17416	951	1058	9690	1131	2343	196	226297	26493	57114	133106	142098
Primary	13041	18045	1883	2882	20902	2325	59871	6640	114548	105473	15683	850934	455407

Figure 45 Sector employment by corridor zone: F2, F3, H1a, H1b year 24

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	118022	173883	12618	13983	147236	1514	815271	402022	238067	2313251	755310
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	82023	178791	19384	3204	62115	2495	512456	393716	229920	845814	299847
Fishing	5538	16834	950	1058	9423	196	226302	25723	61445	130329	134394
Primary	155675	354261	22508	37587	210237	824	1425645	189781	156589	2409479	1091123

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	117235	173737	12579	13941	146952	18668	18042	1514	839984	403454	238121	2318077	741979
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	81476	178640	19324	3195	61995	17023	21600	2495	527990	395119	229973	847579	294555
Fishing	5538	16834	950	1058	9423	1094	2346	196	226302	25723	61445	130329	134394
Primary	155675	354261	22508	37587	210237	18065	21749	824	1377078	184536	156483	2383538	1102456

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	110695	164842	12363	12852	144165	1470	800494	393986	229993	2304972	732858
Navigation	3335	743	246	129	1008	0	20798	6026	5427	48378	18226
Secondary	76931	169495	18991	2945	60820	2422	503167	385845	222122	842787	290933
Fishing	17567	36464	1573	2431	18430	317	250368	41631	77317	141635	165760
Primary	156066	352967	22533	37604	205596	821	1425645	189781	156589	2409479	1091123

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Tertiary	111840	156099	12337	12234	140527	18011	14119	1468	805821	391917	228192	2391302	731585
Navigation	4669	1040	344	180	1412	491	170	0	29117	8437	5427	67729	25516
Secondary	77726	160505	18952	2804	59285	16424	16903	2420	506516	383819	220383	874353	290428
Fishing	14168	36464	1573	2431	18430	2351	3727	317	250368	41631	77317	141635	165760
Primary	156191	370405	22500	38313	210365	18065	28988	824	1408649	191465	160130	2272232	1085611

A key outcome of the CS employment analysis is an estimation of how the water related development scenarios are likely to affect the levels of sector employment. The M1 comparison of year 1 and year 24 to assess the effects of population growth is detailed in Figure 46. The % sector employment changes in the M2 and M3 development scenarios (year 24) compared to the M1 baseline employment are illustrated in Figure 47 and Figure 48.

The M1 comparison across the 24-year time horizon indicates, that *ceteris paribus* agricultural productivity, there are substantial increases in the secondary, tertiary and navigation sectors and relatively modest increases in the primary sector across the majority of corridor zones. That is, projected increases in the working population over the 24-year project tome horizon are sufficient to meet potential labour demands associated with expanding secondary, tertiary and navigation sectors.

The estimated reductions in the tertiary sector in year 24 of the 2B and 3C zones in Thailand and the 4A zone in Cambodia are the exceptions. The zones are characterized by low relative population growth and high out migration rates. The 10% and 20% increase in estimated primary sector employment reflect the need to increase agricultural production (at constant productivity levels) to meet the increase, albeit low, food security needs. The 4A zone primary sector and tertiary sector reductions are an artefact of the climate variance predicted to affect the yields of rainfed rice production.

Note that the navigation employment estimates are substantially lower than those estimated by the CS Navigation theme. Both SIMVA and EMRF surveys focused on rural communities residing either in the corridor or proximate regions. The Navigation Theme also addresses navigation employment in the major urban centres of for example Vientiane, Pakse, Phnom Penh and Can Tho where most navigation employment occurs or is predicted to occur in the future. Navigation numbers estimated in the SE assessment can be adjusted by reducing the number of secondary and tertiary employment, assuming agricultural and fishing productivity remains constant to meet predicted food security requirements. Alternately additional navigation labour demands could be met through labour migration.

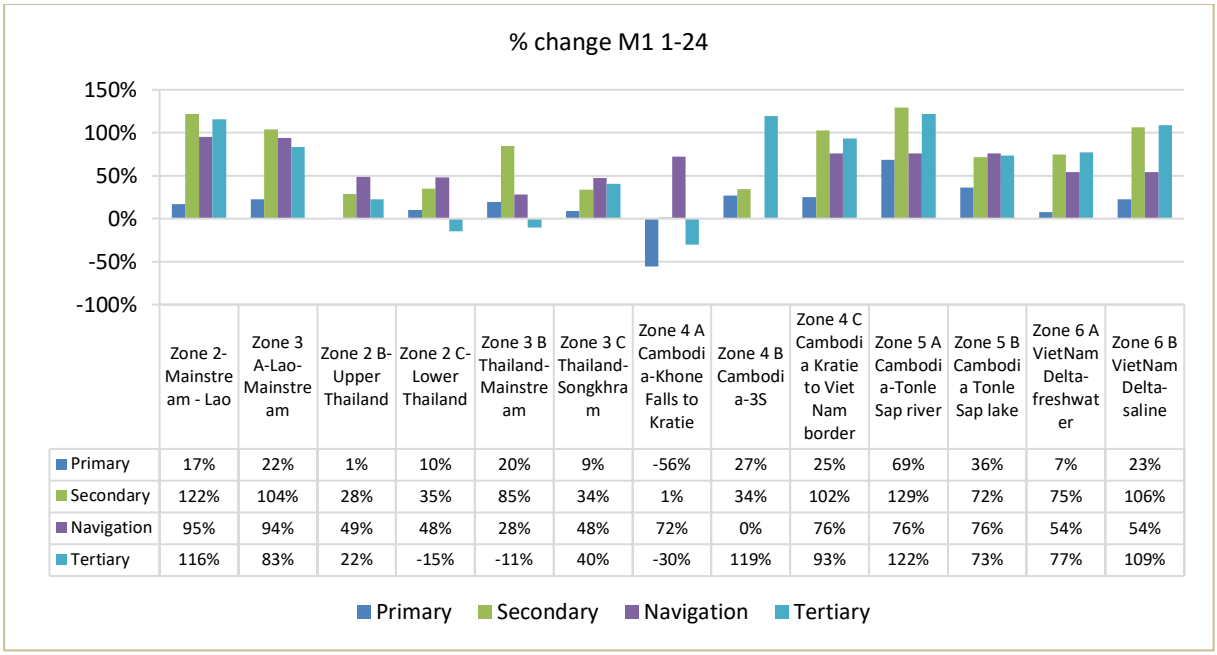
National economic planning for the four member countries focuses on jointly increasing the manufacturing and service sectors of their respective national economies and increasing the productivity of the agricultural sector. Without substantial increases in agricultural productivity, through consolidation, capital investment, mechanization and improved soil and farm management, the strategies potentially introduce conflicting labour demands. The employment analysis depicted in Figure 47 and Figure 48 highlights the estimated M2 and M3 increases in primary sector employment to meet agricultural expansion and food security needs and the associated likelihood of labour shortages in the secondary and tertiary sectors.

The following comparative analysis of employment trends does not consider the multiple and interdependent political, cultural, institutional, technological and economic factors influencing labour decisions and opportunities. The analysis represents only a partial analysis of employment patterns by focusing on the outputs of CS Thematic and Disciplinary teams to isolate the main consequences of the development scenarios compared to the M1 baseline. As a corollary, agricultural productivity, migration patterns, fishing effort, cultural preferences, wage differentials, labour conditions and labour opportunities were assumed to be constant across the analyses. The current analysis does provide one aspect of data and analytical basis, the effect of the water development scenarios, as a foundation for future research that accounts for labour influencing factors.

Substantial changes in the proportion of year 24 sectoral employment were predicted for the M2 and M3 scenarios compared to the M1 baseline. For all zones, the Navigation sector increases were established at 25% for the M2 and 75% for the M3 scenarios, based on the estimates reported by the

Navigation Thematic team. Note that the primary sector employment represents an aggregation of employment in agriculture and fishing.

Figure 46 Changes in sector employment: M1 years 1-24



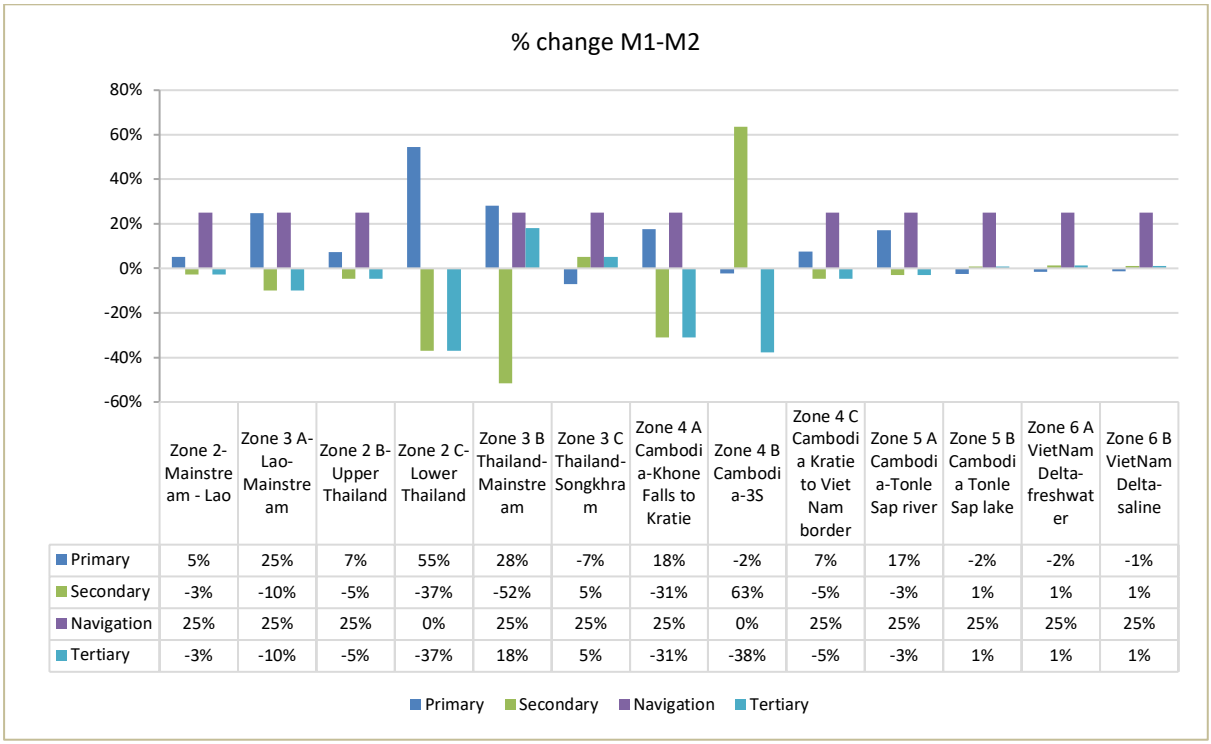
	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	17%	22%	1%	10%	20%	9%	-56%	27%	25%	69%	36%	7%	23%
Secondary	122%	104%	28%	35%	85%	34%	1%	34%	102%	129%	72%	75%	106%
Navigation	95%	94%	49%	48%	28%	48%	72%	0%	76%	76%	76%	54%	54%
Tertiary	116%	83%	22%	-15%	-11%	40%	-30%	119%	93%	122%	73%	77%	109%

Cambodia: The increase in primary sector employment estimates to meet the food security requirements of growing zone populations in the M2 scenario were generally offset by employment reductions in the secondary and tertiary sectors. The % reduced primary sector employment predicted for the 5B Tonle Sap and 1% increase in secondary and tertiary employment is primarily a function of reduced fishing effort, a consequence of declining fish catch and biomass. The reduction in fishing effort is also an influence in the 2% reduction in primary sector employment ratios (offset by 1% increase in secondary and tertiary employment) estimated for the M3 scenario in the Tonle Sap. Substantial agricultural expansion is proposed for the remaining Cambodian zones, reflected by the 15%-18% increase in the primary sector employment. The increased agricultural labour demands imply that there is less available labour to meet the proposed expansion of the manufacturing and service sectors (reductions of up to 26% are predicted).

The capital required to achieve the considerable expansion of irrigation systems proposed as part of the M3 scenario are likely additional constraints on secondary and tertiary expansion. Without substantial improvements in agricultural productivity (estimated in the order of 24-30%) or reduced expansion, of irrigation, substantial competition for industry labour is likely, potentially an important factor in improved labour conditions.

Lao PDR: similar employment changes are predicted to occur in the Lao PDR zones as those described for Cambodia, although the magnitude of change and likely labour shortage is substantially greater especially in the M3 scenario compared to the M1 baseline. A substantial expansion of irrigated agriculture is proposed for Lao PDR coupled with high rates of population growth are proposed as the primary factors influencing the up to 88% primary sector increase predicted for the M3 scenario. The increased primary sector increase is associated with 18%-35% declines in secondary and tertiary sector employment. Similar initiatives and labour competition are likely to apply to the Lao PDR zones as those proposed for Cambodia.

Figure 47 Changes in sector employment: M1 compared to M2 (year 24)

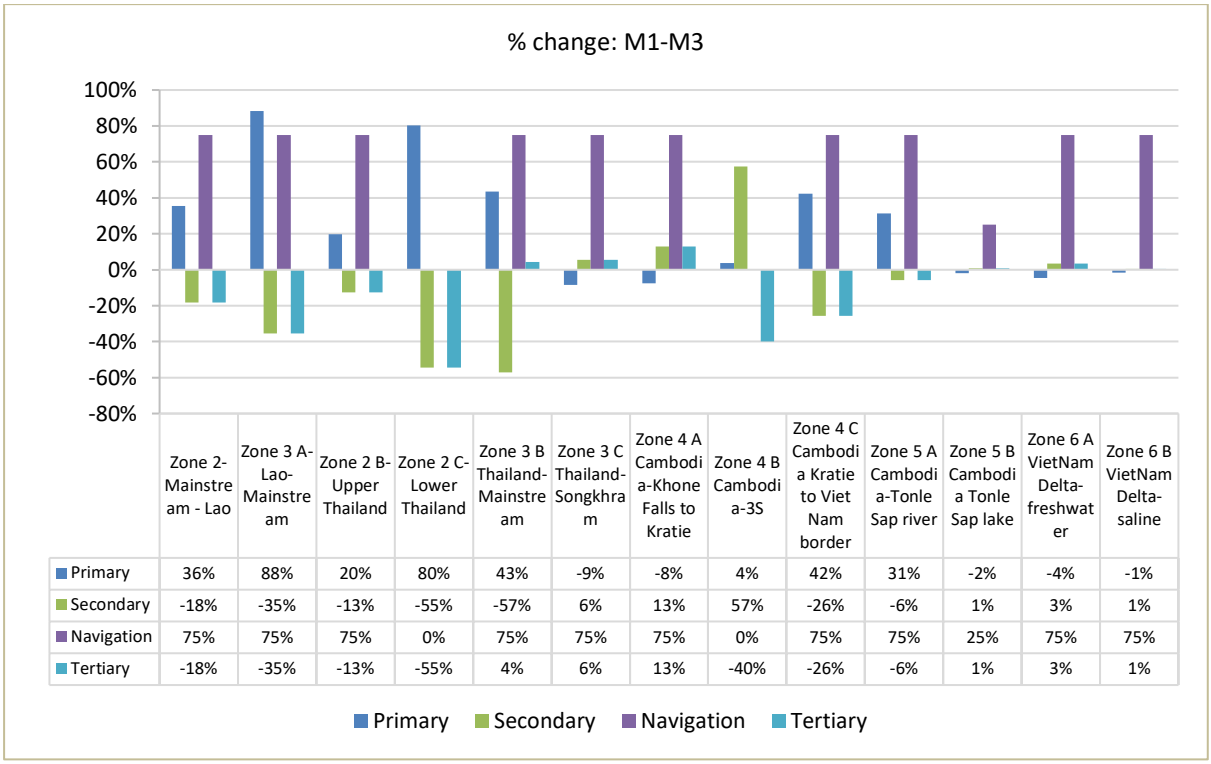


	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	5%	25%	7%	55%	28%	-7%	18%	-2%	7%	17%	-2%	-2%	-1%
Secondary	-3%	-10%	-5%	-37%	-52%	5%	-31%	63%	-5%	-3%	1%	1%	1%
Navigation	25%	25%	25%	0%	25%	25%	25%	0%	25%	25%	25%	25%	25%
Tertiary	-3%	-10%	-5%	-37%	18%	5%	-31%	-38%	-5%	-3%	1%	1%	1%

Thailand: The corridor zones located in Thailand are characterized by low population growth, and reduced fish catch. Proposed agricultural expansion was predicted to be sufficiently large to offset these labour reducing influences. Primary sector employment is predicted to increase (20%- 82% in the M3 scenario) associated with corresponding decreases in secondary and tertiary employment (37%-57%). The estimated labour shortage is likely to be amplified by the high out migration rates to major urban centres characterizing the zones. Zone 3C is the exception: decreased primary sector employment is likely a function of primarily rainfed rice cultivation, minimal agricultural expansion and reduced fishing effort to match declining fish biomass.

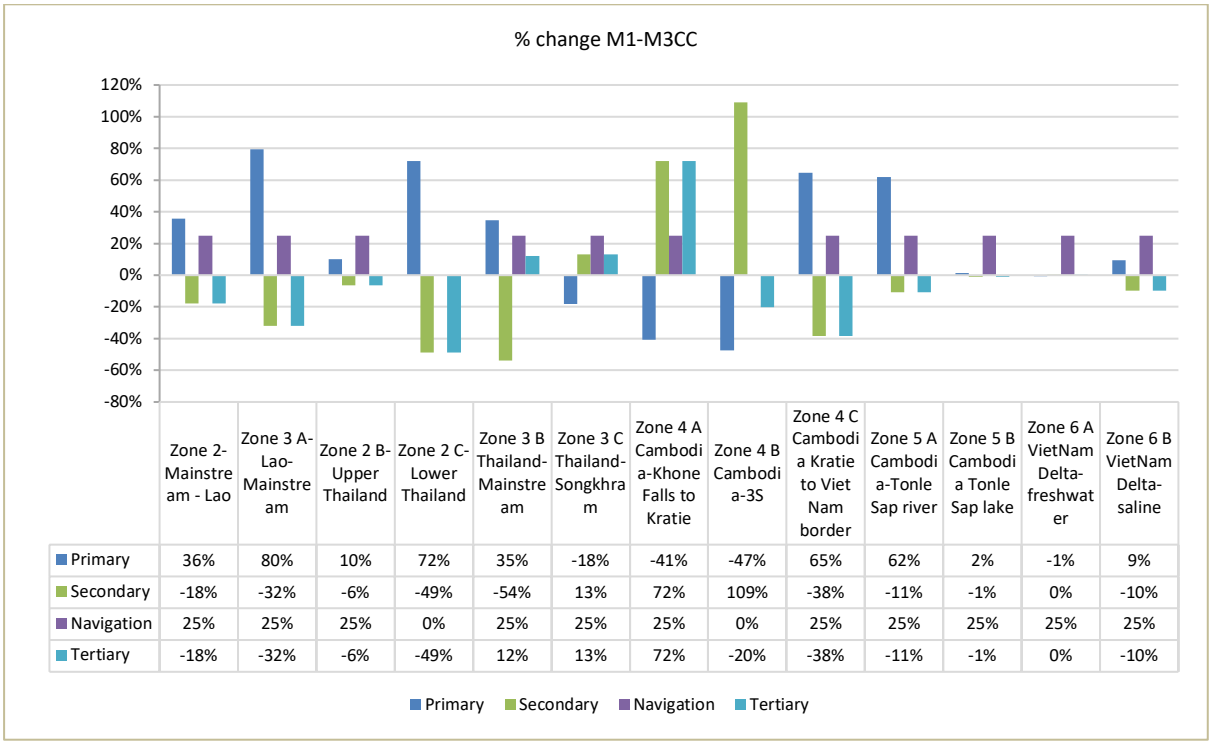
Viet Nam: sectoral employment in the corridor zones is relatively stable compared to the other corridor zones. Primary sector reduction in the M2 and M3 scenarios is a function of decreasing rice production and reduced fishing effort aligned with estimated reduction in fish biomass and catch.

Figure 48 Changes in sector employment: M1 compared to M3 (year 24)



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	36%	88%	20%	80%	43%	-9%	-8%	4%	42%	31%	-2%	-4%	-1%
Secondary	-18%	-35%	-13%	-55%	-57%	6%	13%	57%	-26%	-6%	1%	3%	1%
Navigation	75%	75%	75%	0%	75%	75%	75%	0%	75%	75%	25%	75%	75%
Tertiary	-18%	-35%	-13%	-55%	4%	6%	13%	-40%	-26%	-6%	1%	3%	1%

Figure 49 Changes in sector employment: M1 compared to M3CC (year 24)



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	36%	80%	10%	72%	35%	-18%	-41%	-47%	65%	62%	2%	-1%	9%
Secondary	-18%	-32%	-6%	-49%	-54%	13%	72%	109%	-38%	-11%	-1%	0%	-10%
Navigation	25%	25%	25%	0%	25%	25%	25%	0%	25%	25%	25%	25%	25%
Tertiary	-18%	-32%	-6%	-49%	12%	13%	72%	-20%	-38%	-11%	-1%	0%	-10%

7.10.1 Employment effects of the Council Study development sub scenarios

Climate change (M3CC, C2 and C3 sub scenarios)

The changes in sectoral employment associated with the M3CC main climate change scenario are depicted in Figure 49; the C2 and C3 sub scenarios illustrated in Figure 58.

Cambodia: up to 65% Increases in the Tonle Sap River and Kratie to the Viet Nam border Zones primary sector employment were estimated to meet the agricultural expansion and food security requirements of growing zone populations in the M3CC scenario. Secondary and tertiary employment was estimated to decrease by up to 38% by year 24. In contrast 47% decreases in primary sector employment (and increases in secondary and tertiary employment) were estimated for the Khone Falls and 3S zones. Note that the latter two zones are characterized by relatively small populations and subject to substantial annual variation in food security production estimates.

The employment levels for all sectors predicted for the 5B Tonle Sap were predicted to be relatively stable for the M3CC scenario. Similar trends were predicted for the C2 climate change scenario, although the primary sector employment in the Tonle Sap was anticipated to decrease in both the C2 and C3 scenarios (12% and 19% respectively), offset by 5% increases in secondary and tertiary employment. The C2 increased agricultural labour demands in the Kratie to Viet Nam Border zone imply that there is less available labour to meet the proposed expansion of the manufacturing and service sectors (reductions of up to 19% are predicted).

C3 employment in the Kratie to Viet Nam Border zone was estimated to be relatively stable; primary sector employment in the Tonle Sap River estimated to decrease by 13%. The reduction in fishing effort is also an influence in the 19% reduction in primary sector employment ratios (offset by 9% increase in secondary and tertiary employment) estimated for the C3 scenario in the Tonle Sap.

The capital required to achieve the considerable expansion of irrigation systems proposed as part of the M3CC scenario are likely additional constraints on secondary and tertiary expansion. Without substantial improvements in agricultural productivity (estimated in the order of 24-30%) or reduced expansion of irrigation, substantial competition for industry labour is likely, potentially an important factor in improved labour conditions.

Lao PDR: similar employment changes are predicted to occur in the Lao PDR zones as those described for Cambodia, although the magnitude of change and likely labour shortage is substantially greater especially in the M3CC scenario compared to the M1 baseline. A substantial expansion of irrigated agriculture is proposed for Lao PDR coupled with high rates of population growth are proposed as the primary factors influencing the up to 80% primary sector increase predicted for the M3CC scenario. The increased primary sector increase is associated with 18%-32% declines in secondary and tertiary sector employment. Similar initiatives and labour competition are likely to apply to the Lao PDR zones as those proposed for Cambodia.

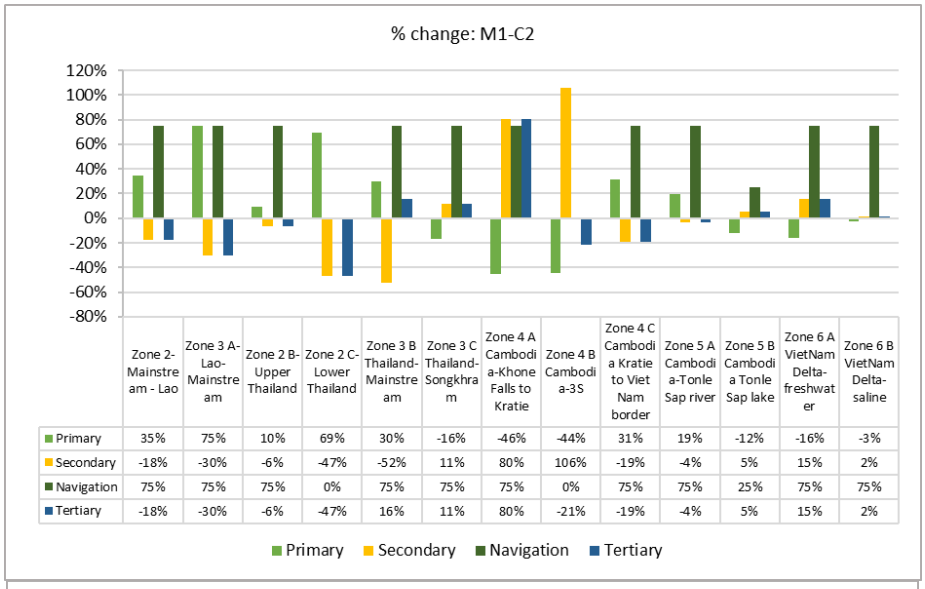
Estimated C2 employment trends in the Lao PDR zones were predicted to follow similar trajectories as the M3CC scenario. Primary sector employment was predicted to decrease by up to 12% in the C3 scenario, associated with 5% increases in secondary and tertiary employment.

Thailand: The corridor zones located in Thailand are characterized by low population growth, and reduced fish catch. Proposed agricultural expansion was predicted to be sufficiently large to offset these labour reducing influences in the M3CC and C2 scenarios. Primary sector employment was predicted to increase (20%- 72% in the M3CC scenario) associated with corresponding decreases in secondary and tertiary employment of 49%-54%). The estimated labour shortage is likely to be amplified by the high out migration rates to major urban centres characterizing the zones. Zone 3C is the exception: decreased primary sector employment is likely a function of primarily rainfed rice cultivation, minimal agricultural expansion and reduced fishing effort to match declining fish

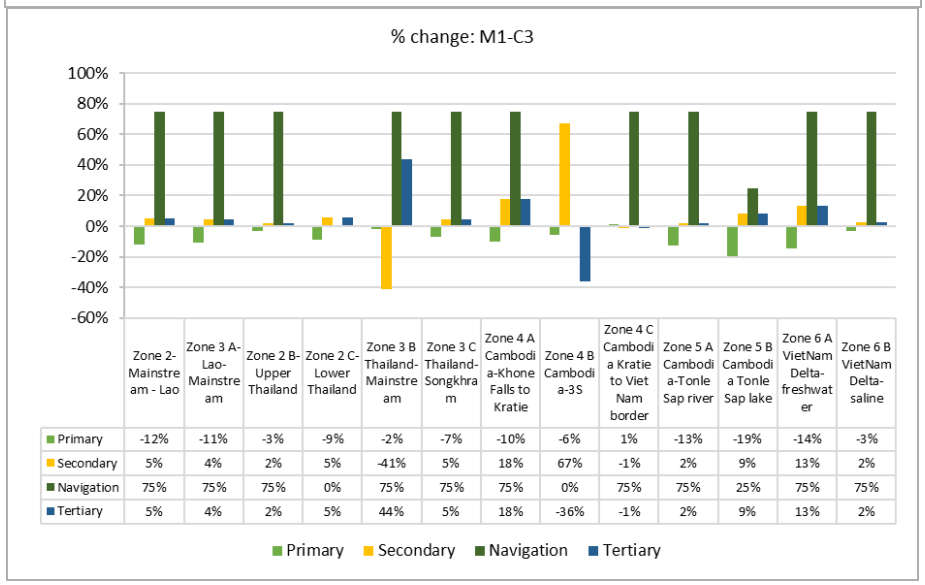
biomass. Similar trends were estimated for the C2 scenario. Tertiary employment in the 3B mainstream zone was estimated to increase by 44% in the C3 scenario (associated with a 41% decrease in secondary employment and 2% decrease in the primary sector).

Viet Nam: sectoral employment in the corridor zones is relatively stable compared to the other corridor zones. Primary sector employment is estimated to increase by up to 9% in the M3CC scenario (zone 6B-saline) and decrease by up to 16% in the C2 and C3 scenarios (Zone 6A-freswater). Secondary and tertiary employment is estimated to increase by up to 15% in the 6A freshwater zone in the C2 and C3 scenarios. Primary sector employment reductions in the C2 and C3 scenarios is assumed to be a function of decreasing rice production and reduced fishing effort aligned with estimated reduction in fish biomass and catch.

Figure 50 Changes in sector employment: M1 compared to the C2 and C3 sub scenarios (year 24)



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	35%	75%	10%	69%	30%	-16%	-46%	-44%	31%	19%	-12%	-16%	-3%
Secondary	-18%	-30%	-6%	-47%	-52%	11%	80%	106%	-19%	-4%	5%	15%	2%
Navigation	75%	75%	75%	0%	75%	75%	75%	0%	75%	75%	25%	75%	75%
Tertiary	-18%	-30%	-6%	-47%	16%	11%	80%	-21%	-19%	-4%	5%	15%	2%



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	-12%	-11%	-3%	-9%	-2%	-7%	-10%	-6%	1%	-13%	-19%	-14%	-3%
Secondary	5%	4%	2%	5%	-41%	5%	18%	67%	-1%	2%	9%	13%	2%
Navigation	75%	75%	75%	0%	75%	75%	75%	0%	75%	75%	25%	75%	75%
Tertiary	5%	4%	2%	5%	44%	5%	18%	-36%	-1%	2%	9%	13%	2%

Land use change (ALU1, ALU2, IRr1 and Irr2 sub scenarios)

The changes in sectoral employment associated with the ALU and IRR scenarios are depicted in Figure 51 and Figure 52 respectively.

Cambodia: Considerable variation in changes in sectoral employment were estimated across the Cambodian corridor zones for the A1, A2, Irr1 and Irr2 sub scenarios.

Nineteen percent to 31% primary sector employment increases in the Kratie to the Viet Nam border and Tonle Sap River Zones were estimated respectively to meet proposed agricultural expansion and food security requirements of growing zone populations in the A1 and A2 scenarios. Secondary and tertiary employment was estimated to decrease by up to 19% by year 24. The increased agricultural labour demands in the Kratie to Viet Nam Border zone imply that there is less available labour to meet the proposed expansion of the manufacturing and service sectors (reductions of up to 19% were predicted). Similar employment estimates were derived for the Irr1 scenario for the Kratie to the Viet Nam border and Tonle Sap River Zones.

In contrast, up to 59% decreases in primary sector employment (and increases in secondary and tertiary employment) were estimated for the Khone Falls and 3S zones in the A1 scenario. Note that the latter two zones are characterized by relatively small populations and subject to substantial annual variation in food security production estimates.

The primary sector employment levels predicted to decrease for the A1 and A2 scenarios (-19% and -9% respectively) for the 5B Tonle Sap. Primary sector decreases were offset by 5%-9% increases in secondary and tertiary employment. Primary sector employment was predicted to decrease by 8% in the Irr2 scenario (and 9% decrease in Irr1) associated with 3% increases in secondary and tertiary employment. Irr2 primary sector increases of 32% and 19% were estimated in the Kratie to Viet Nam Border and Tonle Sap River zones (secondary and tertiary employment decreases by up to 19%).

The capital required to achieve the considerable expansion of irrigation systems proposed as part of the A1 scenario are likely additional constraints on secondary and tertiary expansion. Without substantial improvements in agricultural productivity (estimated in the order of 24-30%) or reduced expansion of irrigation, substantial competition for industry labour is likely, potentially an important factor in improved labour conditions.

Lao PDR: similar employment changes are predicted to occur in the Lao PDR zones as those described for Cambodia, although the magnitude of change and likely labour shortage is substantially greater especially in the A2 and Irr1 and Irr2 scenarios compared to the M1 baseline. A substantial expansion of irrigated agriculture is proposed for Lao PDR coupled with high rates of population growth are proposed as the primary factors influencing the up to 36% to 85% primary sector increase predicted for the A2, Irr1 and Irr2 scenarios (zones 2 mainstream and 3A mainstream respectively). The increased primary sector increase is associated with 18%-34% declines in secondary and tertiary sector employment. Similar initiatives and labour competition are likely to apply to the Lao PDR zones as those proposed for Cambodia.

Without substantial improvements in agricultural productivity (estimated in the order of 24-30%) or reduced expansion of irrigation, substantial competition for industry labour is likely, potentially an important factor in improved labour conditions.

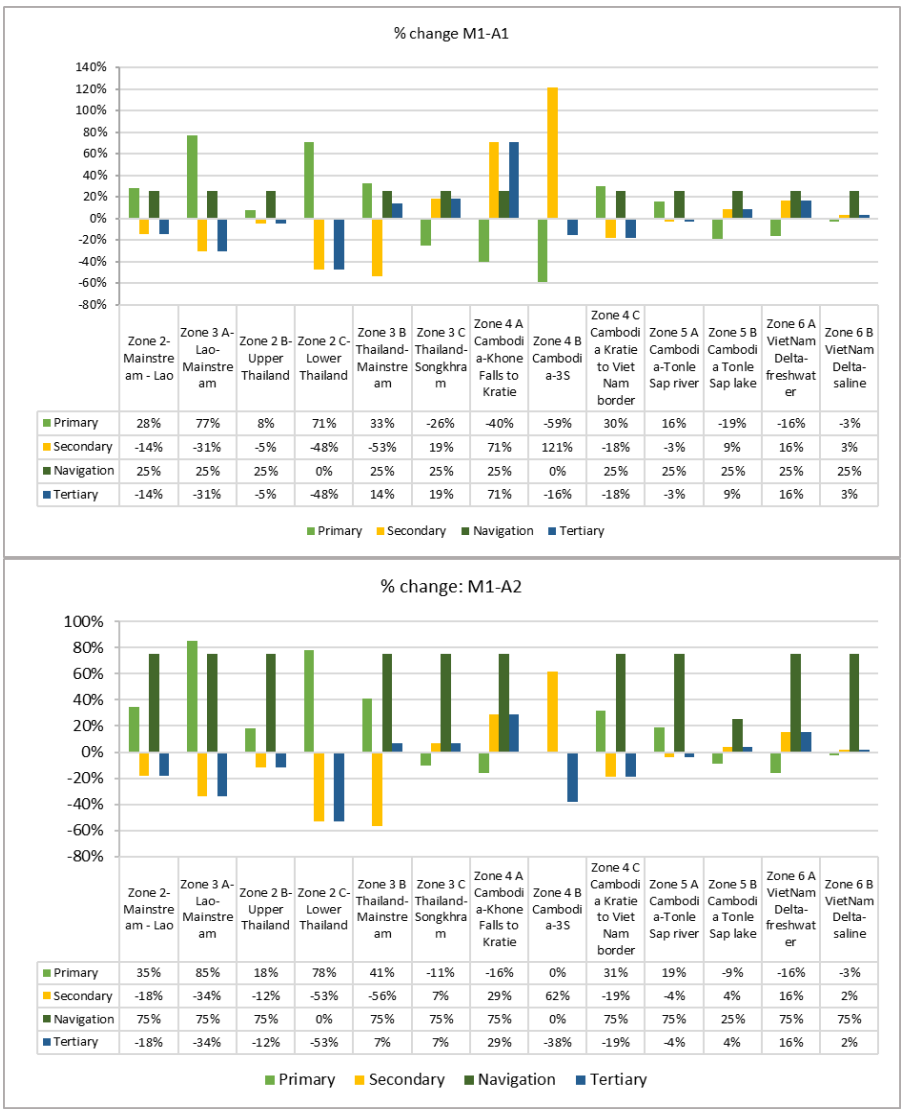
Thailand: The corridor zones located in Thailand are characterized by low population growth, and reduced fish catch. Proposed agricultural expansion was predicted to be sufficiently large to offset these labour reducing influences in the A1, A2, Irr1 and Irr2 scenarios. Primary sector employment was predicted to increase (8%- 71% in the A1 scenario) associated with corresponding decreases in secondary and tertiary employment of 48%-53%). Primary sector employment was predicted to increase (18%- 78% in the A2 scenario) associated with corresponding decreases in secondary and

tertiary employment of 12%-56%). Similar A1 and A2 employment rates for the CS sectors were predicted for the Irr1 and Irr2 scenarios.

The estimated labour shortage is likely to be amplified by the high out migration rates to major urban centres characterizing the zones. Zone 3C is the exception: decreased primary sector employment is likely a function of primarily rainfed rice cultivation, minimal agricultural expansion and reduced fishing effort to match declining fish biomass. Similar trends were estimated for the C2 scenario. Tertiary employment in the 3B mainstream zone was estimated to increase by 44% in the C3 scenario (associated with a 41% decrease in secondary employment and 2% decrease in the primary sector).

Viet Nam: sectoral employment in the corridor zones is relatively stable compared to the other corridor zones. Primary sector employment is estimated to decrease by 3%-16% in the A1, A2, Irr1 and Irr2 scenarios (zone 6B-saline and 6A freshwater respectively). Secondary and tertiary employment is estimated to increase by up to 16% in the 6A freshwater zone 3% in the 6B-saline zones. Primary sector employment reductions in the land use and irrigation scenarios was assumed to be a function of decreasing rice production and reduced fishing effort aligned with estimated reduction in fish biomass and catch.

Figure 51 Changes in sector employment: M1 compared to A1 and A2 sub scenarios (year 24)



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	28%	77%	8%	71%	33%	-26%	-40%	-59%	30%	16%	-19%	-16%	-3%
Secondary	-14%	-31%	-5%	-48%	-53%	19%	71%	121%	-18%	-3%	9%	16%	3%
Navigation	25%	25%	25%	0%	25%	25%	25%	0%	25%	25%	25%	25%	25%
Tertiary	-14%	-31%	-5%	-48%	14%	19%	71%	-16%	-18%	-3%	9%	16%	3%

	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	35%	85%	18%	78%	41%	-11%	-16%	0%	31%	19%	-9%	-16%	-3%
Secondary	-18%	-34%	-12%	-53%	-56%	7%	29%	62%	-19%	-4%	4%	16%	2%
Navigation	75%	75%	75%	0%	75%	75%	75%	0%	75%	75%	25%	75%	75%
Tertiary	-18%	-34%	-12%	-53%	7%	7%	29%	-38%	-19%	-4%	4%	16%	2%

Figure 52 Changes in sector employment: M1 compared to Irr1 and Irr2 sub scenarios (year 24)

Flood Plain Development

The estimated changes in sectoral employment associated with the F1, F2 and F3 sub scenarios are depicted in Figure 53.

Cambodia: The employment changes predicted for the Flood plain development sub scenarios were consistent across the F1, F2 and F3 scenarios in Cambodia.

Increases of 48-49% were estimated in primary sector employment in the Kratie to the Viet Nam border and Tonle Sap River Zones across the F1-F3 scenarios. Secondary and tertiary employment was estimated to decrease by up to 30% by year 24. The increased agricultural labour demands in the Kratie to Viet Nam Border zone imply that there is less available labour to meet the proposed expansion of the manufacturing and service sectors.

In contrast, up to 47% decreases in primary sector employment (and increases in secondary and tertiary employment) were estimated for the Khone Falls and 3S zones. Note that the latter two

zones are characterized by relatively small populations and subject to substantial annual variation in food security production estimates.

The primary sector employment levels predicted to decrease by 1% for the 5B Tonle Sap. Navigation was predicted to increase by 25%, a function of the 25% scalar recommended by the Navigation theme (75% in the F3 scenario).

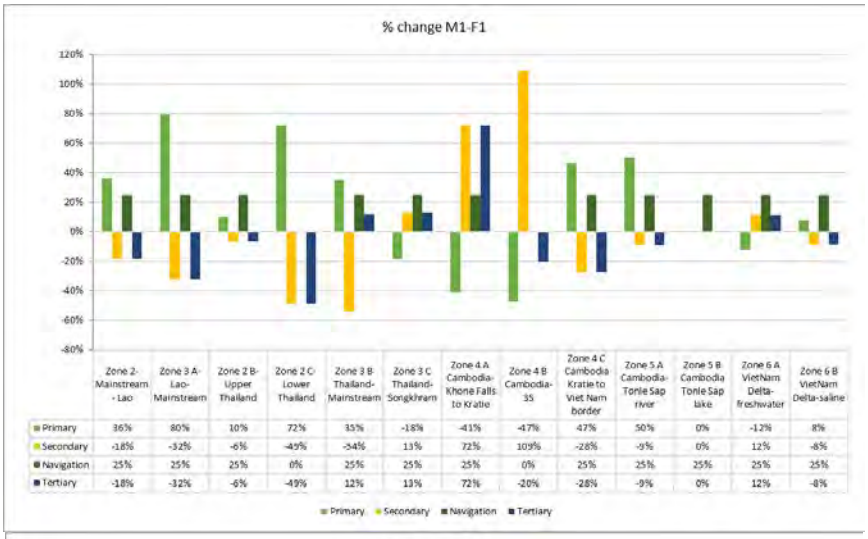
Lao PDR: similar employment changes are predicted to occur in the Lao PDR zones as those described for Cambodia, although the magnitude of change and likely labour shortage is substantially greater compared to the M1 baseline. Substantial expansion of irrigated agriculture for Lao PDR coupled with high rates of population growth are proposed as the primary factors influencing the up to 36% to 80% primary sector increase predicted for the F1-F3 scenarios (zones 2 mainstream and 3A mainstream respectively). The increased primary sector increase is associated with 18%-32% declines in secondary and tertiary sector employment. Similar initiatives and labour competition are likely to apply to the Lao PDR zones as those proposed for Cambodia.

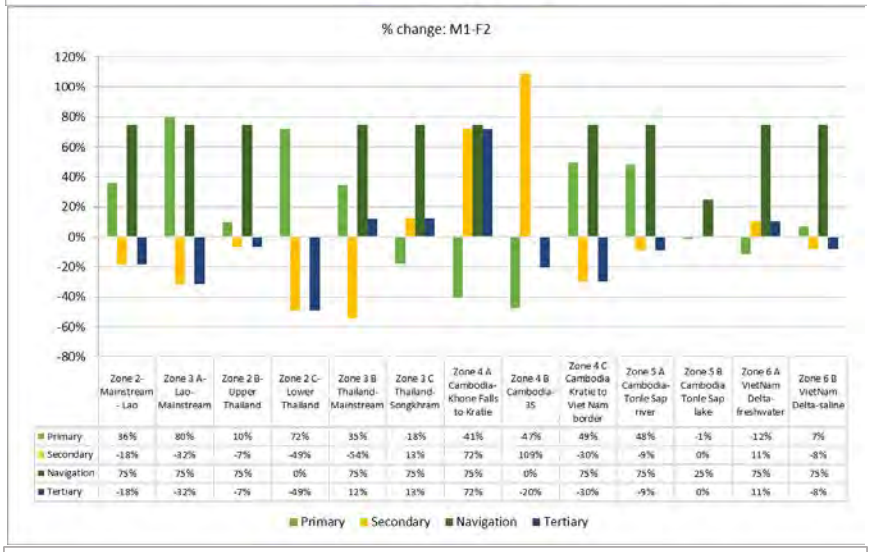
Without substantial improvements in agricultural productivity (estimated in the order of 24-30%) or reduced expansion of irrigation, substantial competition for industry labour is likely, potentially an important factor in improved labour conditions.

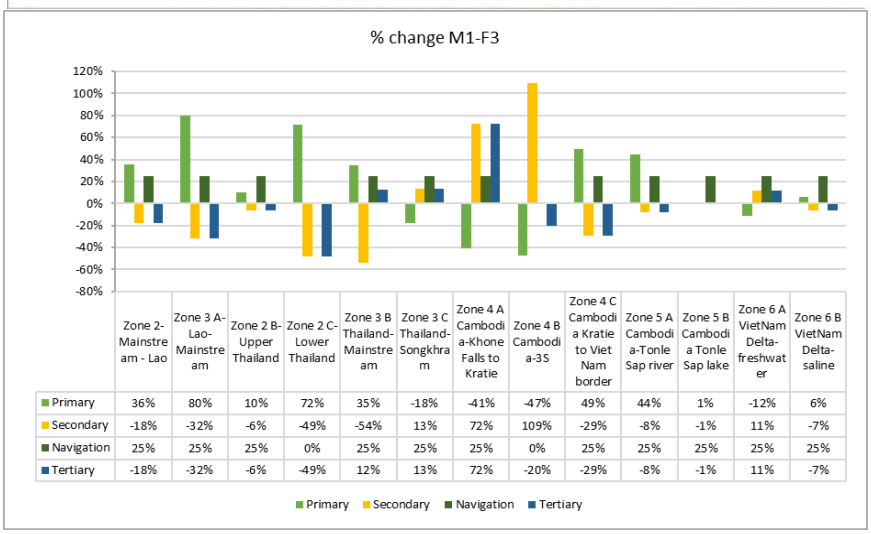
Thailand: The corridor zones located in Thailand are characterized by low population growth, and reduced fish catch. Proposed agricultural expansion was predicted to be sufficiently large to offset these labour reducing influences in the F1-F3 scenarios. Primary sector employment was predicted to increase (10%- 72% across the three flood plain development scenarios) associated with corresponding decreases in secondary and tertiary employment of 6%-54%). Primary sector employment in the 3C-Songkhram zone was predicted to decrease by 18% (and secondary and tertiary employment increase by 13%). The decreased primary sector employment is likely a function of primarily rainfed rice cultivation, minimal agricultural expansion and reduced fishing effort to match declining fish biomass.

Viet Nam: sectoral employment in the corridor zones is relatively stable compared to the other corridor zones. Primary sector employment is estimated to decrease by 12% in the 6A freshwater and increase by 8% in the 6b saline zone. Secondary and tertiary employment is estimated to increase by up to 12% in the 6A freshwater zone and decrease by 8% in the 6B-saline zones. Primary sector employment reductions in the flood plain development scenarios was assumed to be a function of decreasing rice production and reduced fishing effort aligned with estimated reduction in fish biomass and catch.

Figure 53 Changes in sector employment: M1 compared to F1, F2 and F3 sub scenarios (year 24)







Hydropower sub-scenarios

The estimated changes in sectoral employment associated with the H1a, H1b and H3 sub scenarios are depicted in Figure 53 and Figure 54.

Cambodia: The employment changes predicted for the Flood plain development sub scenarios were consistent across the F1, F2 and F3 scenarios in Cambodia.

Increases of 50-56% were estimated in primary sector employment in the Kratie to the Viet Nam border and Tonle Sap River Zones across the H1a, H1b and H3 hydropower scenarios. Secondary and tertiary employment was estimated to decrease by up to 31% by year 24. The increased agricultural labour demands in the Kratie to Viet Nam Border zone imply that there is less available labour to meet the proposed expansion of the manufacturing and service sectors.

In contrast, up to 47% decreases in primary sector employment (and increases in secondary and tertiary employment) were estimated for the Khone Falls and 3S zones. Note that the latter two zones are characterized by relatively small populations and subject to substantial annual variation in food security production estimates.

The primary sector employment levels predicted to increase by 9% for the 5B Tonle Sap, a function of increased fish biomass and subsequent fishing effort. Navigation was predicted to increase by 25%, a function of the 25% scalar recommended by the Navigation theme (75% in the F3 scenario).

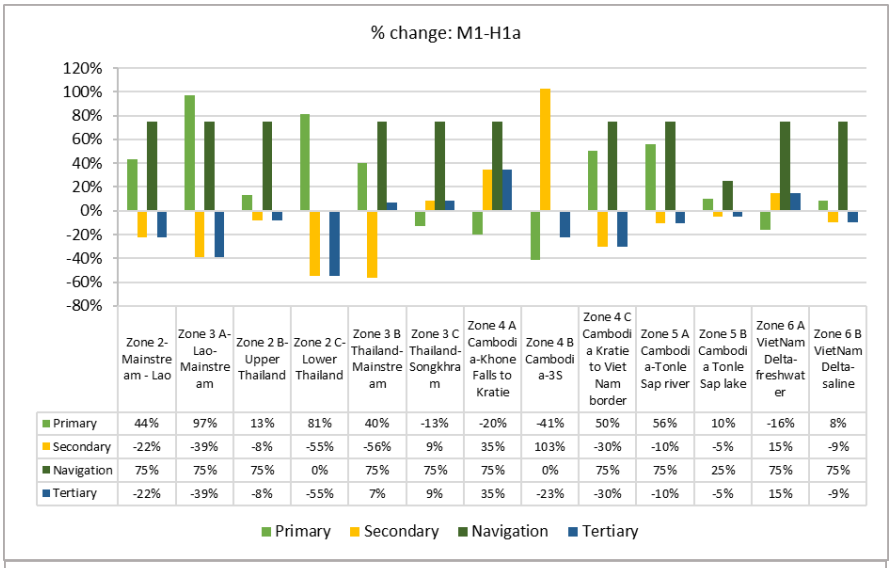
Lao PDR: Substantial expansion of irrigated agriculture for Lao PDR, increased fish biomass coupled with high rates of population growth are proposed as the primary factors influencing the up to 46% to 88% primary sector increase predicted for the H1a, H1b and H3 scenarios (zones 2 mainstream and 3A mainstream respectively). The increased primary sector increase is associated with 23%-35% declines in secondary and tertiary sector employment. Similar initiatives and labour competition are likely to apply to the Lao PDR zones as those proposed for Cambodia.

Without substantial improvements in agricultural productivity (estimated in the order of 24-30%) or reduced expansion of irrigation, substantial competition for industry labour is likely, potentially an important factor in improved labour conditions.

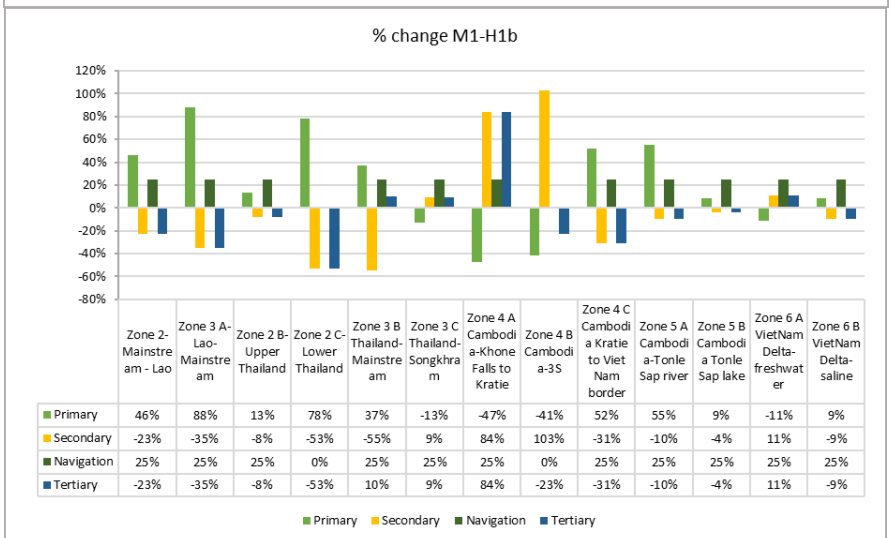
Thailand: The corridor zones located in Thailand are characterized by low population growth, and variable increases in fish catch associated with the H1a,H1b and H3 scenarios. Primary sector employment was predicted to increase (13%- 81% across the three hydropower scenarios) associated with corresponding decreases in secondary and tertiary employment of 8%-55%). Primary sector employment in the 3C-Songkhram zone was predicted to decrease by 13% (and secondary and tertiary employment increase by 9%). The increased primary sector employment is likely a function of primarily rainfed rice cultivation, minimal agricultural expansion and increased fishing effort to match predicted increases in fish biomass.

Viet Nam: sectoral employment in the corridor zones is relatively stable compared to the other corridor zones. Primary sector employment is estimated to decrease by 11-16% in the 6A freshwater and increase by 8-9% in the 6b saline zone (H1a and H3 respectively). Secondary and tertiary employment is estimated to increase by up to 15% in the 6A freshwater zone and decrease by 9% in the 6B-saline zones. Primary sector employment reductions was assumed to be a function of decreasing rice production and reduced fishing effort aligned with estimated reduction in fish biomass and catch.

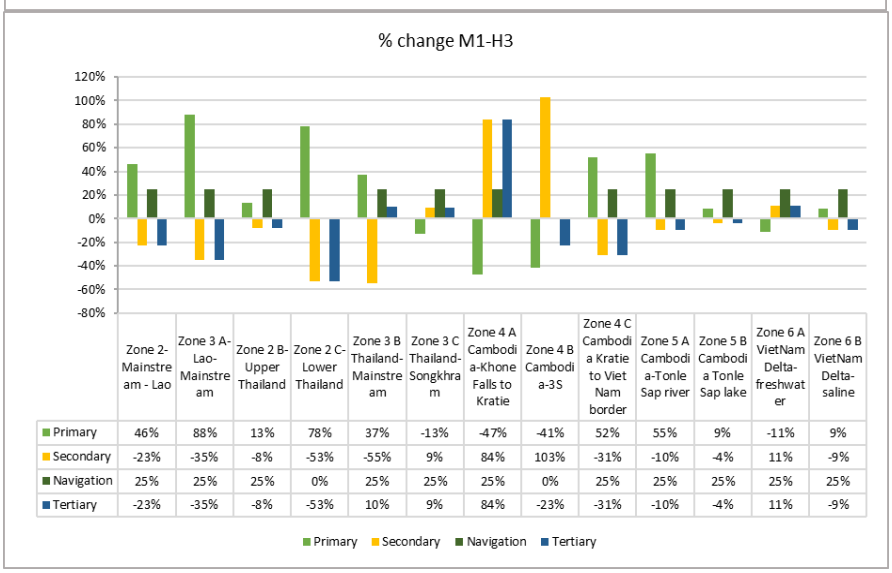
Figure 54 Changes in sector employment: M1 compared to H1a, H1b and the H3 sub scenarios (year 24)



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	44%	97%	13%	81%	40%	-13%	-20%	-41%	50%	56%	10%	-16%	8%
Secondary	-22%	-39%	-8%	-55%	-56%	9%	35%	103%	-30%	-10%	-5%	15%	-9%
Navigation	75%	75%	75%	0%	75%	75%	75%	0%	75%	75%	25%	75%	75%
Tertiary	-22%	-39%	-8%	-55%	7%	9%	35%	-23%	-30%	-10%	-5%	15%	-9%



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	46%	88%	13%	78%	37%	-13%	-47%	-41%	52%	55%	9%	-11%	9%
Secondary	-23%	-35%	-8%	-53%	-55%	9%	84%	103%	-31%	-10%	-4%	11%	-9%
Navigation	25%	25%	25%	0%	25%	25%	25%	0%	25%	25%	25%	25%	25%
Tertiary	-23%	-35%	-8%	-53%	10%	9%	84%	-23%	-31%	-10%	-4%	11%	-9%



	Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline
Primary	46%	88%	13%	78%	37%	-13%	-47%	-41%	52%	55%	9%	-11%	9%
Secondary	-23%	-35%	-8%	-53%	-55%	9%	84%	103%	-31%	-10%	-4%	11%	-9%
Navigation	25%	25%	25%	0%	25%	25%	25%	0%	25%	25%	25%	25%	25%
Tertiary	-23%	-35%	-8%	-53%	10%	9%	84%	-23%	-31%	-10%	-4%	11%	-9%

7.10.2 Labour migration

Labour mobility and the willingness and capacity to migrate for work are critical factors in estimating employment levels and changes in the CS sectors. The labour demands of expanding agricultural production to meet national food security objectives and export earnings may be in potential competition with the labour demands of expanding manufacturing and service sectors. Labour requirements are a key variable of the sectoral assessments and GDP affects being conducted as part of Council Study Macro-Economic assessment and the Social Economic Assessment.

The CS Macro-Economic assessment for example indicates that the labour force required for proposed agricultural expansion, and the countervailing demands of the expansion in the secondary and tertiary sectors may mean the aggregate gains for the Cambodian economy may be only partially realized. That is potential labour constraints (and associated migration) will limit either agricultural expansion or non-agricultural expansion. As a corollary, Cambodia may be left with large losses in the fisheries sector and small gains in hydropower and navigation sectors.

The Council Study Macroeconomic Assessment also indicates the rates and demographic patterns of immigration and emigration are key factors influencing the feedbacks between environmental, social and economic variables. Forest loss is likely to be correlated with migration levels and patterns and dependent on how the requirements for specific livelihoods change.

Migration is identified as a critical driver for both urbanisation and/or deforestation, significant factors in the status of environmental conditions including water. Poor households without necessary access to land are likely to face substantial work challenges and potentially forced to replace their livelihood diversification strategy and migrate into urban areas to realize the necessary income increases. Evidence from developing countries suggests high levels of rural to urban (and vice versa) migration pressures demand substantial public investments in urban infrastructure.

The evaluation of the multiple factors affecting migration, such as capacity to migrate, vulnerability, institutional settings and regulations, natural resource conditions, perceived opportunities, social norms and community obligations, are interdependent, generally non-linear and require a dynamic modelling approach compared to the static analysis necessarily applied in the Council Study. The development integrated, dynamic modelling capable of evaluating cross sectoral, coupled social and ecological systems is one of the main recommendations for the future MRC strategic activities.

SIMVA (2015) assessed migration rates and patterns of Corridor communities. Responses from the majority of sample villages have some people who work outside the village (Figure 55). In Sub-zone 4B 3S in Cambodia, and in Sub-zone 2A Mainstream Lao PDR 50% and 64% of the villages had people who worked outside the villages representing the Sub-zones with the highest number of villages with migratory workers. The destination for work migration is an indicator for both the time spent away from a respondent's home village and the mobility of the work force and thereby locations of concentrations of economic development and opportunities.

The mean percentage of the village population that worked outside the village was 11% for the entire sample. The Songkhram area in Thailand had 23% of the population who migrated for work outside the village; Sub-zone 3B Thailand mainstream was 16%; Cambodian Sub-zones 4C Kratie to the Viet Nam border and 5A Tonle Sap River was 17%-18% respectively. Migration was assessed to establish economic and labour opportunities at four administrative levels (Figure 56). The % of the village population that migrated to: 1) another village in the same district, indicating level of local work force mobility; 2) another district or province, indicating level of within-country regional economic integration; 3) the country capital, indicating country level urban concentration in large urban conglomerates; and 4) another country, indicating the level of economic opportunities within the country compared to regional work opportunities.

illustrates local level work integration was high in Viet Nam, especially in the freshwater zone, with 66% of the villages having people that work in another village within the same district. Slightly lower levels were found in the Sub-zone saline in Viet Nam at 45% and in Sub-zone 3S in Cambodia at 50% of the villages. The highest percentage of villages that have people who work in another district or province was in Sub-zone 2 mainstream Lao PDR, at 57% of the villages. In Cambodian Sub-zones 4A Khone Falls to Kratie and Sub-zone 5A Tonle Sap River the percentages are also high at 55% and 41% of the villages. In Thailand, work migration from the LMB corridor to the country capital, i.e., Bangkok is very high: 85% of the villages reported to have people who work there. Work migration to another country was highest from Sub-zone 3A mainstream Lao PDR. Though the destination was not asked for, it is likely to be Thailand. In Sub-zone 5B Tonle Sap Lake 64% of the villages reported that village people were working in another country. The SIMVA (2015) report indicates that work migration for both short and/or long periods of time is a widespread and economically important alternative livelihood option for households in the LMB corridor. The report concludes that the LMB corridor is an important source of workers for other areas within the member countries and countries outside the LMB.

Figure 55 Work migration in Corridor Zones

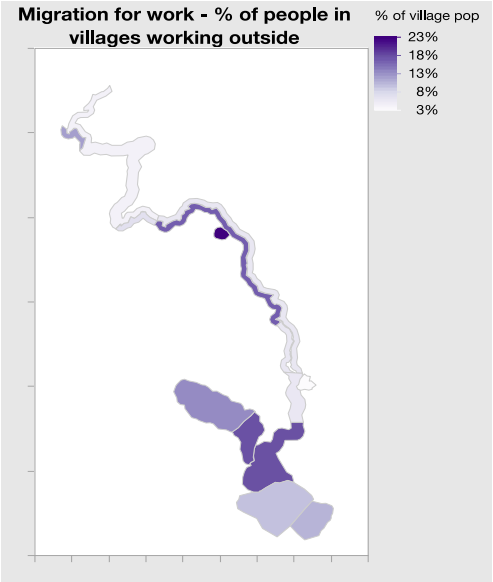
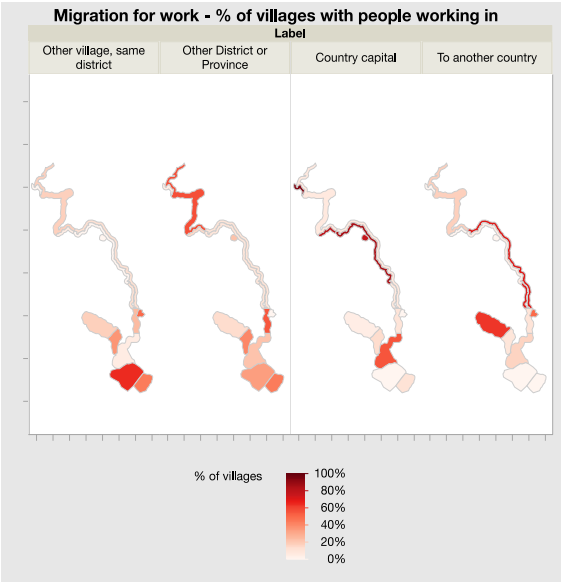


Figure 56 Migration for work - % of villages with



Source: SIMVA (2015)

Migration patterns and adaptive behaviors are not included in the CS employment analysis and the assessment acknowledges the limitations of the approach used. A recommendation has been made to the MRC to undertake investigations to expand their capacity to model these dynamic factors. A review of corridor employment and migration can be found in Section 11.8.

7.11 Council Study Sector incomes

Households in the Lower Mekong undertake a diversity of concurrent livelihood activities expressed as a diversity of income sources (see Figure 115, Figure 116 and Figure 117). Undertaking a diversity of livelihoods and relying on multiple incomes sources represents a widely implemented risk management strategy for poorer and more vulnerable communities and households where endowments, entitlements and capacities allow. The diversity of income sources as is included as one of the Social and Economic sub assessment indicators.

Reported incomes for the Tonle Sap, Nam Ngum River Basin, Huai Sai Bart and the Viet Nam Delta were disaggregated into farm incomes, off-farm income and subsistence income. The monetized value of subsistence production is discussed in section 7.3 and is therefore not included in the analysis of sector incomes.

Median incomes calculated from the SIMVA and EMRF surveys and referenced against national data where available was used as the basis to calculate aggregate sector incomes. The main livelihood activity reported by respondents was assigned to the main economic sectors of the Council Study: agriculture, secondary, tertiary, navigation, fishing and mining reported in the employment section (7.10).

Outlier incomes were censored at USD 10,000 and students and those not working excluded from the analysis. The majority of households across all sectors had farm, off-farm and subsistence income sources, including those working in the secondary and tertiary sectors. The median total household income in Lao PDR ranged from USD 2074 -4731 across sectors; USD 2185-2838 in Cambodia; USD 2068-2035 in Thailand and USD 2476-3920 in the Viet Nam Delta.

Median incomes for the agricultural sector in 2012-2013 ranged from USD 2930 in the Tonle Sap - 5965 in Huai Sai Bart and Viet Nam; Manufacturing incomes from USD USD 499 -3354 in Huai Sai Bart and Viet Nam and the Nam Ngum respectively; Service sector incomes from USD 2789 in the Tonle Sap to USD1110 in Huai Sai Bart and mining income of USD 3570 in the Nam Ngum. Note that manufacturing and service sector livelihoods were generally reported as secondary occupations and mean incomes were significantly higher. Details of the income calculation method and imputed median incomes can be found in Section 10.3.

The gender differences in 2012 median farm based, off farm and subsistence for four corridor sites are detailed in Table 42. Total incomes for women are lower than men except in Lao PDR (both farm and subsistence income are higher than men). The monetary value of subsistence production is approximately equal between the four sites. The median total income of women was 21% lower in the Cambodian corridor site, 4% lower in Lao PDR, 14% lower in Thailand and 66% lower in the Viet Nam delta.

Table 41 median income ($) by source and gender across corridor sites

	Cambodia		Lao PDR		Thailand		Vietnam delta	
Income source (median annual $)	male	female	male	female	male	female	male	female
Farm income	513	341	396	407	1541	1078	2739	1757
Subsistence income	294	294	620	660	705	734	260	294
Off-farm income	1056	950	1100	1056	1451	1410	514	288
Total HH income	1595	1257	1892	1819	3697	3222	3169	1409

Agriculture and fishing incomes were aggregated in the Primary sector; manufacturing, service and navigation incomes aggregated into secondary sector incomes. The income results for each zone by sector are detailed in Table 43 and Table 45.

Importantly, the income estimates represent estimates for the SIMVA corridor zones only and do not account for employment multipliers, input out multipliers and wider GDP income effects. The GDP estimates and basin wide employment effects of the various scenarios are detailed in the Council Study Macro-economic assessment.

The BioRA (fish biomass) and IWRM (rice yields and production area) are the primary data inputs to the social and economic assessment, establishing the functional relationships between the employment indicators describing the corridor zones and the CS main development scenarios and

sub-scenarios. The estimates of fish and rice production therefore establish the foundation data to estimate the relative proportions of primary sector incomes. Secondary and tertiary incomes were calculated as median income estimates multiplied by the residual number of working population after agriculture and fishing employment estimates were subtracted from the working population.

In summary, the largest change in total corridor sectoral income (primary + manufacturing and service) was estimated for M1 scenario (comparing year 1 with year24) where total income increased by US$ 6.4 billion. The M1-M2 total income increased by US$ 96.4 million. The percent changes comparing the M1 baseline with the M2 and M3 scenarios (year 24) are detailed in Table 43. The sectoral incomes for the corridor zones, aggregated to the national level, are detailed in Figure 58.

Multiplier effects and employment differences in urban centres are not included in the income estimates. The macroeconomic assessment has used the income calculations for the corridor to estimate sector contributions to Lower Mekong Basin GDP.

Total corridor income increases by US$ 6.4 billion when comparing M1 (year 1) with M1 (year 24: Table 43 and Table 45). The gains in total income occur in the manufacturing sector, which increases by US $7.9 billion and primary sector income declines by US$ 1.48 billion. Note that the estimates conducted for food security indicate that Lao PDR zone 2 has a shortfall in rice surplus to meet year 24 food security needs and the rice surplus is reduced across other zones. The analysis of M1 (year 24) food security indicates the rice surplus for the whole of the corridor is sufficient to meet aggregate food security demands, dependent on distribution systems and the purchasing capacity of non-agricultural households.

The M2 scenario total corridor income (year 24) declines by US$ 245 million compared to the M1 baseline. The main losses are in the manufacturing sector (-US$ 439 million) offset by a US$ 194 million gain in the primary sector. The M2 scenario is characterized by substantial declines in fish catch and increases in rice surpluses across the corridor zone.

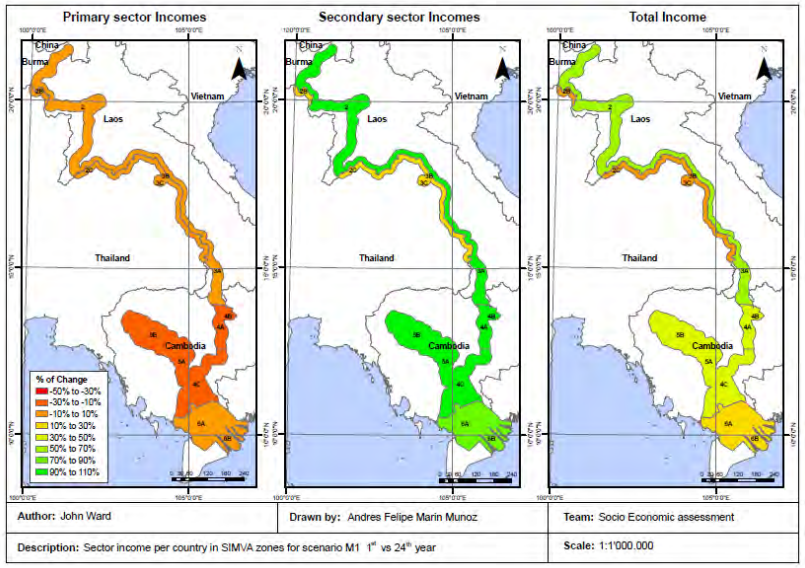
The M3 scenario total corridor income (year 24) declines by US$ 630 million compared to the M1 baseline. The main losses are in the manufacturing sector (-US$ 1.5 billion) offset by a US$ 881 million gain in the primary sector. The scenario is characterized by increasing fish biomass declines and increases in rice surpluses across the corridor.

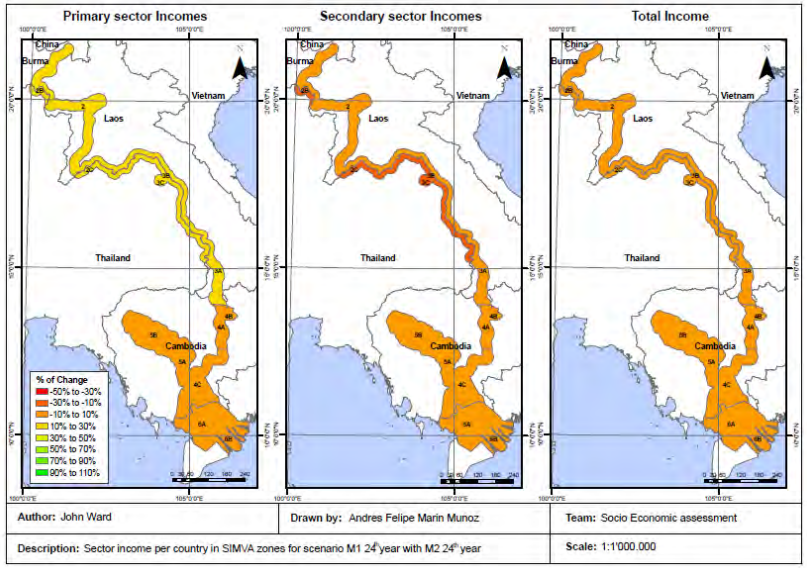
The spatial representation of the main development scenarios total sector incomes for each of the Corridor zones is illustrated in Figure 57. The maps represent the changes in mean value (%) of year year24 compared to the M1 pre-development scenario.

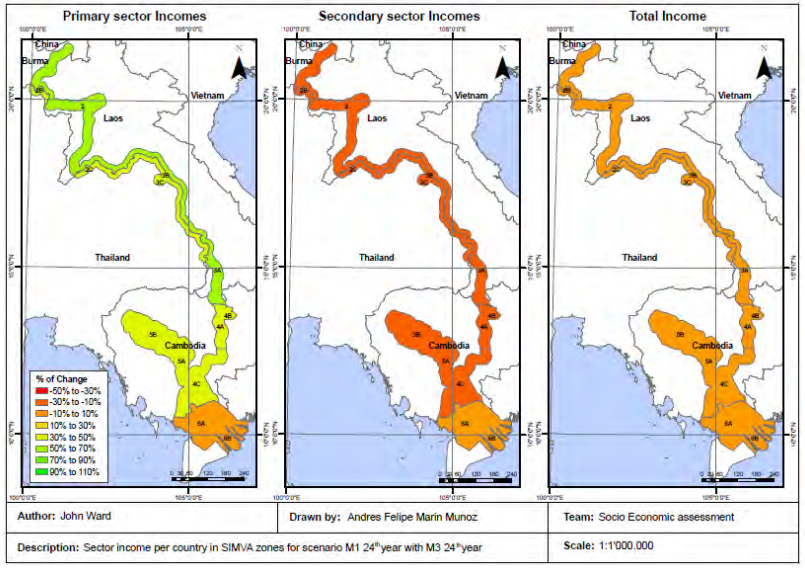
The spatial representation of the Council Study sub-scenario total sector incomes for each of the Corridor zones can be located in Annex 9.5. The maps represent the changes in value (% change) of year24 compared to the M1 pre-development scenario and the M3 2040 development scenario.

Details of the total sector income estimates by SIMVA zone and at the National level for the M1, M2 and M3 scenarios are tabled in Table 45 and Figure 58 respectively.

Figure 57 Changes (%) in sector incomes: M2, M3 and M3CC compared to M1 (year 24)







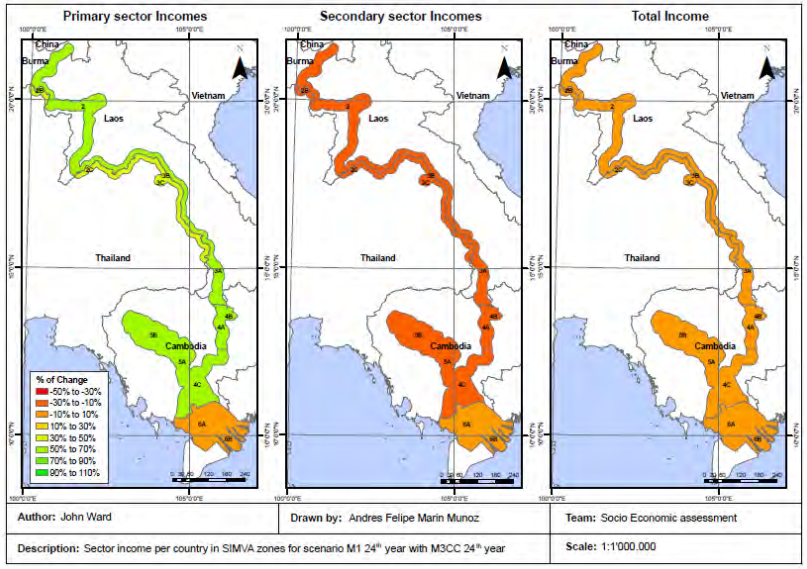


Table 42 Changes (%) in national sector incomes across the M1 (1-24), M2 and M3 scenarios (year 24)

	M1 (year1)-M1 (year 24)		M1-M2		M1-M3		M2-M3	
	Primary	Manufacturing and Service	Primary	Manufacturing and Service	Primary	Manufacturing and Service	Primary	Manufacturing and Service
Lao PDR	-2%	109%	18%	-8%	69%	-30%	44%	-24%
Thailand	-5%	14%	25%	-16%	40%	-25%	12%	-11%
Cambodia	-15%	101%	7%	-3%	34%	-16%	25%	-13%
Viet Nam Delta	-5%	82%	-1%	1%	-4%	3%	-2%	2%
Income (% change)	-6%	81%	1%	-2%	4%	-9%	3%	-6%

Corridor zone incomes for each of the Council Study scenarios were aggregated into national level and scenarios ranked from highest to lowest income Table 44. Importantly, the income estimates represent estimates for the SIMVA corridor zones only and do not account for employment multipliers, input out multipliers and GDP income effects. The GDP estimates and basin wide employment effects of the various scenarios are detailed in the Council Study Macro-economic assessment.

The A1, M1 and M2 scenarios (in that ranking order) confer the highest income effects for the Lao PDR zones and the corridor zones located in Thailand. The H1a, H1band H3 scenarios are ranked lowest in the Lao PDR zones. The Irr1, Irr2 and M3 scenarios ranked lowest in the Thai corridor zones.

The M1, A1 and M2 scenarios confer the highest benefits to the Cambodian zones and the M1, M3CC and M2 scenarios are ranked the highest in the Viet Nam delta zones. The H1b, H3 and M3CC scenarios were ranked lowest in Cambodia and the Irr1, Irr2 and C3 scenarios ranked lowest in the Viet Nam delta zones.

Table 43 scenarios ranked from highest aggregate income value to lowest across scenarios by corridor zone

Lao PDR		Thailand		Cambodia		Viet Nam		LMB Corridor	
Scenario	US$ M	Scenario	US$ M	Scenario	US$ M	Scenario	US$ M	Scenario	US$ M
A1	2,292	M1	2,146	M1	8,556	M3CC	27,349	M1	40,100
M1	2,272	A1	2,142	A1	8,552	M1	27,130	M3CC	40,084
M2	2,236	M2	2,095	M2	8,549	M2	26,976	M2	39,855
C3	2,153	C2	2,089	C3	8,532	H3	26,911	H3	39,629
C2	2,151	C3	2,089	A2	8,531	M3	26,750	M3	39,470
M3CC	2,145	M3CC	2,085	C2	8,529	H1a	26,579	H1a	39,299
F2	2,145	F2	2,085	I1	8,529	F1	26,495	F1	39,238
F3	2,144	F3	2,083	I2	8,528	F2	26,474	F2	39,221
F1	2,144	F1	2,083	M3	8,520	F3	26,424	F3	39,169
A2	2,138	H1a	2,079	F3	8,517	H1b	26,214	A1	38,996
I1	2,138	H3	2,074	F2	8,516	A1	26,006	H1b	38,916
I2	2,137	A2	2,073	F1	8,516	A2	25,891	C2	38,653
M3	2,133	H1b	2,073	H1a	8,514	C2	25,884	C3	38,649
H3	2,132	I2	2,071	H1b	8,513	I2	25,882	A2	38,633
H1a	2,127	I1	2,071	H3	8,513	I1	25,876	I2	38,618
H1b	2,117	M3	2,067	M3CC	8,505	C3	25,874	I1	38,614

Table 44 Sector incomes (US$) by corridor zone (M1, M2 and M3)

M1 year 1	Primary	Secondary	Navigation	Tertiary
Zone 2-Mainstream - Lao	199,291,589	124,952,257	2,732,769	116,589,277
Zone 3 A-Lao-Mainstream	356,537,263	357,832,892	613,803	225,672,690
Zone 2 B-Upper Thailand	61,541,862	62,836,676	264,168	40,904,344
Zone 2 C-Lower Thailand	68,489,548	18,016,572	139,189	78,617,770
Zone 3 B Thailand-Mainstream	550,539,773	285,165,180	1,256,568	675,947,094
Zone 3 C Thailand-Songkhram	70,571,926	44,087,326	380,091	48,346,971
Zone 4 A Cambodia-Khone Falls to Kratie	41,865,475	19,186,569	112,692	20,713,304
Zone 4 B Cambodia-3S	3,944,736	1,376,956	-	1,079,783
Zone 4 C Cambodia Kratie to Viet Nam border	2,084,287,373	554,725,424	18,882,607	1,140,607,151
Zone 5 A Cambodia-Tonle Sap river	612,573,404	288,711,606	5,473,608	381,016,618
Zone 5 B Cambodia Tonle Sap lake	395,646,064	208,973,924	4,928,956	279,657,702
Zone 6 A VietNam Delta-freshwater	13,578,794,851	981,483,210	50,176,976	2,491,600,440
Zone 6 B VietNam Delta-saline	5,915,925,994	351,706,789	18,890,931	822,345,833
Totals	23,940,009,857	3,299,055,381	103,852,358	6,323,098,980

M1 Year 23	Primary	Secondary	Navigation	Tertiary
Zone 2-Mainstream - Lao	197,840,882	277,265,828	4,268,410	258,708,592
Zone 3 A-Lao-Mainstream	344,552,428	728,951,837	950,959	459,724,429
Zone 2 B-Upper Thailand	66,202,616	80,744,040	314,387	52,561,374
Zone 2 C-Lower Thailand	69,800,160	24,339,369	-	106,208,158
Zone 3 B Thailand-Mainstream	506,129,554	526,225,751	1,290,865	511,780,339
Zone 3 C Thailand-Songkhram	72,594,376	58,916,017	448,709	64,608,386
Zone 4 A Cambodia-Khone Falls to Kratie	71,723,149	19,460,921	155,396	21,009,488
Zone 4 B Cambodia-3S	3,410,088	1,848,044	-	3,799,884
Zone 4 C Cambodia Kratie to Viet Nam border	1,945,326,934	1,123,099,874	26,621,565	2,309,278,953
Zone 5 A Cambodia-Tonle Sap river	262,714,847	661,552,970	7,713,888	873,060,418
Zone 5 B Cambodia Tonle Sap lake	379,017,626	359,015,072	6,947,060	480,449,082
Zone 6 A VietNam Delta-freshwater	13,225,674,508	1,717,446,721	61,923,241	4,359,922,782
Zone 6 B VietNam Delta-saline	5,318,741,239	725,738,925	23,329,220	1,696,891,843
Totals	22,463,728,407	6,304,605,370	133,963,700	11,198,003,728

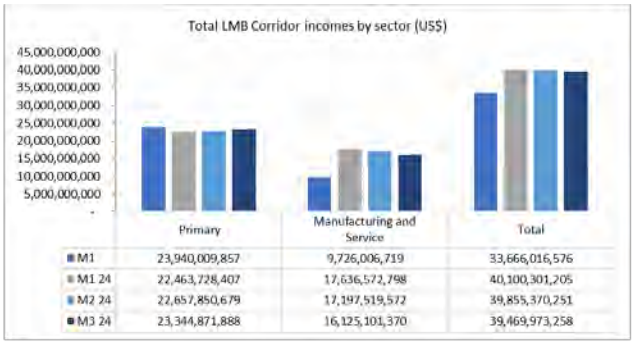
M2 Year 1	Primary	Secondary	Navigation	Tertiary
Zone 2-Mainstream - Lao	243,702,552	97,485,360	2,732,769	90,960,723
Zone 3 A-Lao-Mainstream	553,817,625	190,308,282	613,803	120,020,778
Zone 2 B-Upper Thailand	90,425,351	41,363,787	264,168	26,926,291
Zone 2 C-Lower Thailand	133,111,876	3,165,348	139,189	13,812,429
Zone 3 B Thailand-Mainstream	706,547,068	220,070,364	1,256,568	521,648,270
Zone 3 C Thailand-Songkhram	122,988,960	13,053,801	380,091	14,315,037
Zone 4 A Cambodia-Khone Falls to Kratie	65,818,168	7,492,693	112,692	8,088,911
Zone 4 B Cambodia-3S	10,233,169	(2,114,817)	-	(1,658,400)
Zone 4 C Cambodia Kratie to Viet Nam border	2,041,846,900	571,724,386	18,882,607	1,175,559,825
Zone 5 A Cambodia-Tonle Sap river	852,220,157	179,490,740	5,473,608	236,876,361
Zone 5 B Cambodia Tonle Sap lake	516,978,734	147,459,783	4,928,956	197,336,889
Zone 6 A VietNam Delta-freshwater	17,689,713,762	474,057,799	50,176,976	1,203,446,589
Zone 6 B VietNam Delta-saline	7,058,933,121	203,281,133	18,890,931	475,303,287
Totals	30,086,337,444	2,146,838,658	103,852,358	4,082,636,990

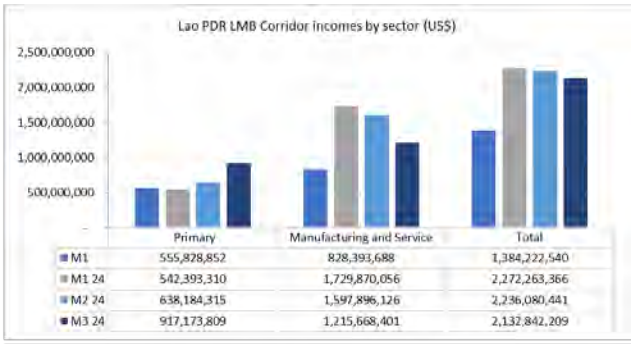
M2 Year 24	Primary	Secondary	Navigation	Tertiary
Zone 2-Mainstream - Lao	208,260,771	269,380,683	5,335,512	251,351,196
Zone 3 A-Lao-Mainstream	429,923,543	656,566,504	1,188,699	414,073,531
Zone 2 B-Upper Thailand	71,095,405	76,904,407	392,984	50,061,916
Zone 2 C-Lower Thailand	107,858,129	15,330,711	205,739	66,897,649
Zone 3 B Thailand-Mainstream	648,430,274	254,698,027	1,613,581	603,728,656
Zone 3 C Thailand-Songkhram	67,396,246	61,900,691	560,886	67,881,434
Zone 4 A Cambodia-Khone Falls to Kratie	84,293,989	13,412,093	194,245	14,479,336
Zone 4 B Cambodia-3S	3,334,274	3,021,543	-	2,369,437
Zone 4 C Cambodia Kratie to Viet Nam border	2,090,117,616	1,071,428,627	33,276,956	2,203,034,329
Zone 5 A Cambodia-Tonle Sap river	307,749,413	641,018,311	9,642,360	845,960,550
Zone 5 B Cambodia Tonle Sap lake	369,708,904	362,214,060	8,683,825	484,730,103
Zone 6 A VietNam Delta-freshwater	13,023,470,407	1,738,195,370	77,404,051	4,412,595,453
Zone 6 B VietNam Delta-saline	5,246,211,706	733,525,803	29,161,525	1,715,098,788
Totals	22,657,850,679	5,897,596,830	167,660,363	11,132,262,379

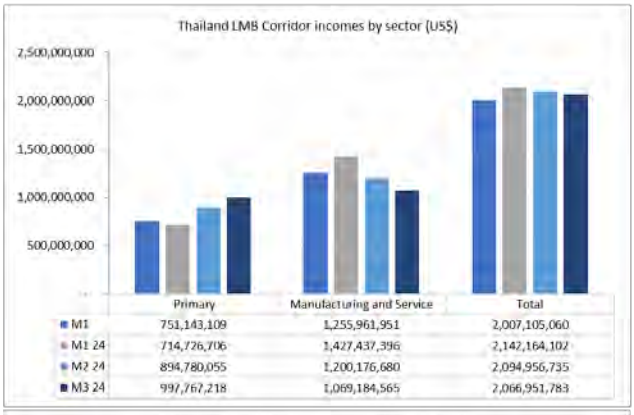
M3 Year 1	Primary	Secondary	Navigation	Tertiary
Zone 2-Mainstream - Lao	269,292,955	79,987,122	2,732,769	74,633,632
Zone 3 A-Lao-Mainstream	661,289,910	99,447,207	613,803	62,717,875
Zone 2 B-Upper Thailand	74,198,295	53,713,172	264,168	34,965,282
Zone 2 C-Lower Thailand	123,438,935	5,431,255	139,189	23,700,024
Zone 3 B Thailand-Mainstream	770,925,252	196,070,765	1,256,568	464,760,331
Zone 3 C Thailand-Songkhram	67,483,123	46,316,858	380,091	50,791,917
Zone 4 A Cambodia-Khone Falls to Kratie	40,091,612	19,829,840	112,692	21,407,763
Zone 4 B Cambodia-3S	4,014,673	1,291,445	-	1,012,727
Zone 4 C Cambodia Kratie to Viet Nam border	2,948,531,216	263,730,086	18,882,607	542,272,644
Zone 5 A Cambodia-Tonle Sap river	688,746,669	250,677,448	5,473,608	330,822,425
Zone 5 B Cambodia Tonle Sap lake	361,738,031	214,585,281	4,928,956	287,167,057
Zone 6 A VietNam Delta-freshwater	13,191,990,200	1,065,946,049	50,176,976	2,706,018,420
Zone 6 B VietNam Delta-saline	5,747,656,169	386,431,285	18,890,931	903,537,171
Totals	24,949,397,039	2,683,457,814	103,852,358	5,503,807,268

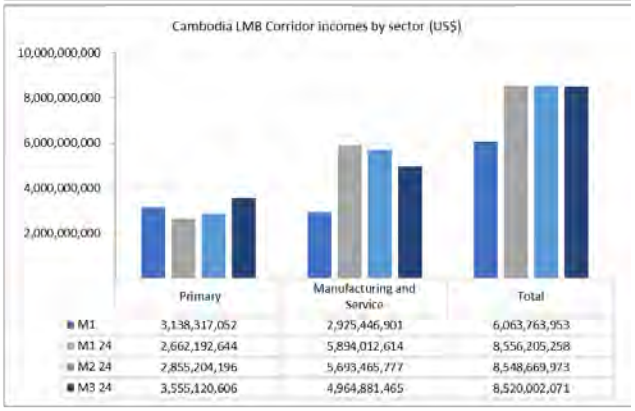
M3 Year 24	Primary	Secondary	Navigation	Tertiary
Zone 2-Mainstream - Lao	268,206,179	226,870,699	7,469,717	211,686,380
Zone 3 A-Lao-Mainstream	648,967,630	470,959,647	1,664,179	297,017,778
Zone 2 B-Upper Thailand	79,234,979	70,477,810	550,178	45,878,440
Zone 2 C-Lower Thailand	125,879,054	11,071,872	288,034	48,313,622
Zone 3 B Thailand-Mainstream	726,231,099	225,227,804	2,259,014	533,873,313
Zone 3 C Thailand-Songkhram	66,422,086	62,223,646	785,240	68,235,593
Zone 4 A Cambodia-Khone Falls to Kratie	66,293,604	22,003,175	271,943	23,754,037
Zone 4 B Cambodia-3S	3,537,318	2,910,323	-	2,282,221
Zone 4 C Cambodia Kratie to Viet Nam border	2,768,884,294	835,882,612	46,587,738	1,718,712,795
Zone 5 A Cambodia-Tonle Sap river	345,089,027	622,910,766	13,499,304	822,063,777
Zone 5 B Cambodia Tonle Sap lake	371,316,362	361,519,001	8,683,825	483,799,946
Zone 6 A VietNam Delta-freshwater	12,635,764,158	1,777,494,735	108,365,671	4,512,361,109
Zone 6 B VietNam Delta-saline	5,239,046,098	729,839,547	40,826,134	1,706,479,742
Totals	23,344,871,888	5,419,391,639	231,250,979	10,474,458,753

Figure 58 Sector incomes for corridor zones across the M1, M2 and M3 development scenarios









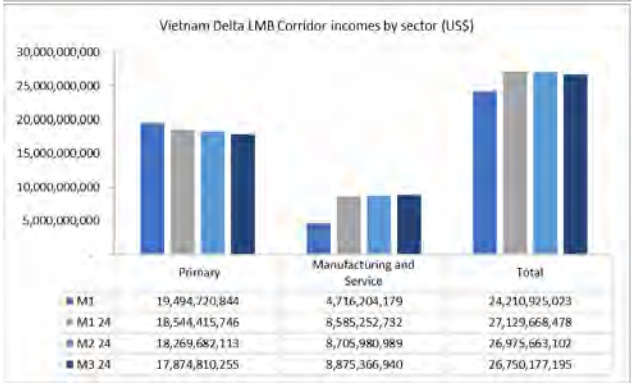
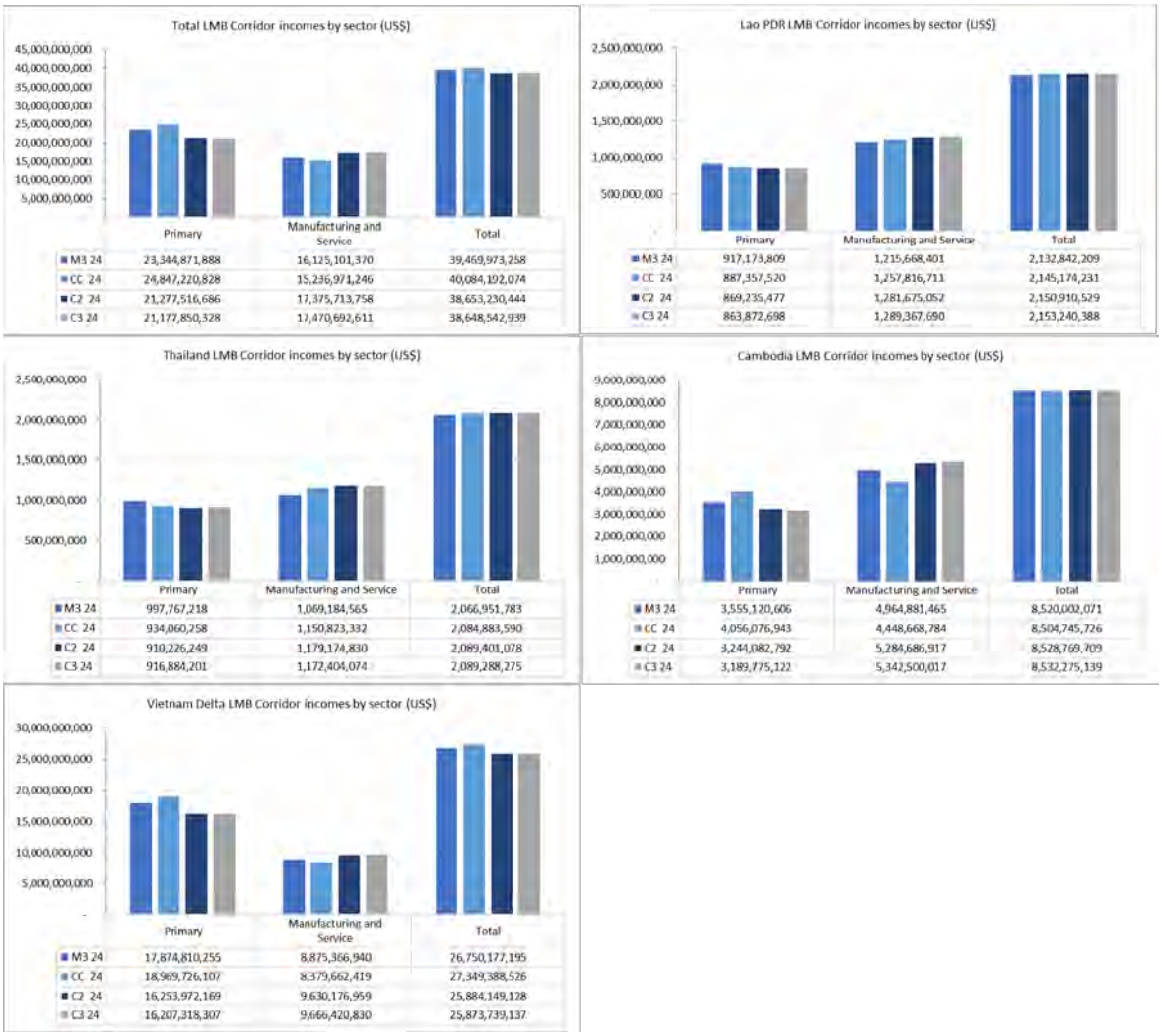


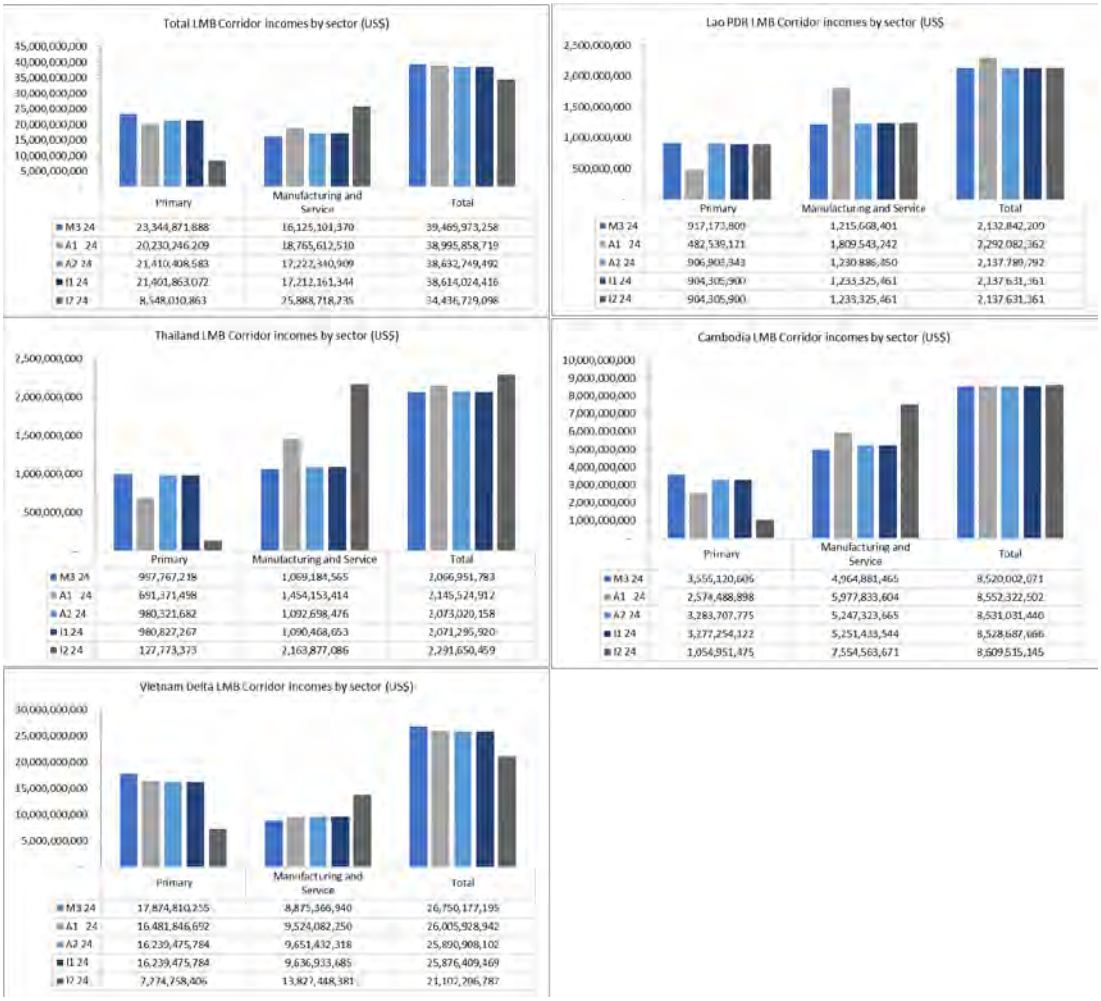
Figure 59 Sector incomes by zone across the M3 and the M3CC, C2 and C3 Climate change sub scenarios (year 24)



% change from M1 (year24)	M3CC			C2			C3		
	Primary	Manufacturing	Total	Primary	Manufacturing	Total	Primary	Manufacturing	Total
Lao PDR	64%	-27%	-6%	60%	-26%	-5%	59%	-25%	-5%
Thailand	31%	-19%	-3%	27%	-17%	-2%	28%	-18%	-2%
Cambodia	52%	-25%	-1%	22%	-10%	0%	20%	-9%	0%
Viet Nam	2%	-2%	1%	-12%	12%	-5%	-13%	13%	-5%
Total Corridor Income	11%	-14%	0%	-5%	-1%	-4%	-6%	-1%	-4%
US$ billion (change from M1 year24)	2.38	-2.39	-.016	-1.18	-.260	-1.45	-1.28	-.16	-1.45

The incomes associated with climate change sub scenarios were generally less than the M1 (year 24) income estimates. Aggregate incomes were reduced by up to US$1.45 billion for the C2 and C3 scenarios.

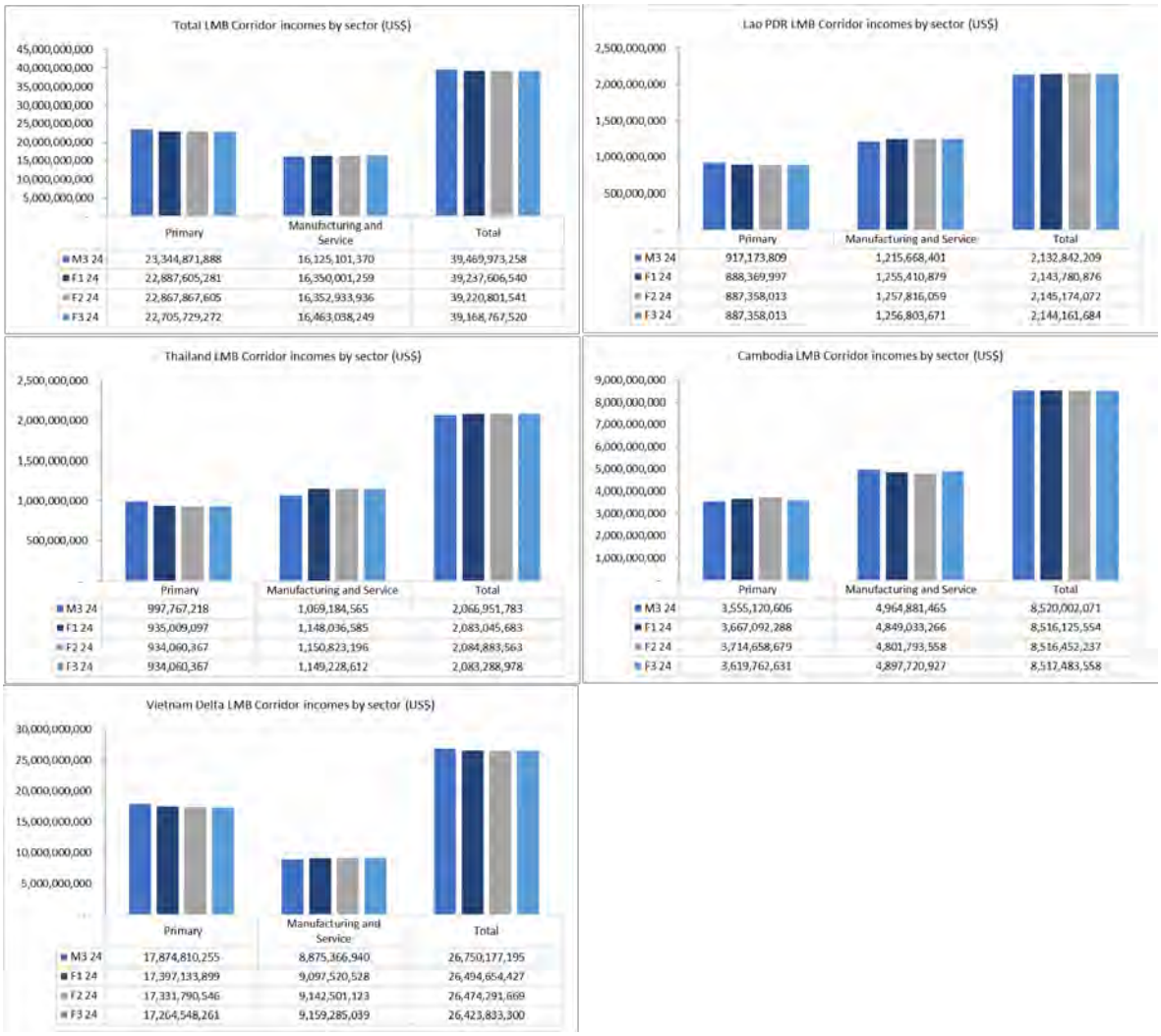
Figure 60 Sector incomes by zone across the M3 and the land use and irrigation sub scenarios (year 24)



% change from M1 (year24)	A1			A2			Irr1			Irr2		
	P'mary	Mf'ing	Total	P'mary	Mf'ing	Total	P'mary	Mf'ing	Total	P'mary	Mf'ing	Total
Lao PDR	-11%	5%	1%	67%	-29%	-6%	67%	-29%	-6%	67%	-29%	-6%
Thailand	-3%	2%	0%	37%	-23%	-3%	37%	-24%	-3%	37%	-24%	-3%
Cambodia	-3%	1%	0%	23%	-11%	0%	23%	-11%	0%	24%	-11%	0%
Viet Nam	-11%	11%	-4%	-12%	12%	-5%	-12%	12%	-5%	-12%	12%	-5%
Total Corridor Income	-10%	6%	-3%	-5%	-2%	-4%	-5%	-2%	-4%	-5%	-3%	-4%
US$ billion (change from M1 year24)	-2.2	1.13	-1.1	-1.1	-.41	-1.47	-1.06	-.42	-1.47	-1.01	-.46	-1.48

The incomes associated with the land use and irrigation sub scenarios were generally less than the M1 (year 24) income estimates. Aggregate incomes were reduced by up to US$1.48 billion for the A2, Irr1 and Irr2 scenarios.

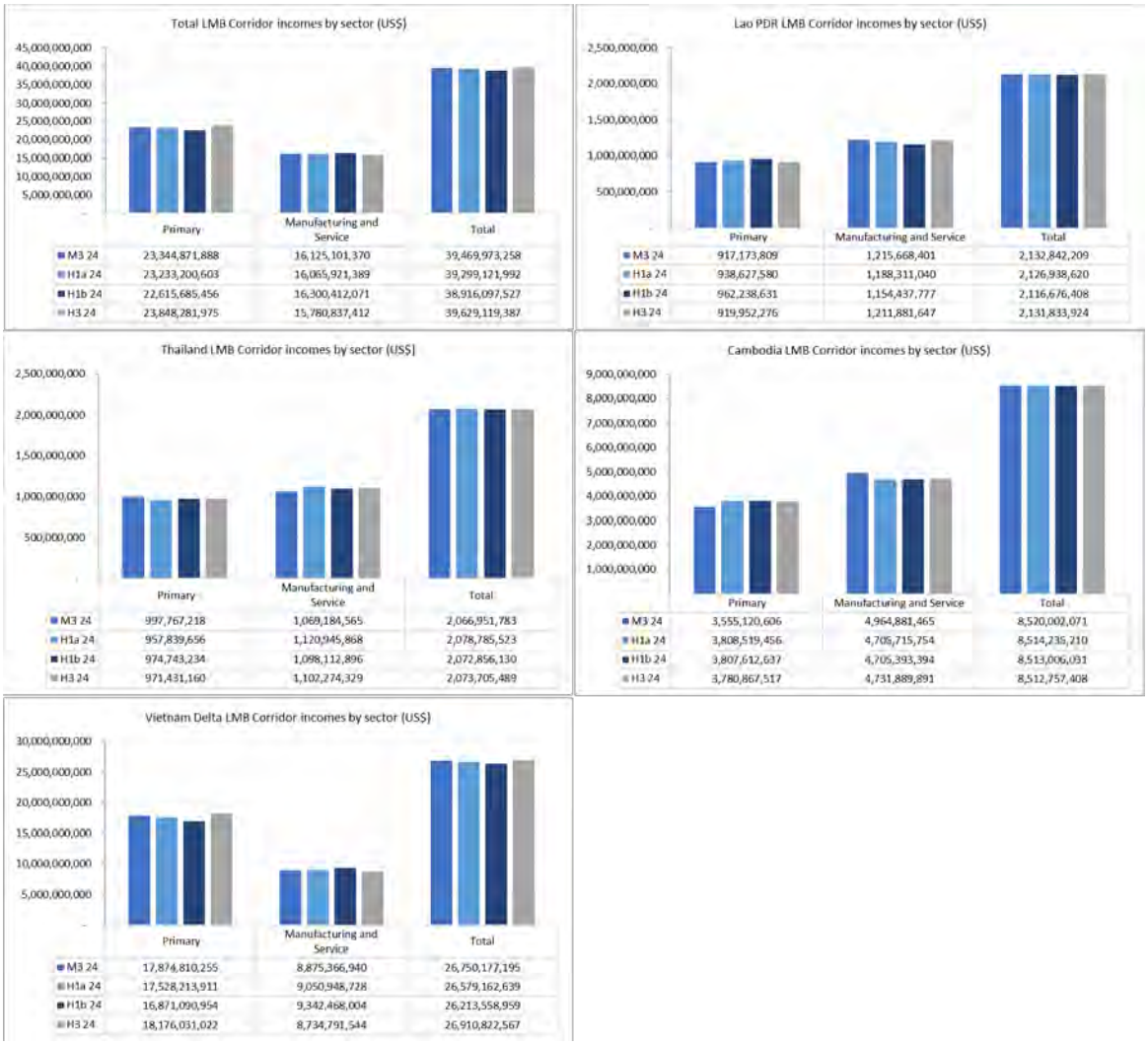
Figure 61 Sector incomes by zone across the M3 and the Flood plain development sub scenarios (year 24)



% change from M1 (year24	F1			F2			F3		
	Primary	Manufacturing	Total	Primary	Manufacturing	Total	Primary	Manufacturing	Total
Lao PDR	64%	-27%	-6%	64%	-27%	-6%	64%	-27%	-6%
Thailand	31%	-20%	-3%	31%	-19%	-3%	31%	-19%	-3%
Cambodia	38%	-18%	0%	40%	-19%	0%	36%	-17%	0%
Viet Nam	-6%	6%	-2%	-7%	6%	-2%	-7%	7%	-3%
Total Corridor Income	2%	-7%	-2%	2%	-7%	-2%	1%	-7%	-2%
US$ billion (change from M1 year24)	.42	-1.29	-.86	.40	-1.28	-.88	.24	-1.17	-.93

The incomes associated with the flood plain development sub scenarios were generally less than the M1 (year 24) income estimates. Aggregate incomes were reduced by up to US$0.98 billion for the F3 scenario.

Figure 62 Sector incomes by zone across the M3 and the H1a, H1b and H3 hydropower sub scenarios (year 24)



% change from M1 (year24	H1a			H1b			H3		
	Primary	Manufacturing	Total	Primary	Manufacturing	Total	Primary	Manufacturing	Total
Lao PDR	73%	-31%	-6%	77%	-33%	-7%	70%	-30%	-6%
Thailand	34%	-21%	-3%	36%	-23%	-3%	36%	-23%	-3%
Cambodia	43%	-20%	0%	43%	-20%	-1%	42%	-20%	-1%
Viet Nam	-5%	5%	-2%	-9%	9%	-3%	-2%	2%	-1%
Total Corridor Income %	3%	-9%	-2%	1%	-8%	-3%	6%	-11%	-1%
US$ billion (change from M1 year24)	.77	-1.57	-.80	.15	-1.33	-1.18	1.38	-1.86	-.47

The incomes associated with the Hydropower development sub scenarios were generally less than the M1 (year 24) income estimates. Aggregate incomes were reduced by up to US$1.18 billion for the H1b scenario and US$0.47 billion for the H3 scenario.

7.12 Income vulnerability

Smajgl et al. (2016) describe vulnerability assessments as the combination and dynamic interaction of exposure, sensitivity and adaptive capacity. Exposure and sensitivity increase a household's overall vulnerability to factors such as changing economic conditions, altered water resource systems and climate change, while adaptive capacity reduces overall vulnerability. Exposure and sensitivity are generally expressed as a series of consequences relevant to affected communities, such as crop productivity, poverty levels, flood and drought risks, enforced migration and land use forest conditions. Adaptive capacity reflects the ability of a household or community to manage or reduce the impact, despite the level of exposure and sensitivity. Adaptive capacity can be measured at multiple levels such as individuals, households, communities or watersheds. Vulnerability then is assessed as the combination and dynamic interaction of exposure, sensitivity and adaptive capacity.

A comprehensive assessment of the multiple dimensions influencing household vulnerability has been beyond the scope and resource constraints of the Council Study. The income vulnerability section describes the changes in vulnerability limited to household incomes aggregated to the level of the corridor zones as a final link between the Development scenarios, food security and employment and income described in the social and economic assessment. However, the importance of vulnerability and associated notions of resilience and livelihood systems in the development of Mekong communities warrants a brief review of the central tenets of vulnerability and livelihood scholarship.

Vulnerability and the livelihoods system concept has largely evolved in a development context, to inform the twin goals of improving equity and prosperity of poor communities whilst maintaining or improving the environmental condition of the spaces they operate within (Chambers and Conway 1992; Scoones 1998). Importantly, use of the term 'livelihood' became popular in the development literature as a more encompassing alternative to terms such as income, subsistence and employment (Ellis, 2000).

Chambers and Conway (1992 p.1) defined a sustainable livelihood as one comprising of "*the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base*". The assets referred to include tangible assets and resources as well as intangible assets such as property rights, claims and access (Krantz, 2001). Specifically, the five types of assets described in the livelihood framework are: social, human, physical, financial and natural. Thus, a livelihood system encompasses such things as cash income, non-cash exchanges, self-produced items, property rights and social relations (Ellis, 1998), with the expected outcomes of improved, sustained human wellbeing and the capacity to manage vulnerability.

Sen (1981) and Drèze and Sen (1989) developed the entitlement and endowment approach to expand the concept of poverty from a strict food-per-capita approach to a consideration of power relationships. Entitlements are "the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces" (Sen, 1984, p. 497). Apart from entitlements, people also have endowments (assets and resources, including labour power). Sen (1981, p. 2) divided entitlements into four categories - "production-based entitlement" (growing food), "trade-based entitlement" (buying food), "own-labour entitlement" (working for food) and "inheritance and transfer entitlement" (being given food by others). Although the concept has limitations (Sen 2001, Devereux 2001), it remains a powerful analytical tool and has informed livelihoods approaches to poverty alleviation. Vulnerability to food insecurity, for instance is often explained through the entitlement theory as a set of linked economic and institutional factors (Adger, 2006).

Entitlements deliver particular capabilities that in the Dreze and Sen framework are the basis for well-being and managing exposure, sensitivity and adaptive capacity. Such capabilities also include notions of rights of access, exclusion and modification, and liberty (Sen, 2001).

Chambers (1983) and Chambers and Conway (1992) and Ellis (1998, 2000) represent seminal writings in the heritage of the livelihoods approach. The sustainable livelihoods framework was largely initiated by Chambers and Conway (1992). The United Nations Conference on Environment and Development expanded on these concepts and pragmatically viewed the achievement of sustainable livelihoods as a broad goal for poverty eradication (Krantz, 2001). Livelihoods take into account the many dimensions of poverty and differ radically from conventional evaluations of poverty by focusing on peoples' lives rather than on resources or defined project outputs (Ashley and Hussein, 2000).

Livelihoods research has been primarily focused on the Household as a unit of study (Hussein and Nelson, 1998) and has been associated with a diversification of activities as a means of increasing prosperity (Alexandridis and Measham, 2007). Although most research focuses on the Household level, the outcomes and measures of improvement have been defined as "maintaining or enhancing the local and global assets on which livelihoods depend" (Chambers and Conway, 1992, p. 1). Thus considerations of the "micro-to-macro" linkage present in all social and economic systems are essential in order to provide the transition from individual to collective social inference mechanisms (Alexandridis and Measham, 2007).

The functioning of livelihoods systems depends on several domains: context, condition and trends of influential factors; Institutional structures and function; household and community norms traditions and strategies; and resource condition and outcomes.

The social and economic assessment recognizes the complexities of vulnerability and the sustainable livelihoods system, however important factors such as policy settings, migrations and household behaviour as key income system drivers have not been addressed in the income vulnerability assessment.

Estimating income vulnerability

Calculating the household incomes across sectors and the corridor was the first step of the income and income vulnerability analysis. The SIMVA and EMRF surveys addressed occupations, livelihood activities and incomes for randomly selected households located in the Council Study corridors (and the Nam Ngum basin in Lao site adjacent to the corridor). Median incomes were aggregated to country level and categorized as percentile (Table 46).

Four discrete income classes were used in the analysis based on the income percentile. The Income Classes for each country were defined as:

1 Low: up to 25^{th} percentile

2 Median: 25^{th} to 50^{th} percentile

3 High: 50^{th} to 95^{th} percentile

4 Very High: greater than 95^{th} percentile

Table 45 Median income percentiles (US$) by Country

	Percentiles (income US$)						
Zone	5	10	25	50	75	90	95
Cambodia	290.7	411.1	785.49	1542.8	3474.9	7802.3	11842.4
Lao PDR	484.4	646.6	1126.24	1889.0	3168.7	5237.4	6764.6
Thailand	246.4	443.6	867.32	1775.7	3319.0	6406.3	9248.8
Viet Nam delta	273.7	623.6	1370.00	3084.0	6083.7	11351.8	18095.2

The relative income class proportions for the Primary, manufacturing and Service or Tertiary CS sectors were derived from the employment data detailed in Section 7.10 and are detailed Table 47. The income class proportions were assumed to be uniformly distributed across the corridor zones located in the respective country and across the CS development main scenarios and sub-scenarios. People assigned to the low income class across the CS sectors would generally be described as at or below national income related poverty levels.

Table 46 Relative proportions of income classes by sector and Country

Sector	Agriculture	Manufacturing	Tertiary
	Lao PDR		
Income class	Proportion %	Proportion %	Proportion %
1 Low	30.0%	10.9%	11.0%
2 Median	26.4%	23.9%	19.9%
3 High	39.9%	56.5%	59.1%
4 Very high	3.7%	8.7%	9.9%
	Thailand		
1 Low	23.6%	63.6%	30.2%
2 Median	25.0%	9.1%	27.9%
3 High	46.6%	27.3%	30.2%
4 Very high	4.8%	0.0%	11.6%
	Cambodia		
1 Low	30.0%	23.1%	9.5%
2 Median	25.2%	23.1%	24.3%
3 High	41.1%	43.6%	57.2%
4 Very high	3.6%	10.3%	9.0%
	Viet Nam Delta		
1 Low	28.3%	41.5%	30.4%
2 Median	26.2%	27.5%	31.5%
3 High	40.8%	28.2%	33.5%
4 Very high	4.7%	2.8%	4.7%

The next step in the income vulnerability analysis estimated the total number of people in each of the four income classes across the four employment sectors. The estimates were derived by multiplying the numbers of employed for each sector (estimated using the employment spreadsheet

tool) by the respective income class proportions for each of the corridor zones across the full set of main development scenarios and sub-scenarios.

The estimated numbers of people defined as income vulnerable by corridor zone and sector for the M1 (year 1) and M1 (year 24) the M2 (year 24) and M3 (year 24) development scenarios are detailed in Table 48. Changes in the M1 year 1 to year 24 are indicative of the income effects of population growth occurring in the corridor zones and represent a baseline reference for the subsequent development scenario analyses. Income vulnerability was defined by a developed metric. The metric classifies vulnerable households as those assigned to the either the Low or Median income classes.

Table 47 Estimated membership of income classes by sector and corridor zone (M1 year1 and 24, M2 and M3 year 24)

M1 year1	Vulnerability (Low + median)			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	58000	9418	15634	20538
Zone 3 A-Lao PDR	101617	18994	44771	38849
Zone 2 B-Thailand	8941	698	11718	6194
Zone 2 C-Thailand	9645	1083	3360	11771
Zone 3 B Thailand	78064	8171	53178	101224
Zone 3 C Thailand	9999	1055	8221	7345
Zone 4 A Cambodia	11229	1915	5717	3519
Zone 4 B Cambodia	1075	163	410	182
Zone 4 C Cambodia	545679	108684	165285	196465
Zone 5 A Cambodia	172911	19407	86024	65452
Zone 5 B Cambodia	88042	36172	62266	48233
Zone 6 A VietNam Delta	1536554	71216	299398	753482
Zone 6 B VietNam Delta	623889	76574	107287	249586
Total	3245646	353550	863269	1502840

M1 year 24	Vulnerability (Low + median)			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	56070	10856	34691	45226
Zone 3 A-Lao PDR	93496	23061	91204	79084
Zone 2 B-Thailand	9570	800	15057	7950
Zone 2 C-Thailand	9658	1275	4539	15833
Zone 3 B Thailand	69330	9949	98131	76763
Zone 3 C Thailand	10090	1281	10987	9795
Zone 4 A Cambodia	20437	2080	5799	3578
Zone 4 B Cambodia	894	177	551	641
Zone 4 C Cambodia	488754	121982	334638	395312
Zone 5 A Cambodia	60542	21937	197116	148958
Zone 5 B Cambodia	79615	39378	106972	82543
Zone 6 A VietNam Delta	1489987	75972	523901	1308472
Zone 6 B VietNam Delta	542799	86956	221384	508962
Total	2931242	395706	1644968	2683116

M2 year 24	Vulnerability (Low + median)			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	64379	6072	33704	44170
Zone 3 A-Lao PDR	131428	14009	82148	71295
Zone 2 B-Thailand	10542	595	14341	7606
Zone 2 C-Thailand	16090	805	2859	10048
Zone 3 B Thailand	95201	6368	47496	90588
Zone 3 C Thailand	9776	781	11543	10323
Zone 4 A Cambodia	24680	1784	3996	2484
Zone 4 B Cambodia	896	151	900	400
Zone 4 C Cambodia	551409	104784	319242	378789
Zone 5 A Cambodia	78134	18484	190997	144792
Zone 5 B Cambodia	82209	33862	107925	83632
Zone 6 A VietNam Delta	1469124	72894	530231	1329977
Zone 6 B VietNam Delta	542750	78417	223760	516581
Total	3076617	339006	1569142	2690683

M3 year 24	Vulnerability (Low + median)			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	87190	3908	10008	37775
Zone 3 A-Lao PDR	205091	18614	12443	51297
Zone 2 B-Thailand	11107	516	10016	7039
Zone 2 C-Thailand	18795	541	1013	7307
Zone 3 B Thailand	112736	8021	36563	80408
Zone 3 C Thailand	9537	1034	8637	10458
Zone 4 A Cambodia	11231	1355	5908	4066
Zone 4 B Cambodia	1146	114	385	385
Zone 4 C Cambodia	820862	104830	78581	299870
Zone 5 A Cambodia	201978	14254	74692	141574
Zone 5 B Cambodia	89306	24262	63938	83475
Zone 6 A VietNam Delta	1498821	63151	325163	1371342
Zone 6 B VietNam Delta	626339	54201	117880	518553
Total	3694137	294800	745226	2613549

The scenario analyses were constrained to year 24 of the projection horizon comparing the relative change in income vulnerability of each of the development scenarios with the M1 baseline, expressed as % changes. The % change calculated for the M1 (year 1 compared to year 24) and the M1 comparison with the M2and M3 development scenario income vulnerability are detailed in Table 49. A negative sign indicates the sector income vulnerability has decreased compared to the M1 year 24 estimates. A positive sign indicates the opposite, an increase in income vulnerability.

A cautious approach to interpreting the changes in income vulnerability is recommended. A decrease or increase in income vulnerability in one sector, zone or country does not necessarily equate to net change in vulnerability across the entire Mekong Corridor. The entitlements, endowments and capacities of vulnerable households are likely to limit the autonomous choice of employment. Income vulnerability levels are likely to be maintained for those households in the vulnerable Low income class, despite changes in sectoral employment and manifest as the % changes in Table 49, unless improved endowments and entitlements accompany those changes.

Households who are income vulnerable in one sector are likely to continue being vulnerable in another sector. Holding the proportions of the income classes constant across the analytical framework implies that observed changes are primarily due to changes in sectoral employment. Historical and contemporary data and analysis to support claims of amended income classes influencing income vulnerability levels through time and space are absent for the corridor.

Table 48 Relative % change in of M1-M2, M3and M3CC income vulnerability membership

	Vulnerability M1 yr 1-yr24			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	-3%	15%	122%	120%
Zone 3 A-Lao PDR	-8%	21%	104%	104%
Zone 2 B-Thailand	7%	15%	28%	28%
Zone 2 C-Thailand	0%	18%	35%	35%
Zone 3 B Thailand	-11%	22%	85%	-24%
Zone 3 C Thailand	1%	21%	34%	33%
Zone 4 A Cambodia	82%	9%	1%	2%
Zone 4 B Cambodia	-17%	8%	34%	252%
Zone 4 C Cambodia	-10%	12%	102%	101%
Zone 5 A Cambodia	-65%	13%	129%	128%
Zone 5 B Cambodia	-10%	9%	72%	71%
Zone 6 A VietNam Delta	-3%	7%	75%	74%
Zone 6 B VietNam Delta	-13%	14%	106%	104%

	Vulnerability M1 yr 24 M2 yr 24			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	15%	-44%	-3%	-2%
Zone 3 A-Lao PDR	41%	-39%	-10%	-10%
Zone 2 B-Thailand	10%	-26%	-5%	-4%
Zone 2 C-Thailand	67%	-37%	-37%	-37%
Zone 3 B Thailand	37%	-36%	-52%	18%
Zone 3 C Thailand	-3%	-39%	5%	5%
Zone 4 A Cambodia	21%	-14%	-31%	-31%
Zone 4 B Cambodia	0%	-15%	63%	-38%
Zone 4 C Cambodia	13%	-14%	-5%	-4%
Zone 5 A Cambodia	29%	-16%	-3%	-3%
Zone 5 B Cambodia	3%	-14%	1%	1%
Zone 6 A VietNam Delta	-1%	-4%	1%	2%
Zone 6 B VietNam Delta	0%	-10%	1%	1%

	Vulnerability M2 yr 24 M3 yr 24			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	35%	-36%	-70%	-14%
Zone 3 A-Lao PDR	56%	33%	-85%	-28%
Zone 2 B-Thailand	5%	-13%	-30%	-7%
Zone 2 C-Thailand	17%	-33%	-65%	-27%
Zone 3 B Thailand	18%	26%	-23%	-11%
Zone 3 C Thailand	-2%	32%	-25%	1%
Zone 4 A Cambodia	-54%	-24%	48%	64%
Zone 4 B Cambodia	28%	-24%	-57%	-4%
Zone 4 C Cambodia	49%	0%	-75%	-21%
Zone 5 A Cambodia	159%	-23%	-61%	-2%
Zone 5 B Cambodia	9%	-28%	-41%	0%
Zone 6 A VietNam Delta	2%	-13%	-39%	3%
Zone 6 B VietNam Delta	15%	-31%	-47%	0%

	Vulnerability M1 yr 24 M3 yr 24			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	56%	-64%	-71%	-16%
Zone 3 A-Lao PDR	119%	-19%	-86%	-35%
Zone 2 B-Thailand	16%	-36%	-33%	-11%
Zone 2 C-Thailand	95%	-58%	-78%	-54%
Zone 3 B Thailand	63%	-19%	-63%	5%
Zone 3 C Thailand	-5%	-19%	-21%	7%
Zone 4 A Cambodia	-45%	-35%	2%	14%
Zone 4 B Cambodia	28%	-35%	-30%	-40%
Zone 4 C Cambodia	68%	-14%	-77%	-24%
Zone 5 A Cambodia	234%	-35%	-62%	-5%
Zone 5 B Cambodia	12%	-38%	-40%	1%
Zone 6 A VietNam Delta	1%	-17%	-38%	5%
Zone 6 B VietNam Delta	15%	-38%	-47%	2%

	Vulnerability M1 yr 24 M3CC yr 24			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	57%	-71%	-18%	-17%
Zone 3 A-Lao PDR	114%	-53%	-32%	-32%
Zone 2 B-Thailand	14%	-40%	-7%	-6%
Zone 2 C-Thailand	89%	-57%	-49%	-48%
Zone 3 B Thailand	47%	-49%	-54%	12%
Zone 3 C Thailand	-13%	-53%	12%	13%
Zone 4 A Cambodia	-41%	-38%	72%	72%
Zone 4 B Cambodia	-49%	-39%	109%	-20%
Zone 4 C Cambodia	80%	1%	-38%	-37%
Zone 5 A Cambodia	95%	-36%	-11%	-10%
Zone 5 B Cambodia	18%	-23%	-2%	-2%
Zone 6 A VietNam Delta	0%	-9%	0%	1%
Zone 6 B VietNam Delta	12%	-22%	-9%	-7%

	Vulnerability M3 yr 24 M3CC yr 24			
Corridor zone	Primary	Fishing	Manufacturing	Service
Zone 2 Lao PDR	1%	-10%	-1%	0%
Zone 3 A-Lao PDR	-3%	0%	3%	3%
Zone 2 B-Thailand	-7%	0%	6%	6%
Zone 2 C-Thailand	-3%	0%	8%	8%
Zone 3 B Thailand	-5%	0%	5%	5%
Zone 3 C Thailand	-9%	0%	5%	5%
Zone 4 A Cambodia	-37%	0%	47%	47%
Zone 4 B Cambodia	-53%	0%	29%	29%
Zone 4 C Cambodia	15%	0%	-16%	-15%
Zone 5 A Cambodia	32%	0%	-7%	-6%
Zone 5 B Cambodia	13%	0%	-4%	-4%
Zone 6 A VietNam Delta	4%	0%	-4%	-4%
Zone 6 B VietNam Delta	13%	0%	-11%	-10%

The categorization of income vulnerability does point to changes in the corridor zones that warrant further investigation and deliberation regarding distributional equity and planned development trajectories. First, the analyst determination of the vulnerability metric highlights the subjective nature of vulnerability evaluation and characterization. Conducting participatory based processes to

facilitate agreed measures amongst affected interests is warranted to avoid definitional skirmishes in contrast to productive discussion and decisions based on the implications and information the analyses convey.

Second, the M1 year 1-24 results suggest that population growth in the corridor zones matters. Generally, vulnerability decreases in the Primary sector (that is less people are employed) and increases mostly in in the Manufacturing sector, less so in the Service sector, but all zones are affected by both increases and decreases. The Lao PDR zones are characterized by modest decreases in the primary and fish sectors compared to substantial increases in the manufacturing and service sectors, consistent with Zones 4C (Kratie to the Viet Nam Border) and 5A (Tonle Sap River) in Cambodia (assessed with metric IV1) and the 6B saline Delta zone. The Thai zones, the Tonle Sap Lake and the Delta freshwater zone are less affected in comparison.

The M1 % changes are generally greater than the M1-M2. The vulnerability increases in the primary sector are a function of increased employment associated with planned agricultural expansion. The increases are evident in Lao PDR and Thai zones and the 5A zone in Cambodia. The vulnerability increases are partially countervailed by reduced employment in the remaining sectors, (and therefore less number of vulnerable households). The same rationale applies to the reductions in income vulnerability in the fish sector, counter-intuitively a consequence of reduced fish biomass and employment.

The greatest magnitude of the change in income vulnerability was observed for the M1-M3 and to a lesser extent the M2-M3 scenario comparisons. The increasing reduction in fish sector income vulnerability in the M1-M3 comparison is a consequence of the biomass reductions predicted by the BioRA Discipline Team and the associated employment reductions.

Income vulnerability evaluation of the CS Sub Scenarios

The % changes calculated for the set of Council Study sub-scenarios are detailed in Table 50 (comparing the M1 with the climate change C2 and C3 scenarios, and land use change A1 and A2 scenarios) and Table 51 (comparing M1 with the irrigation I1 and I2, flood plain development F1, F2 and F3 scenarios and the hydropower H1a, H1b and H3 scenarios). The C2 scenario was compared to the C3 scenario for reference. The observed changes in income vulnerability when comparing across the I1 and I2, F1 and F2, H1b and H3 ranged from -2% to 10% and are not reported.

Consistent with the income vulnerability of the main Council Study scenarios, the changes in income vulnerability varied substantially in magnitude as well as valency, suggesting a disproportionate distribution of vulnerability in the corridor in response to the modelled climate change related effects.

The observed climate change related changes in income vulnerability in the fish sector were substantial in both the C2 and C3 scenarios and dispersed across the corridor zones. The increased vulnerability in the Thai, Lao PDR and Cambodian agricultural sector were greater in the C2 scenario. The C3 scenario was characterized by substantial decrease across the zones in the service sector.

The increased vulnerability in the agriculture sector (Lao PDR, Thai mainstream and the Kratie to the border and the Tonle Sap River zones in Cambodia) were more pronounced in the A2 land use sub scenario compared A1. A similar disrtibtion of vulnerability changes were observed for the irrigation I1 and I2 sub scenarios s those described A2, as were the F1, F2 and F3 flood plain development sub-scenarios, although the magnitude of change (both increases and decreases) were higher in the Cambodian zones.

The distribution magnitude and sign of the vulnerability changes in response to the hydropower H1a, H1b and H3 sub-scenarios were consistent with the land use, irrigation and flood plain development sub scenarios. The changes in income vulnerability observed in the Viet Nam ranged -17% to 17%

across the set of sub-scenarios, except C2 and C3 where changes ranged from -47% to 46%. The fish sector was especially affected in both the freshwater and saline zones.

Table 49 Relative % change of M3-M3CC, C2, C3, A1, A2, Irr1 and Irr2 income vulnerability

	Vulnerability M3 C2				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	0%	-8%	1%	0%	-2%
Zone 3 A-Lao PDR	-5%	-31%	8%	8%	-5%
Zone 2 B-Thailand	-8%	-18%	7%	6%	-3%
Zone 2 C-Thailand	-5%	-35%	17%	16%	-2%
Zone 3 B Thailand	-8%	-27%	11%	11%	-3%
Zone 3 C Thailand	-7%	-31%	6%	5%	-7%
Zone 4 A Cambodia	-42%	-27%	59%	58%	12%
Zone 4 B Cambodia	-49%	-28%	31%	31%	-4%
Zone 4 C Cambodia	-11%	18%	9%	8%	6%
Zone 5 A Cambodia	-8%	-20%	3%	2%	-6%
Zone 5 B Cambodia	-6%	-13%	3%	3%	-3%
Zone 6 A VietNam Delta	-13%	1%	12%	11%	3%
Zone 6 B VietNam Delta	-1%	2%	1%	1%	1%

	Vulnerability M3 C3				
Corridor zone	Primary	Fishing	Manufacturing	Service	Total
Zone 2 Lao PDR	-11%	-6%	-56%	-54%	-32%
Zone 3 A-Lao PDR	-6%	29%	-73%	-72%	-30%
Zone 2 B-Thailand	-15%	-15%	-17%	-16%	-16%
Zone 2 C-Thailand	-4%	-41%	-41%	-41%	-32%
Zone 3 B Thailand	-4%	22%	-2%	-2%	3%
Zone 3 C Thailand	-21%	28%	-14%	-13%	-5%
Zone 4 A Cambodia	-34%	-26%	-18%	-18%	-24%
Zone 4 B Cambodia	1%	-26%	-45%	-45%	-29%
Zone 4 C Cambodia	7%	-5%	-68%	-66%	-33%
Zone 5 A Cambodia	129%	-31%	-60%	-59%	-5%
Zone 5 B Cambodia	10%	-52%	-38%	-37%	-29%
Zone 6 A VietNam Delta	5%	-10%	-40%	-39%	-21%
Zone 6 B VietNam Delta	16%	-22%	-48%	-47%	-25%

	Vulnerability M3 M3CC				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	1%	-10%	-1%	0%	-2%
Zone 3 A-Lao PDR	-3%	0%	3%	3%	1%
Zone 2 B-Thailand	-7%	0%	6%	6%	1%
Zone 2 C-Thailand	-3%	0%	8%	8%	3%
Zone 3 B Thailand	-5%	0%	5%	5%	1%
Zone 3 C Thailand	-9%	0%	5%	5%	0%
Zone 4 A Cambodia	-37%	0%	47%	47%	14%
Zone 4 B Cambodia	-53%	0%	29%	29%	2%
Zone 4 C Cambodia	15%	0%	-16%	-15%	-4%
Zone 5 A Cambodia	32%	0%	-7%	-6%	5%
Zone 5 B Cambodia	13%	0%	-4%	-4%	1%
Zone 6 A VietNam Delta	4%	0%	-4%	-4%	-1%
Zone 6 B VietNam Delta	13%	0%	-11%	-10%	-2%

	Vulnerability M3 A1				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	-36%	-4%	29%	27%	4%
Zone 3 A-Lao PDR	-53%	-28%	60%	60%	10%
Zone 2 B-Thailand	-19%	-22%	17%	15%	-2%
Zone 2 C-Thailand	-50%	-34%	131%	129%	44%
Zone 3 B Thailand	-31%	-24%	37%	37%	5%
Zone 3 C Thailand	5%	-27%	-1%	-2%	-6%
Zone 4 A Cambodia	0%	-27%	4%	4%	-5%
Zone 4 B Cambodia	-6%	-28%	6%	6%	-5%
Zone 4 C Cambodia	-34%	20%	32%	30%	12%
Zone 5 A Cambodia	-34%	-16%	8%	7%	-9%
Zone 5 B Cambodia	-6%	-19%	4%	4%	-4%
Zone 6 A VietNam Delta	-11%	0%	10%	9%	2%
Zone 6 B VietNam Delta	-1%	-1%	2%	1%	0%

	Vulnerability M3 A2				
Corridor zone	Primary	Fishing	Manufacturing	Service	Total
Zone 2 Lao PDR	1%	-11%	0%	0%	-3%
Zone 3 A-Lao PDR	0%	-28%	2%	2%	-6%
Zone 2 B-Thailand	0%	-22%	1%	1%	-5%
Zone 2 C-Thailand	0%	-34%	4%	4%	-7%
Zone 3 B Thailand	0%	-24%	2%	2%	-5%
Zone 3 C Thailand	0%	-27%	1%	1%	-6%
Zone 4 A Cambodia	3%	-27%	0%	0%	-6%
Zone 4 B Cambodia	0%	-28%	3%	3%	-6%
Zone 4 C Cambodia	-11%	20%	9%	8%	6%
Zone 5 A Cambodia	-8%	-16%	2%	2%	-5%
Zone 5 B Cambodia	-6%	-19%	4%	4%	-4%
Zone 6 A VietNam Delta	-13%	0%	12%	11%	2%
Zone 6 B VietNam Delta	-1%	-1%	1%	1%	0%

	Vulnerability M3 Irrl				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	0%	-6%	1%	0%	-1%
Zone 3 A-Lao PDR	0%	-30%	2%	2%	-6%
Zone 2 B-Thailand	0%	-22%	1%	0%	-5%
Zone 2 C-Thailand	0%	-34%	4%	4%	-7%
Zone 3 B Thailand	0%	-26%	2%	2%	-5%
Zone 3 C Thailand	0%	-29%	2%	1%	-7%
Zone 4 A Cambodia	-8%	-26%	14%	13%	-2%
Zone 4 B Cambodia	0%	-27%	2%	2%	-6%
Zone 4 C Cambodia	-11%	25%	8%	7%	7%
Zone 5 A Cambodia	-8%	-20%	3%	2%	-6%
Zone 5 B Cambodia	-6%	-6%	3%	2%	-2%
Zone 6 A VietNam Delta	-13%	0%	12%	11%	2%
Zone 6 B VietNam Delta	-1%	-1%	2%	1%	0%

	Vulnerability M3 Irr2				
Corridor zone	Primary	Fishing	Manufacturing	Service	Total
Zone 2 Lao PDR	1%	-10%	0%	0%	-2%
Zone 3 A-Lao PDR	0%	-30%	2%	2%	-6%
Zone 2 B-Thailand	0%	-22%	1%	1%	-5%
Zone 2 C-Thailand	0%	-34%	4%	4%	-7%
Zone 3 B Thailand	0%	-26%	2%	2%	-5%
Zone 3 C Thailand	0%	-29%	1%	1%	-7%
Zone 4 A Cambodia	3%	-26%	-1%	-1%	-6%
Zone 4 B Cambodia	0%	-27%	2%	2%	-6%
Zone 4 C Cambodia	-11%	25%	8%	8%	7%
Zone 5 A Cambodia	-8%	-20%	2%	2%	-6%
Zone 5 B Cambodia	-6%	-6%	3%	2%	-2%
Zone 6 A VietNam Delta	-13%	0%	12%	11%	2%
Zone 6 B VietNam Delta	-1%	-1%	1%	1%	0%

Table 50 Relative % change in of M3 F1, F2, F3, H1a, H1b and H3 income vulnerability

	Vulnerability M3 F1				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	1%	-9%	0%	-1%	-2%
Zone 3 A-Lao PDR	-3%	-31%	5%	5%	-6%
Zone 2 B-Thailand	-7%	-22%	7%	6%	-4%
Zone 2 C-Thailand	-3%	-36%	13%	12%	-4%
Zone 3 B Thailand	-5%	-27%	7%	7%	-4%
Zone 3 C Thailand	-9%	-31%	7%	6%	-7%
Zone 4 A Cambodia	-37%	-27%	52%	51%	10%
Zone 4 B Cambodia	-53%	-28%	33%	33%	-4%
Zone 4 C Cambodia	1%	20%	-3%	-4%	3%
Zone 5 A Cambodia	19%	-7%	-3%	-4%	1%
Zone 5 B Cambodia	7%	-9%	-1%	-1%	-1%
Zone 6 A VietNam Delta	-8%	0%	8%	7%	2%
Zone 6 B VietNam Delta	11%	-1%	-9%	-9%	-2%

	Vulnerability M3 F2				
Corridor zone	Primary	Fishing	Manufacturing	Service	Total
Zone 2 Lao PDR	1%	-10%	0%	0%	-2%
Zone 3 A-Lao PDR	-3%	-31%	5%	5%	-6%
Zone 2 B-Thailand	-7%	-22%	7%	7%	-4%
Zone 2 C-Thailand	-3%	-36%	13%	12%	-4%
Zone 3 B Thailand	-5%	-27%	7%	7%	-4%
Zone 3 C Thailand	-9%	-31%	7%	6%	-7%
Zone 4 A Cambodia	-37%	-27%	52%	51%	10%
Zone 4 B Cambodia	-53%	-28%	33%	33%	-4%
Zone 4 C Cambodia	3%	20%	-6%	-5%	3%
Zone 5 A Cambodia	17%	-7%	-3%	-3%	1%
Zone 5 B Cambodia	5%	-9%	0%	0%	-1%
Zone 6 A VietNam Delta	-8%	0%	7%	7%	1%
Zone 6 B VietNam Delta	10%	-1%	-8%	-8%	-2%

	Vulnerability M3 F3				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	1%	-10%	1%	-1%	-2%
Zone 3 A-Lao PDR	-3%	-32%	6%	5%	-6%
Zone 2 B-Thailand	-7%	-22%	7%	6%	-4%
Zone 2 C-Thailand	-3%	-36%	13%	12%	-4%
Zone 3 B Thailand	-5%	-28%	8%	7%	-5%
Zone 3 C Thailand	-9%	-32%	7%	6%	-7%
Zone 4 A Cambodia	-37%	-27%	52%	51%	10%
Zone 4 B Cambodia	-53%	-28%	33%	33%	-4%
Zone 4 C Cambodia	0%	19%	-2%	-2%	4%
Zone 5 A Cambodia	13%	-12%	-2%	-2%	-1%
Zone 5 B Cambodia	5%	3%	-2%	-2%	1%
Zone 6 A VietNam Delta	-9%	-1%	8%	7%	1%
Zone 6 B VietNam Delta	11%	-3%	-8%	-9%	-3%

	Vulnerability M3 H1a				
Corridor zone	Primary	Fishing	Manufacturing	Service	Total
Zone 2 Lao PDR	1%	186%	-6%	-6%	44%
Zone 3 A-Lao PDR	-3%	-32%	6%	6%	-6%
Zone 2 B-Thailand	-7%	-22%	7%	7%	-4%
Zone 2 C-Thailand	-3%	-36%	12%	12%	-4%
Zone 3 B Thailand	-7%	-28%	10%	10%	-4%
Zone 3 C Thailand	-9%	-32%	7%	7%	-7%
Zone 4 A Cambodia	-49%	-27%	67%	67%	15%
Zone 4 B Cambodia	-53%	-28%	33%	33%	-4%
Zone 4 C Cambodia	3%	19%	-6%	-5%	3%
Zone 5 A Cambodia	17%	-12%	-3%	-3%	0%
Zone 5 B Cambodia	5%	3%	-2%	-2%	1%
Zone 6 A VietNam Delta	-8%	-1%	7%	7%	1%
Zone 6 B VietNam Delta	10%	-3%	-8%	-8%	-2%

	Vulnerability M3 H1b				
Corridor zone	Primary	Fishing	Manufacturing	Service	Av'ge
Zone 2 Lao PDR	1%	131%	-4%	-5%	31%
Zone 3 A-Lao PDR	2%	7%	-2%	-2%	1%
Zone 2 B-Thailand	-7%	19%	6%	5%	5%
Zone 2 C-Thailand	-2%	23%	2%	1%	6%
Zone 3 B Thailand	-5%	6%	5%	5%	3%
Zone 3 C Thailand	-9%	7%	5%	4%	2%
Zone 4 A Cambodia	-16%	2%	21%	20%	7%
Zone 4 B Cambodia	-53%	2%	30%	30%	2%
Zone 4 C Cambodia	2%	16%	-3%	-4%	2%
Zone 5 A Cambodia	18%	8%	-4%	-4%	5%
Zone 5 B Cambodia	7%	6%	-3%	-3%	2%
Zone 6 A VietNam Delta	-13%	4%	12%	11%	4%
Zone 6 B VietNam Delta	9%	11%	-9%	-9%	0%

	Vulnerability M3 H3				
Corridor zone	Primary	Fishing	Manufacturing	Service	Total
Zone 2 Lao PDR	0%	-3%	0%	0%	-1%
Zone 3 A-Lao PDR	-3%	7%	3%	3%	2%
Zone 2 B-Thailand	-7%	19%	5%	5%	6%
Zone 2 C-Thailand	-3%	23%	6%	6%	8%
Zone 3 B Thailand	-5%	6%	5%	5%	3%
Zone 3 C Thailand	-9%	7%	5%	5%	2%
Zone 4 A Cambodia	-60%	2%	79%	78%	25%
Zone 4 B Cambodia	-53%	2%	30%	30%	2%
Zone 4 C Cambodia	2%	16%	-4%	-4%	2%
Zone 5 A Cambodia	17%	8%	-4%	-4%	4%
Zone 5 B Cambodia	6%	6%	-3%	-3%	2%
Zone 6 A VietNam Delta	-2%	4%	2%	2%	1%
Zone 6 B VietNam Delta	9%	11%	-10%	-9%	0%

8 Conclusions and Recommendations

Main findings

In addition to it's iconic value, the Mekong River corridor as defined by the MRC is central to the social, cultural, ecological and economic status of the riparian countries. In conducting the Council Study, the near absence of social and economic data and information specific to the corridor and the 13 bio-zones has been evident. Two surveys have been conducted by the MRC that represent point data in time, although the differing survey focus and spatial boundaries limits their use as a panel data set. The data deficit severely limits the ability for National decision makers to understand the rapid and connected changes occurring in the Corridor and detect and manage points of effective intervention. **The riparian Member Countries could treat the Corridor as a defined administrative boundary, as part of their formal data collection activities, in addition to and complementing traditional census and natural resource management boundaries (Provinces, districts, eco-zones).**

Gender

Gender issues are relevant to water resource developments since women are more vulnerable than men during flood and drought due to their higher dependence on natural resources and the social barriers thought to limit their adaptive capacity. The lower median incomes of women compared to men vary from 22% in the Cambodian zones, 4% in Lao PDR, 14% in Thailand and 45% in Viet Nam. The equivalent dollar of subsistence incomes of women are from 3-5% higher than male counterparts. The incidence of women in the primary sector having incomes below national poverty lines is significantly higher than males except Lao PDR, varying by 12% in Cambodia, 4.6% in Thailand and 17% in Viet Nam. Aspirations of gender equity are generally not reflected in the Council Study assessment and indicate a need for sustained efforts to correct the imbalance.

Notably the MRC Social impact and vulnerability assessments (SIMVA) did not treat gender as a specific survey dimension and data class. **A central recommendation of the social and economic assessment is the future investigation of the status of gender equity in the corridor and the vulnerability and opportunities for women be undertaken by the MRC to correct this important omission.**

Capacity to maintain food security

Increasing food security is a priority for the Member Countries, particularly important to Cambodia and Lao PDR to graduate from LDC status. The analyses indicate that policies and initiatives to manage reduced food security will be one the most important deliberations to be undertaken by Member Country Governments. The analyses also highlight the interdependency between food water and energy security and the imperative for cross sectoral, collaborative decision making.

Differences between the M1 and main development scenarios revealed by the food security analysis are an indication of the main development scenario effects on fish and rice production and subsequent effects on food security. Daily food security/per capita needs for 100% of the population were kept constant across all development scenarios and the production surplus calculated as a measure of a countries capacity to meet predicted food shortfalls and increasing food security. The comparative aggregate reductions in surplus fish production after meeting food security across all corridor zones compared to the M1 baseline (year24) were summarized as reductions of:

M1-M2= -32%
M1-M3 = -43%

M1-M3CC = -40%

Aggregate fish surplus was estimated to be sufficient to provide essential protein and micronutrients for the corridor population, but were subject to substantial regional variation and distributional factors. Fish reductions were especially acute across all development scenarios in Lao PDR and Cambodia. Compared to the M1 baseline, the comparative aggregate increases in surplus rice production after meeting food security across all corridor zones were:

M1-M2= +6%
M1-M3 = +16%
M1-M3CC = +13%

Capacity to maintain food security, measured as food surpluses, declines in Lao PDR and Cambodia and remains relatively stable in Thailand and Viet Nam for the M2 and M3 development scenarios. The production of both rice and fish varies substantially across the 24-year projection horizon. The assessment revealed years where both low fish biomass and catch and rice production coincide, introducing the potential for acute food shortages in Cambodia and Lao PDR. **There is sufficient overall production and surplus in the Corridor to maintain 100% food security, but will require effective, willing distribution networks and cooperation of Member Countries to avoid significant increases in undernourishment.**

Increases in aquaculture production are likely to substitute protein deficiencies. Fish prices are likely to increase as fish catch declines, introducing an incentive to convert land to aquaculture. **Vigilance regarding the management of economic, social and environmental impacts of expanded aquaculture is recommended.** Current aquaculture production is capital and labour intensive and associated with widespread use of antibiotics, reductions in water quality and possibly water quantity due to the cumulative effect of dam impoundments.

Undernourishment as a measure of food security

The change in the level of household undernourishment was assessed according to the change in available rice production, which increases in M2 and M3, and fish production, which decreases. The number of undernourished people in Cambodia and Lao PDR increased in the M2 and M3 scenarios compared to the 2007 baseline, decreased in Thailand and remained relatively stable in the Viet Nam Delta. Reducing the level of hydropower development (the H1a sub-scenario) improved the levels of undernourishment in Cambodia, Lao PDR and the Viet Nam Delta. Undernourishment generally increased due to the effects of climate change. Analysis of wasting in children under 5 could not be conducted due to very constrained data. **Child morbidity is an important indicator of food status and poverty. A concerted effort to improve the collection and availability of reliable data for the corridor is recommended.**

Consideration of the irrigation and land use scenarios suggests the reduction in fish catch is the primary factor in the change in undernourishment levels. A reduction of 380 tonnes of fish was estimated to correspond with an additional 1000 households defined as undernourished. An increase of 1250 tonnes of rice reduces the number of undernourished households by 1000.

Poverty

Poverty levels were measured as the proportion of people below national lines poverty lines. The changes in poverty levels across scenario comparison were not uniformly distributed both geographically and across the development scenario. The M1 scenario corresponds to the lowest levels of poverty for all zones except 3C Thailand, 5B Cambodia and 6B Viet Nam. Poverty decreased in Lao PDR and Thailand, increased in Cambodia and remained relatively stable in the Viet Nam Delta. The latter are characterized by less than 0.2% difference across the scenarios. The highest levels of poverty were observed in the comparison of the M1 and M3 and M3CC scenarios, where poverty

increases for Lao PDR were estimated at 1.7-3.7%. The increases in Cambodia ranged from -0.01% to 2.0%. Changes in Thailand and Viet Nam were estimated at less than 1%. The M3CC scenario corresponds to the lowest level of poverty for the 4A Cambodia zone.

Water security

Droughts and floods

The 1995-96 El Niño and 2000-2001 floods correspond to 2015-2017 and 2022-2024 of the projection horizon of the Council Study. The number of total people affected in a severe drought year ranged from M1: 700,527; M2: 745,593 and M3: 5387,288. The increase in the M2 scenario reflects the increase in some rainfed production and subsequent increase in the number of people with rice based livelihoods. The population estimated to be affected by the drought represents M1: 3.4%, M2: 3.3% and M3: 2.6% of the total corridor population corresponding with 2000 and 2003.

Rice production of a year in the CS projection horizon that corresponds with the 2000-2001 floods was compared with a non-flood year based. The total number of people affected in the corridor with rice based livelihoods was estimated at 1,137,264 in the M1 development scenario, M2: 1,232,452 and M3: 818,887. The affected population represents M1: 4.8%, M2: 5.23% and M3: 3.5% of the total corridor population corresponding with 2000 and 2003.

The effects of flooding were not uniformly distributed across the corridor zones. The majority of affected people with rice based livelihoods were located in the Kratie to the Viet Nam Border (634,412 people) and the Tonle Sap River (419,376 people). Compared to the 2001 flood year, rice based livelihoods increased in the non-flood year by 50% and 105% in the Katie and Toney Sap River zones respectively.

The social and economic assessment of the 1995-96 drought and 2000-2001 flood estimated a 10-11% decrease in rice production due to flood corresponds to 4.5-5% of the corridor population being affected; and an 11% decrease in rice production due to drought corresponds to 3.1-3.3% % affected.

A drought similar in severity to the 1995-96 or 2015 El Nino or the 2000 flood coinciding with years of significant additional fish declines introduces the prospect of acute food shortages and reduced food security throughout the corridor, particularly Cambodia. Generally, households are less well adapted to severe droughts compared to the natural flooding cycle including low to moderate floods. **Cross sectoral and transboundary planning with a focus on effective distribution systems will be necessary to avert the consequences of the fish-rice-drought coincidence.**

Access to potable water

Access to safe drinking water in rural communities has improved substantially in Lao PDR and Cambodia. Household access in Thailand and Viet Nam is close to 100%. Developing functional relationships between drinking water access and the attributes of the development scenarios is constrained by a deficit of time series data specific to the corridor. The national trends of improved rural water access to safe drinking water were assumed to continue and be independent of the development scenarios. However, MRC corridor surveys conducted in 2014 indicate the quality of water supply varies widely across the LMB.

River water used for drinking water is most frequent in Cambodia and Lao PDR. In terms of inputs to MRC activities, the finding that river water is extensively used for drinking water points to the importance of water quality monitoring. **Recommendations from SIMVA (2015) include developing an inventory of drinking water extraction sites from the Mekong** would be a worthwhile exercise that could more precisely identify critical spots where potable water quality is most important. The Domestic and Industrial Water Theme recommends **vigilance in water quality monitoring, especially TSS, as urbanization and industrial use and untreated sewage discharge increases**.

Energy security

Electricity as part of the rural energy mix is one of the most important factors for economic growth and human development. Energy access as a means for productive use is of key importance for rural communities to improve livelihoods and for the opportunities it creates. There are also strong linkages between rural poverty and electrification rates. The indicators for CS Energy Security are the proportion of the rural population with access to electricity and rural electricity pricing. Electricity fees are charged as block tariffs in Lao PDR from 4c-12c/kWh. Tariffs in Cambodia are currently 9c-17c/kWh. As of 2014-2025 rural electrification in Thailand was 100%, 98.9% in Viet Nam, Thailand 58% in Cambodia (possibly as high as 68% EDC pers. comm.) and 68.1 % in Lao PDR. Available data are generally at national and provincial level and not specific to the corridor zones however.

As Thailand and Viet Nam are at or close to 100% of electricity access, the social and economy assessment focused on the corridor zones in Cambodia and Lao PDR. Both the Lao PDR Government and the Royal Government of Cambodia have planned rural electrification of 90% by 2030 and comprised of grid and off-grid (renewable) supply. Mini-hydro, solar and biofuels are identified as part of the energy mix for rural communities in both Lao PDR and Cambodia. The mix of renewable and grid electrification, ongoing institutional support coupled with increasing national trends from 2000 to 2015 are likely to be far more influential in the determining the level of rural electrification than the investments proposed for the CS development scenarios. The rates of rural electrification are likely to continue independently of the CS development scenarios.

Employment

The M1 comparison across the 24-year time horizon indicates, that at current levels of agricultural productivity, there are substantial increases in the secondary, tertiary and navigation sectors and relatively modest increases in the primary sector across the majority of corridor zones. That is, projected increases in the working population over the 24-year project time horizon are sufficient to meet potential labour demands associated with expanding secondary, tertiary and navigation sectors.

The assessment of sector employment across the development scenarios indicates a potential shortfall in meeting the labour demands required for planned agricultural expansion and increases in the secondary and tertiary sectors in the M2 and M3 development scenarios. Viet Nam is less affected as there is no agricultural expansion planned in the development scenarios.

Resolution within the constraints of the CS, requires either i) agricultural productivity to increase in the order of 30-35% in Lao PDR and Cambodia, ii) reducing the level of either agricultural expansion, industry or both, or iii) increased reliance on migrant labour. Corridor surveys indicate 5-15% of the corridor population are working away from their home village, although migration was a less preferred alternative livelihood adaptations. This a complex issue involving the assessment of multiple interacting factors, including changes in wages, labour conditions, cultural norms, institutional settings and migration patterns. These apply to conditions within and outside the corridor zones.

National economic planning for the four member countries focuses on jointly expanding the agricultural, manufacturing and service sectors of their respective national economies. These are capital and labour intensive. The joint agricultural and secondary sector expansionary strategies potentially introduce conflicting labour demands in the M2 and M3 scenarios introducing the potential of stranded and underutilized infrastructure. Developing a dynamic modelling approach capable of the joint inclusion of these factors, including migration patterns, is recommended as a central feature of trans-boundary planning.

9 Annex A: Results

9.1 Undernourishment coefficients

Table 51 Coefficients and estimations of corridor undernourishment by scenarios

Year 24		HH members	5.38		5.94		3.89		4.35		4.78		4.62		4.88		4.98		5.02		4.880		5.070		4.810		4.460	
		Population	662897		1317295		97729		98177		754420		97089		116194		9143		5455404		1849580.000		1257181.000		9741103.000		3896441.000	
		Zone 2- Mainstream - Lao			Zone 3 A - Lao - Mainstream		Zone 2 B-Upper Thailand		Zone 2 C-Lower Thailand		Zone 3 B Thailand- Mainstream		Zone 3 C Thailand- Songkhram		Zone 4 A Cambodia- Khone Falls to Kratie		Zone 4 B Cambodia-3S		Zone 4 C Cambodia Kratie to Viet Nam border		Zone 5 A Cambodia- Tonle Sap river		Zone 5 B Cambodia Tonle Sap lake		Zone 6 A VietNam Delta - freshwater		Zone 6 B VietNam Delta - saline	
Rice	Coefficients	0.380	R2=0.857			0.242	R2=0.539								0.230	R2=0.619									0.337			
		-0.0000000128	F=21.993			-0.0000000024	F=5.095								-0.0000000004810	F=6.679									-0.00000000507			
		-0.000001170	VIF=5.681			-0.0000003030									-0.00000009270	VIF=2.512												
ratio national/zone production		29.17	% undernourished	5.52	% undernourished	500.694	% undernourished	849.56	% undernourished	71.54	% undernourished	350.41	% undernourished	1493.58	% undernourished	7752	% undernourished	5.46	% undernourished	15.7	% undernourished	5	% undernourished	9	% undernourished	30	% undernourished
M1		89815	23.0%	452081	22.5%	68617	9%	37834	9%	398515	10%	92435	9%	8197	18%	721	18%	1103046	19%	150082	18%	1307487	18%	3742498	16%	1032967	18%
M2		103124	27.6%	635493	26.0%	75584	11%	63030	8%	547224	11%	89554	12%	9899	18%	723	19%	1244448	19%	193692	19%	1350086	19%	3690093	16%	1032874	18%
M3		139791	29.1%	993786	25.2%	84725	11%	74088	7%	617274	11%	88157	14%	7633	20%	775	20%	1725381	19%	222752	20%	1358374	19%	3574789	17%	1031259	18%
CC		140622	29.4%	965975	26.1%	78465	12%	71588	8%	587562	12%	80462	15%	4820	20%	367	20%	1987728	18%	293066	19%	1538957	19%	3730068	16%	1160859	16%
C2		139445	29.4%	939578	26.2%	78196	12%	70496	8%	566859	12%	82154	15%	4399	20%	394	20%	1529763	19%	205708	19%	1280325	19%	3109606	19%	1019023	18%
C3		133424	30.1%	956899	26.8%	76894	12%	71196	8%	581777	12%	73172	16%	4884	20%	268	20%	1529763	19%	205708	20%	1280325	21%	3109606	19%	1019023	18%
A1		89265	31.1%	463482	29.3%	68605	13%	37138	15%	423266	14%	92435	14%	7598	20%	727	20%	1130288	19%	147455	19%	1280325	19%	3191251	19%	1019023	18%
A2		140839	29.4%	995980	25.7%	84765	11%	74094	8%	614872	11%	88157	14%	7851	20%	775	20%	1529763	19%	205708	19%	1280325	19%	3109606	19%	1019023	18%
I1		139328	29.3%	995459	25.7%	84763	11%	74093	7%	615331	11%	88157	14%	7038	20%	775	20%	1529763	18%	205708	19%	1280325	19%	3109606	19%	1019023	18%
I2		140840	29.4%	995976	25.7%	84765	11%	74094	8%	614863	11%	88157	14%	7851	20%	775	20%	1529763	19%	205708	19%	1280325	19%	3109606	19%	1019023	18%
F1		140622	29.4%	965975	26.0%	78465	12%	71588	8%	587562	12%	80462	15%	4820	20%	367	20%	1739489	18%	265014	19%	1453536	19%	3286633	18%	1144465	16%
F2		140622	29.4%	965975	26.1%	78465	12%	71588	8%	587562	12%	80462	15%	4820	20%	367	20%	1777822	18%	259956	19%	1420956	19%	3298419	18%	1131683	16%
F3		140622	29.4%	965975	26.1%	78465	12%	71588	8%	587562	12%	80462	15%	4820	20%	367	20%	1717258	18%	252771	19%	1419991	19%	3262908	18%	1143437	16%
H1a		140974	22.1%	962447	20.2%	78551	8%	71622	3%	574589	8%	80462	11%	3931	18%	366	18%	1777822	18%	259956	18%	1420956	18%	3298419	18%	1131683	16%
H1b		141087	24.1%	1009993	22.9%	78436	9%	72971	4%	587920	10%	80462	13%	6424	18%	367	19%	1756628	19%	262263	18%	1453088	18%	3110537	19%	1125965	16%
H3		140383	0.292	965382	25.9%	78555	12%	71564	8%	586829	12%	80588	15%	3035	20%	364	20%	1761064	18%	259866	19%	1437631	19%	3496819	17%	1127335	16%

9.2 Scenario fish and Rice production ('000 tonnes)

Table 52 Total fish production (tonnes) by development scenario across corridor zones

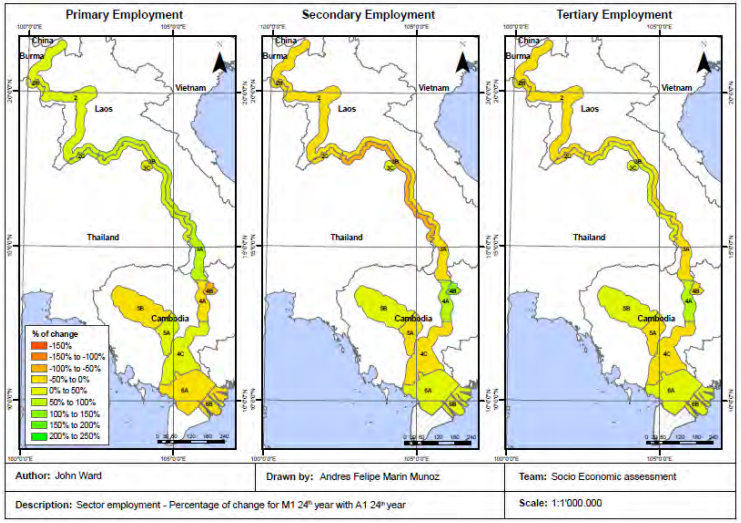
Scenario	Zone 2- - Lao PDR	Zone 3 A – Lao PDR	Zone 2 B- Thailand	Zone 2 C- Thailand	Zone 3 B Thailand-	Zone 3 C Thailand	Zone 4 A Cambodia-	Zone 4 B Cambodia-	Zone 4 C Cambodia	Zone 5 A Cambodia-	Zone 5 B Cambodia	Zone 6 A Viet Nam	Zone 6 B Viet Nam
M1	40768	117590	11365	13569	125170	24545	21292	4830	139105	184900	182441	1219263	529594
M2	22803	71433	8448	8561	80115	14968	18256	4123	119493	155796	156884	1169864	477589
M3	12993	54992	6778	5827	64066	11557	13295	2967	139889	118286	141075	1109790	414347
CC	11726	48406	6563	5474	57638	10191	13295	2967	141867	129548	125416	1168670	476332
C2	11964	49281	6888	5540	58491	10372	13378	2987	140727	124361	137151	1177599	485732
C3	10140	42532	6448	5032	51904	8972	13051	2910	134575	106839	83782	1145180	451603
A1	12444	51698	6560	5674	60851	10874	13351	2980	143197	131287	127169	1164799	472257
A2	11577	49991	6572	5432	59184	10520	13192	2943	142580	127382	139344	1161371	468648
I1	12225	50152	6573	5613	59341	10553	13498	3015	149782	125196	148011	1166304	473841
I2	11729	50080	6571	5474	59272	10538	13252	2957	142593	123382	146213	1164239	471668
F1	11780	49203	6563	5489	58416	10356	13269	2961	142845	144473	142316	1164873	472335
F2	11727	48406	6563	5474	57638	10191	13269	2961	142597	119798	157301	1139948	446095
F3	11727	48266	6563	5474	57501	10162	13268	2961	142612	136823	160886	1154328	461233
H1a	37201	104853	10868	12575	112736	21902	21077	4780	157761	193882	197934	1238845	550209
H1b	30004	76462	10068	10569	85023	16012	18663	4218	138062	168670	166151	1218765	529070
H3	12582	50857	6552	5712	60030	10700	13491	3013	144152	137271	154201	1168599	476258

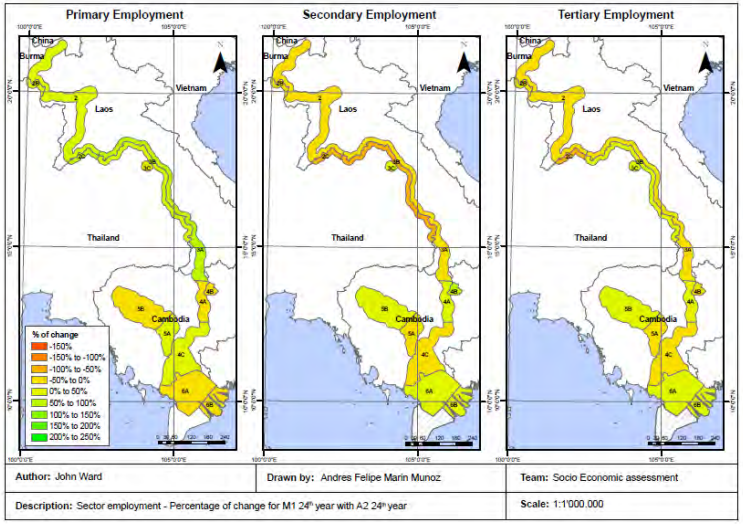
Table 53 Total rice production (tonnes) by development scenario across corridor zones

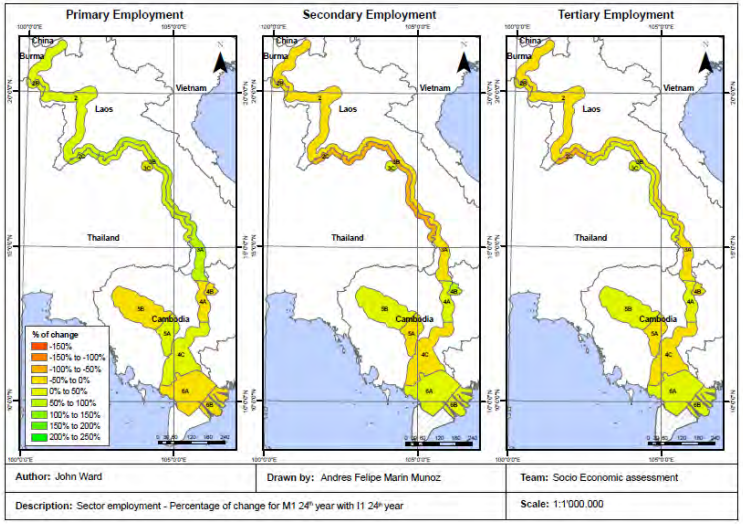
Scenario	Zone 2- - Lao PDR	Zone 3 A – Lao PDR	Zone 2 B- Thailand	Zone 2 C- Thailand	Zone 3 B Thailand-	Zone 3 C Thailand	Zone 4 A Cambodia-	Zone 4 B Cambodia-	Zone 4 C Cambodia	Zone 5 A Cambodia-	Zone 5 B Cambodia	Zone 6 A Viet Nam	Zone 6 B Viet Nam
M1	89815	452081	68617	37834	398515	92435	8197	721	1103046	150082	1307487	3742498	1032967
M2	103124	635493	75584	63030	547224	89554	9899	723	1244448	193692	1350086	3690093	1032874
M3	139791	993786	84725	74088	617274	88157	7633	775	1725381	222752	1358374	3574789	1031259
CC	140622	965975	78465	71588	587562	80462	4820	367	1987728	293066	1538957	3730068	1160859
C2	139445	939578	78196	70496	566859	82154	4399	394	1529763	205708	1280325	3109606	1019023
C3	133424	956899	76894	71196	581777	73172	4884	268	1529763	205708	1280325	3109606	1019023
A1	89265	463482	68605	37138	423266	92435	7598	727	1130288	147455	1280325	3191251	1019023
A2	140839	995980	84765	74094	614872	88157	7851	775	1529763	205708	1280325	3109606	1019023
I1	139328	995459	84763	74093	615331	88157	7038	775	1529763	205708	1280325	3109606	1019023
I2	140840	995976	84765	74094	614863	88157	7851	775	1529763	205708	1280325	3109606	1019023
F1	140622	965975	78465	71588	587562	80462	4820	367	1739489	265014	1453536	3286633	1144465
F2	140622	965975	78465	71588	587562	80462	4820	367	1777822	259956	1420956	3298419	1131683
F3	140622	965975	78465	71588	587562	80462	4820	367	1717258	252771	1419991	3262908	1143437
H1a	140974	962447	78551	71622	574589	80462	3931	366	1777822	259956	1420956	3298419	1131683
H1b	141087	1009993	78436	72971	587920	80462	6424	367	1756628	262263	1453088	3110537	1125965
H3	140383	965382	78555	71564	586829	80588	3035	364	1761064	259866	1437631	3496819	1127335

9.3 Spatial representation of sector employment (CS development sub-scenarios)

Figure 63 Sector employment by corridor zone: A1-I2 sub-scenarios (% change from M1 year24)







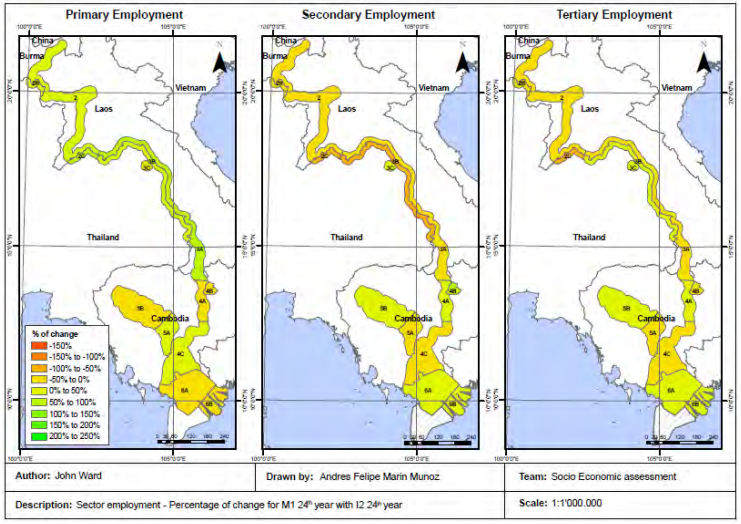
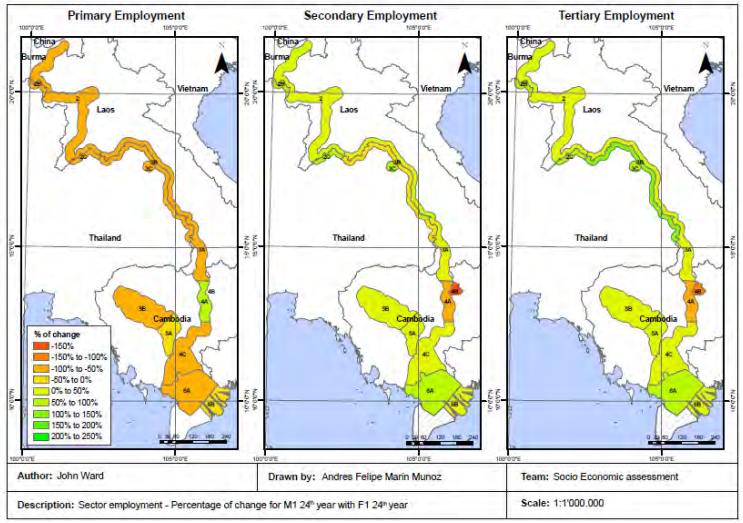
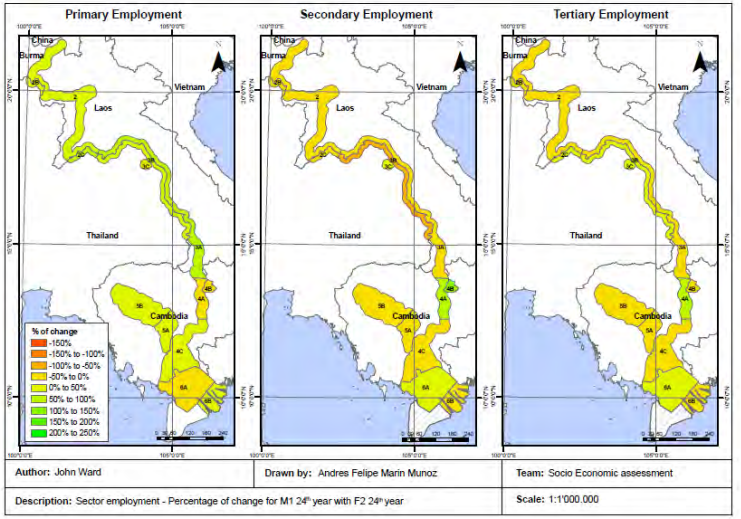
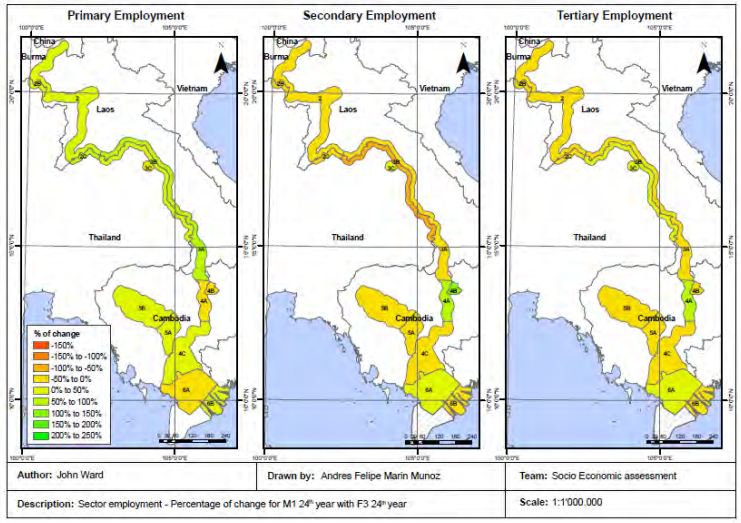


Figure 64 Sector employment by corridor zone: F1-H1a sub-scenarios (% change from M1 year24)







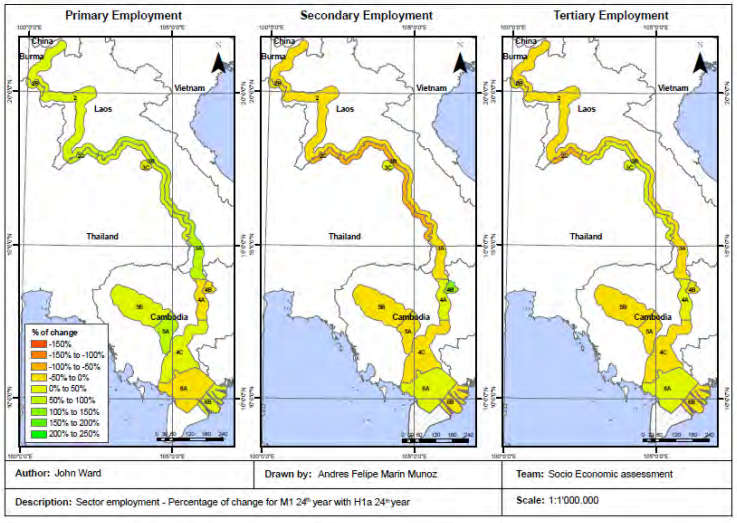
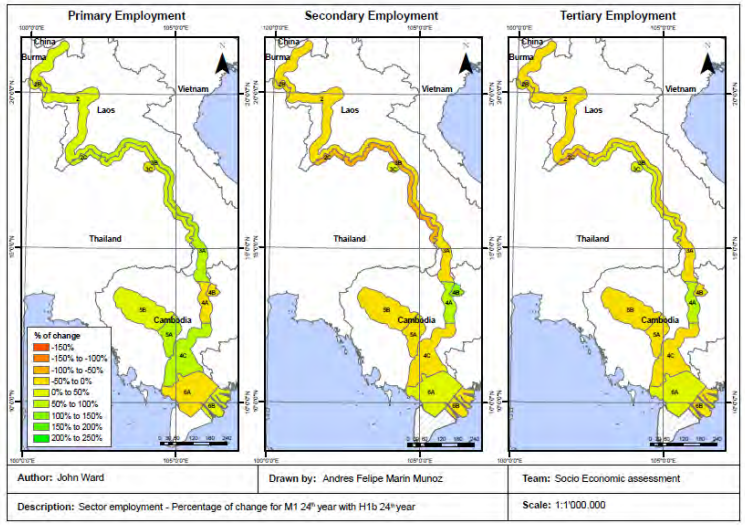
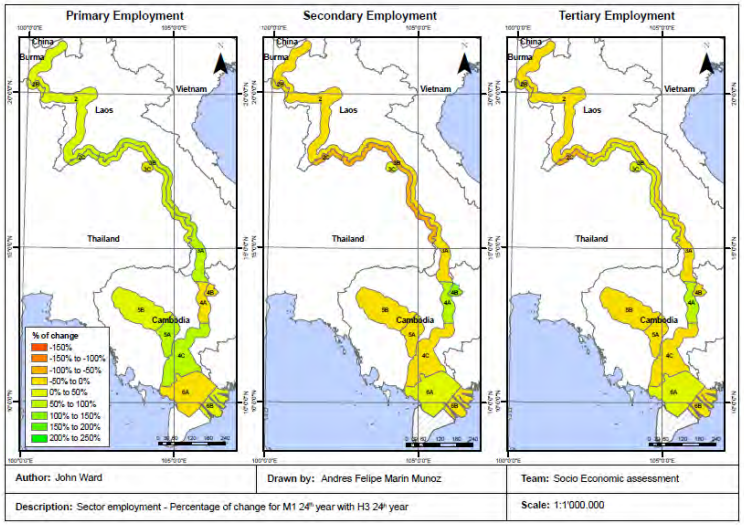
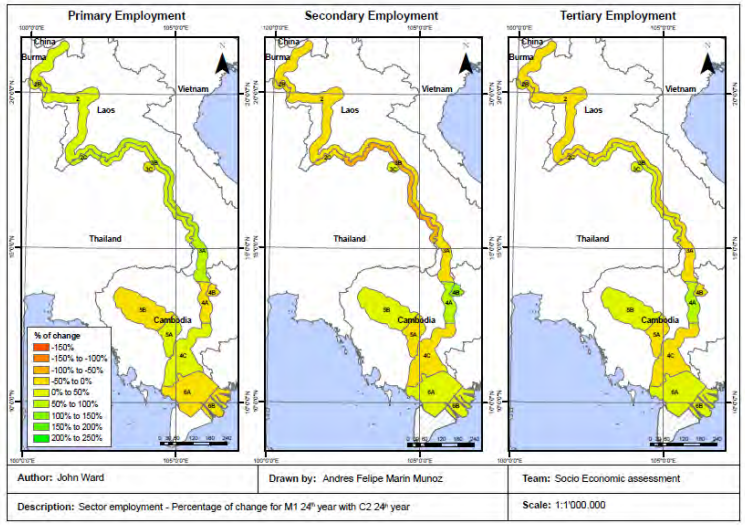
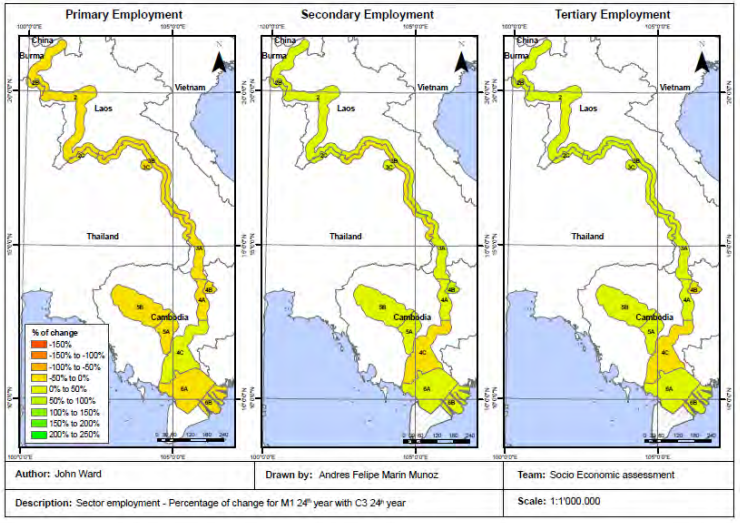


Figure 65 Sector employment by corridor zone: H1b-C3 sub-scenarios (% change from M1 year24)



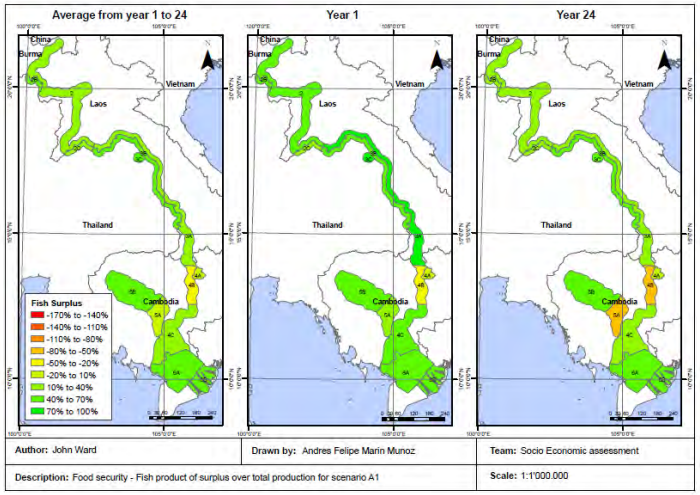


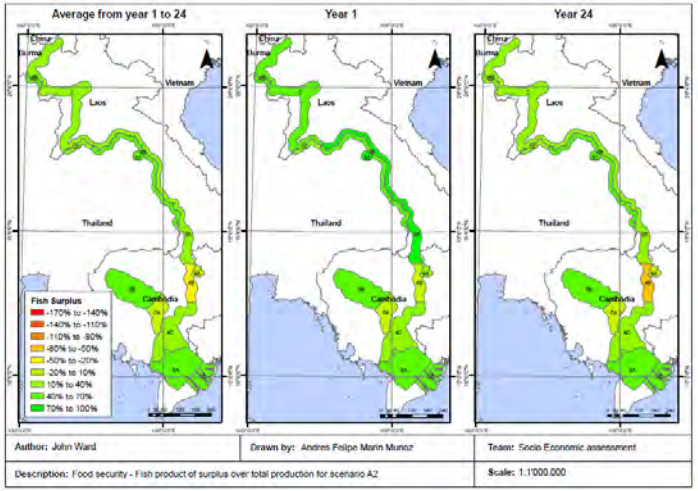


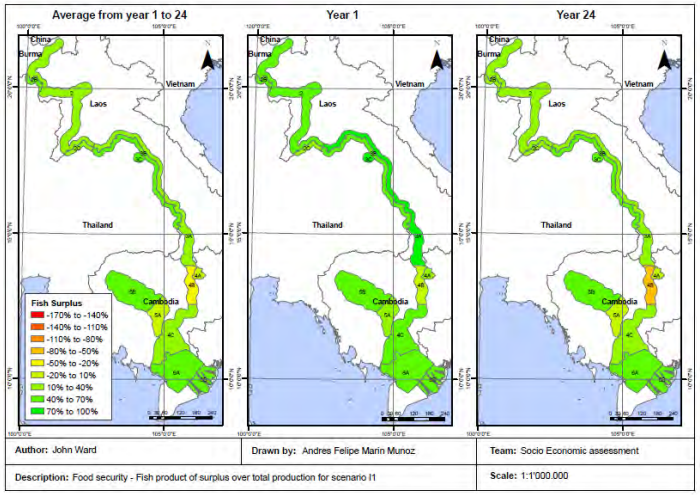


9.4 Spatial representation of fish and rice production (% surplus to meeting food security needs)

Figure 66 Fish surplus to food security needs: A1-I2 sub-scenarios (% surplus compared to total production)







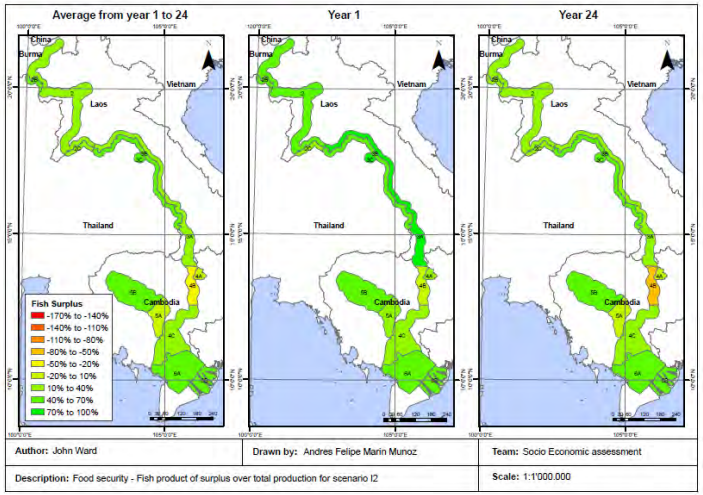
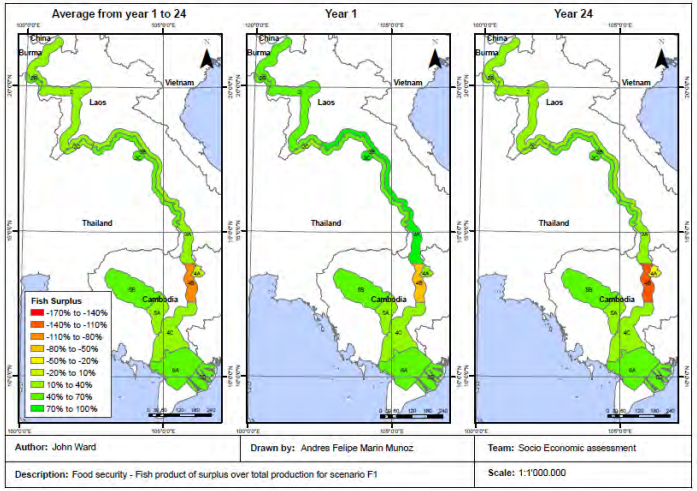
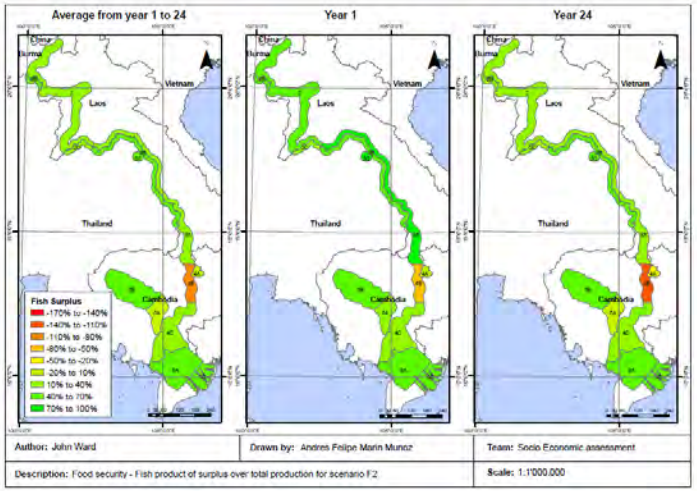
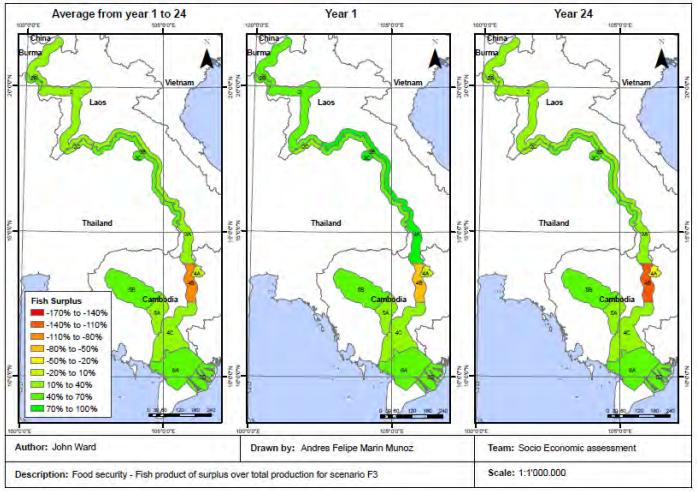


Figure 67 Fish surplus to food security needs: F1-H1a sub-scenarios (% surplus compared to total production)







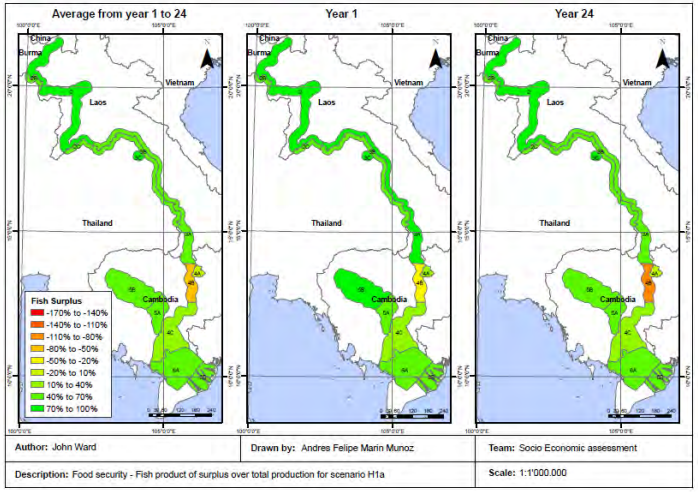
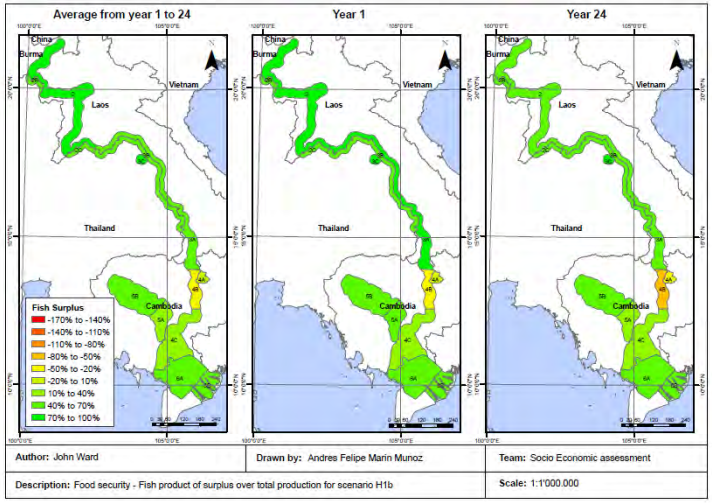
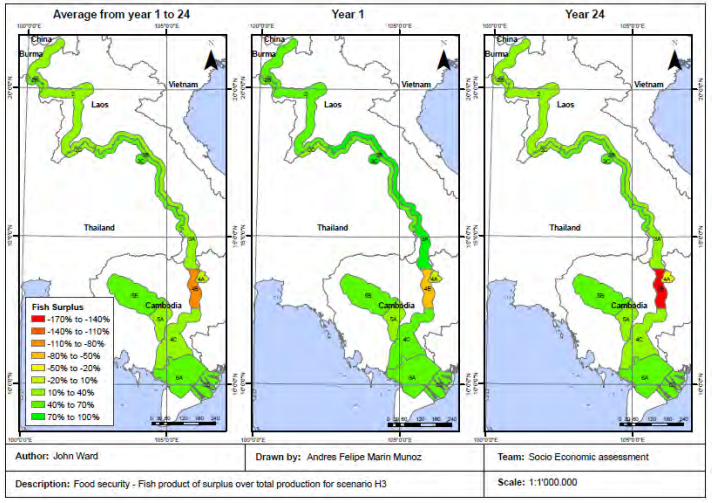
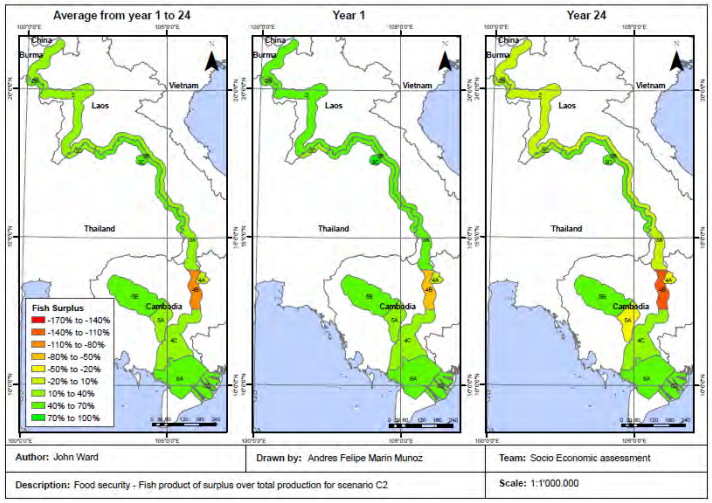


Figure 68 Fish surplus to food security needs: H1b—C3 sub-scenarios (% surplus compared to total production)







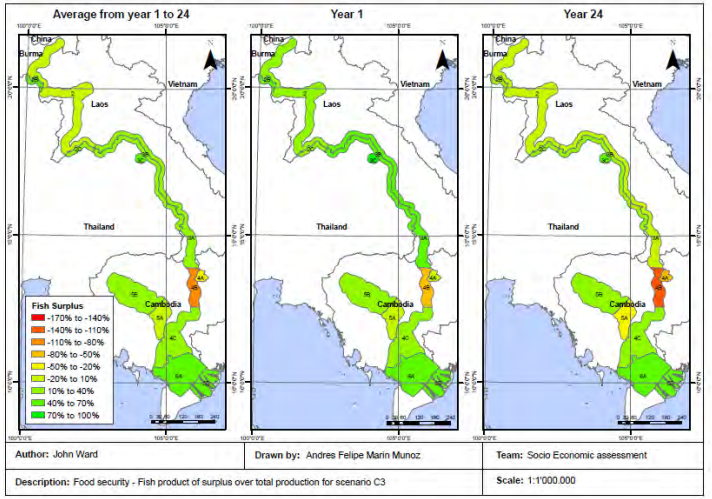
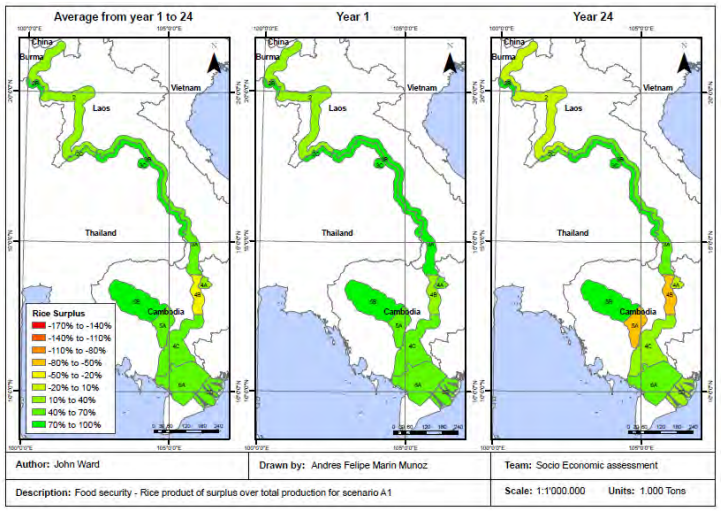
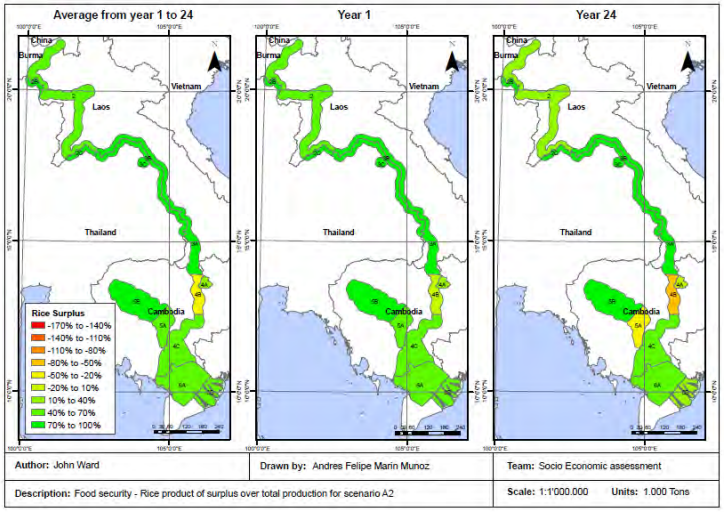
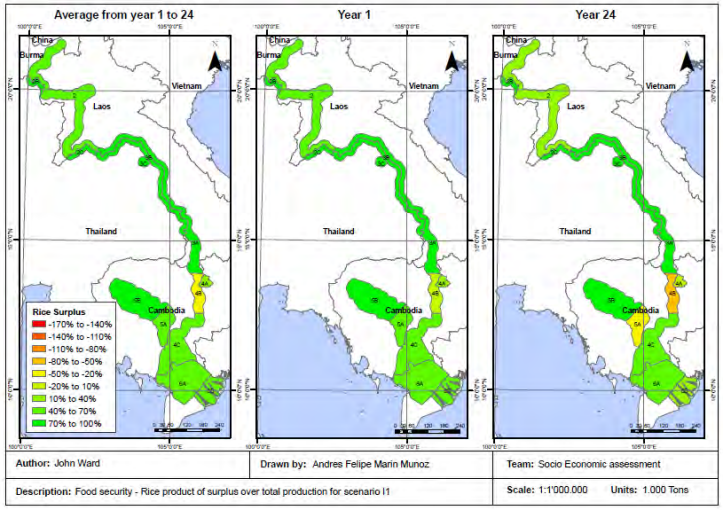


Figure 69 Rice surplus to food security needs: A1-I2 sub-scenarios (% surplus compared to total production)







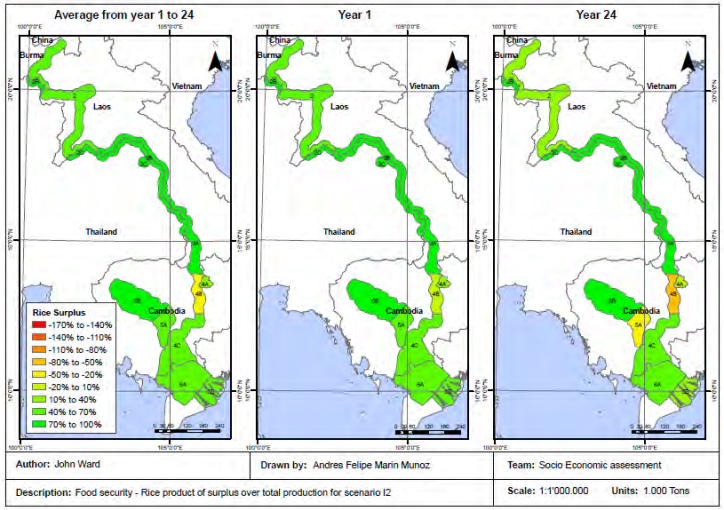
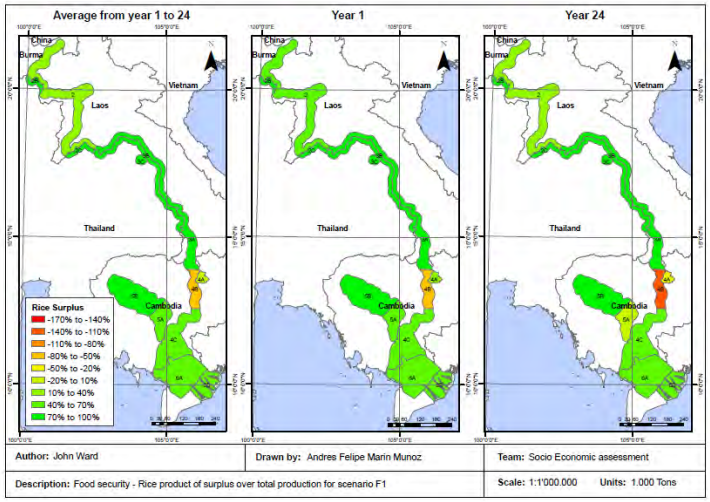
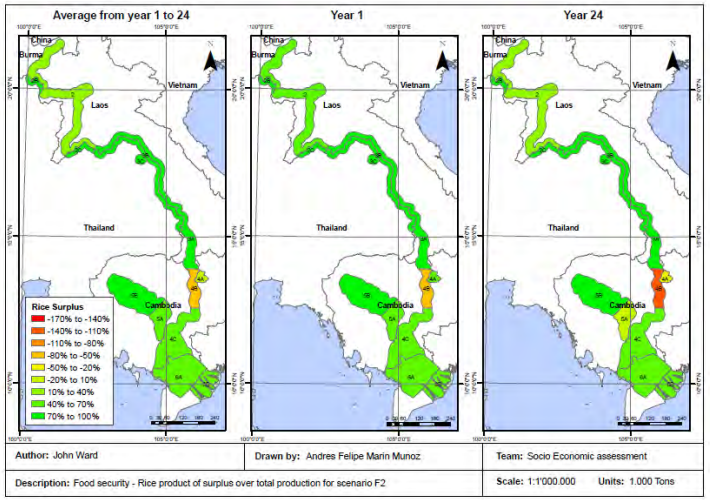
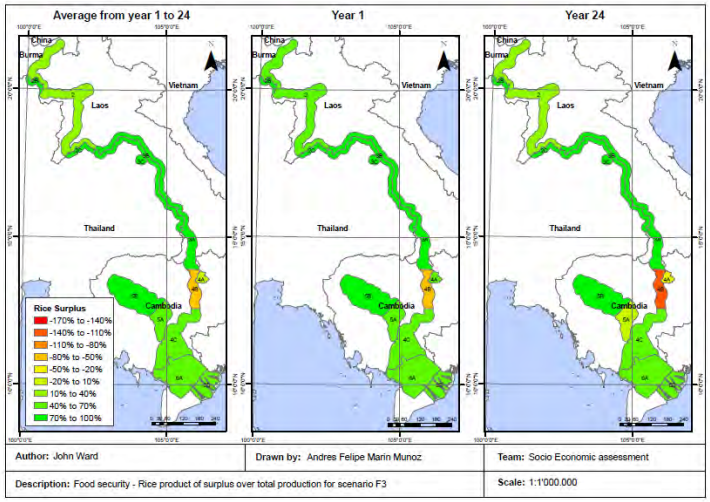


Figure 70 Rice surplus to food security needs: F1-H1a sub-scenarios (% surplus compared to total production)







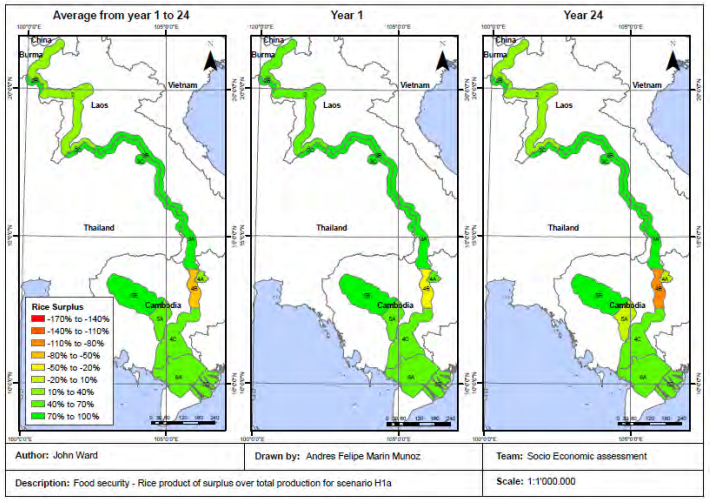
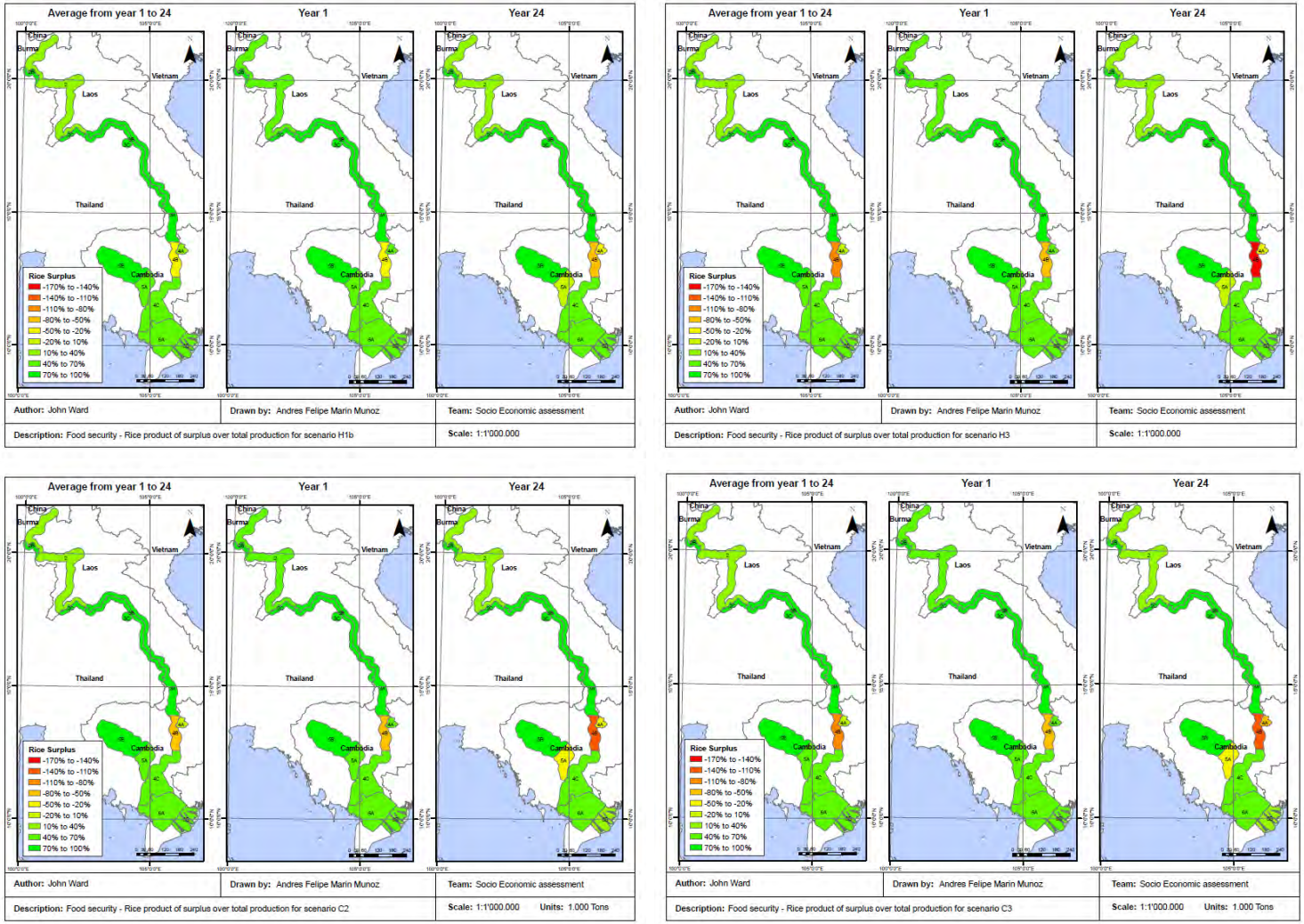
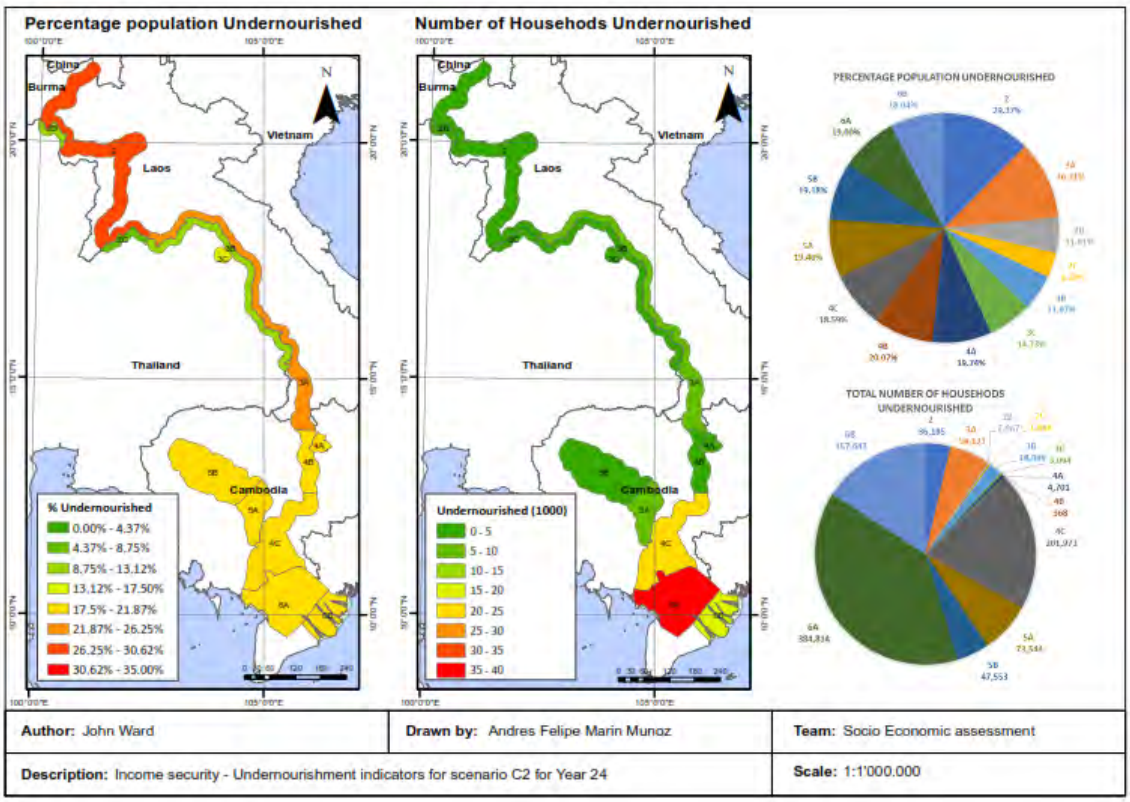


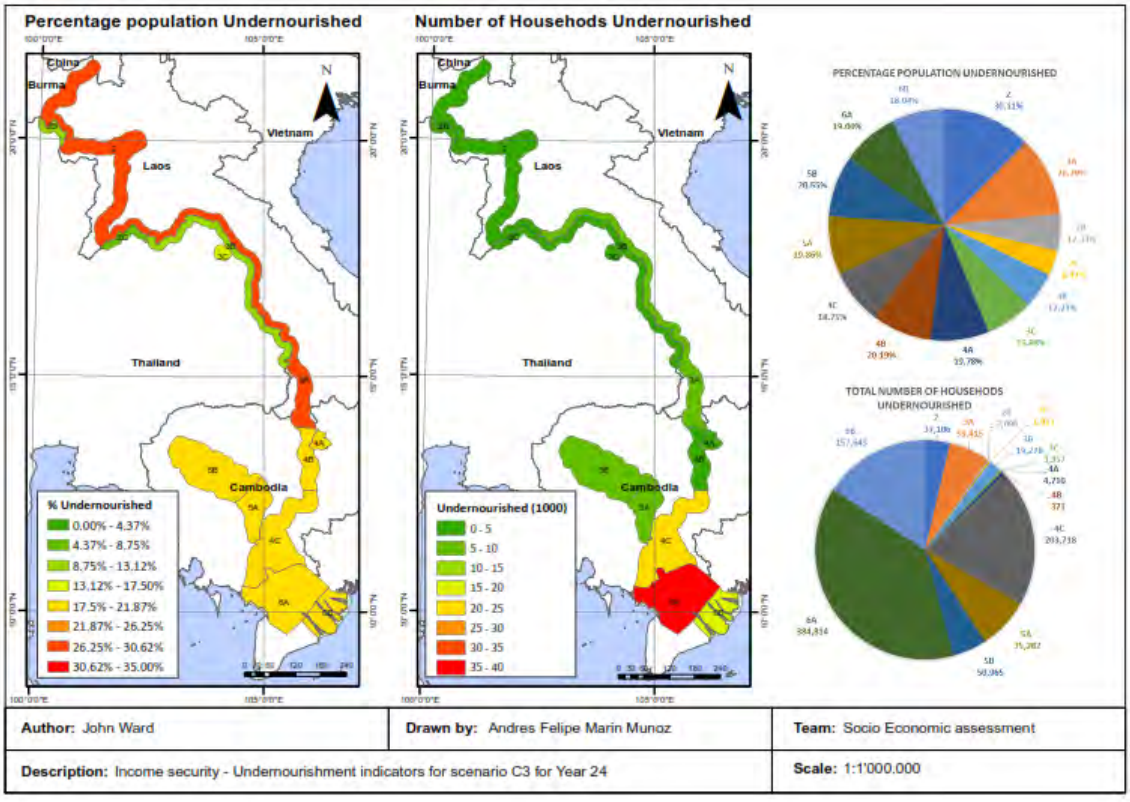
Figure 71 Rice surplus to food security needs: H1b-C3 sub-scenarios (% surplus compared to total production)

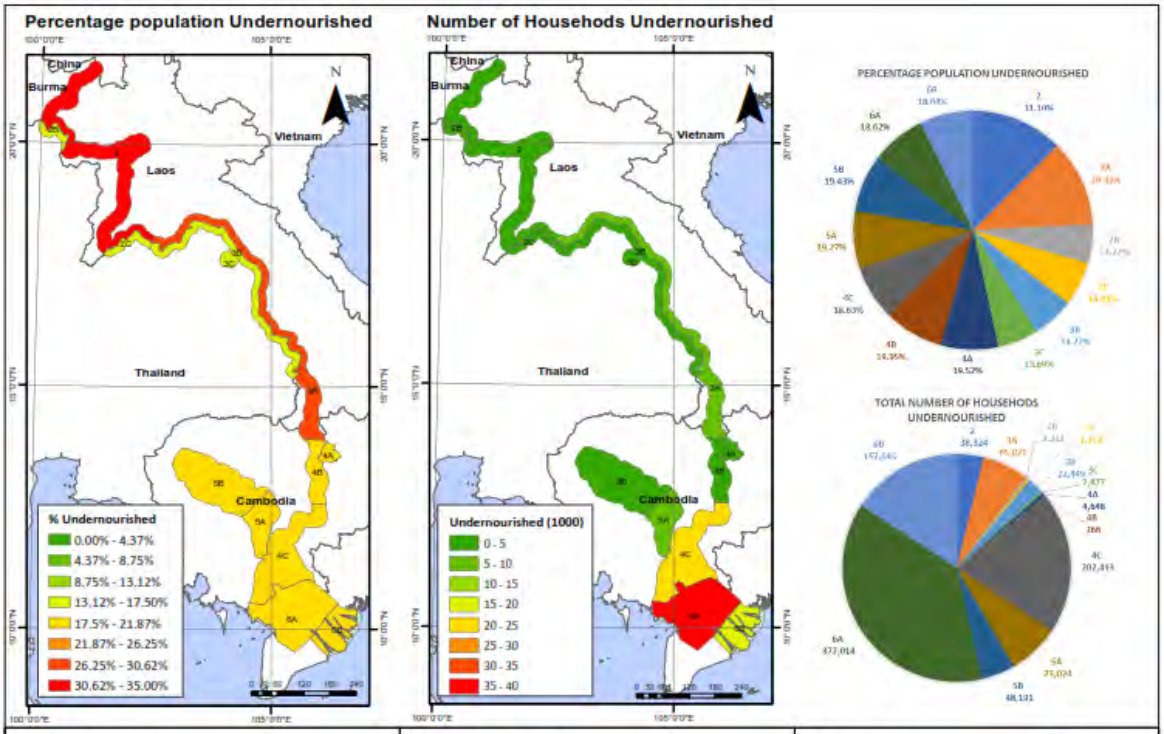


9.5 Spatial representation of undernourished households (CS sub-scenarios)

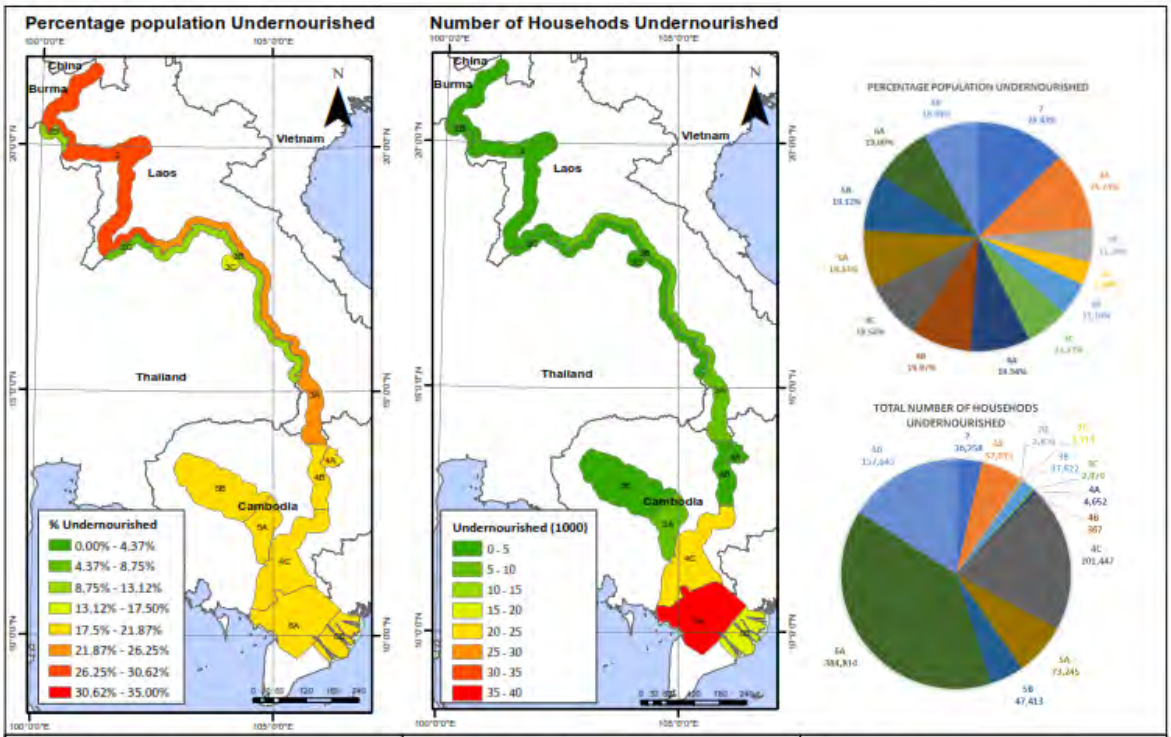
Figure 72 Maps of % and number of undernourished households by CS development sub-scenarios



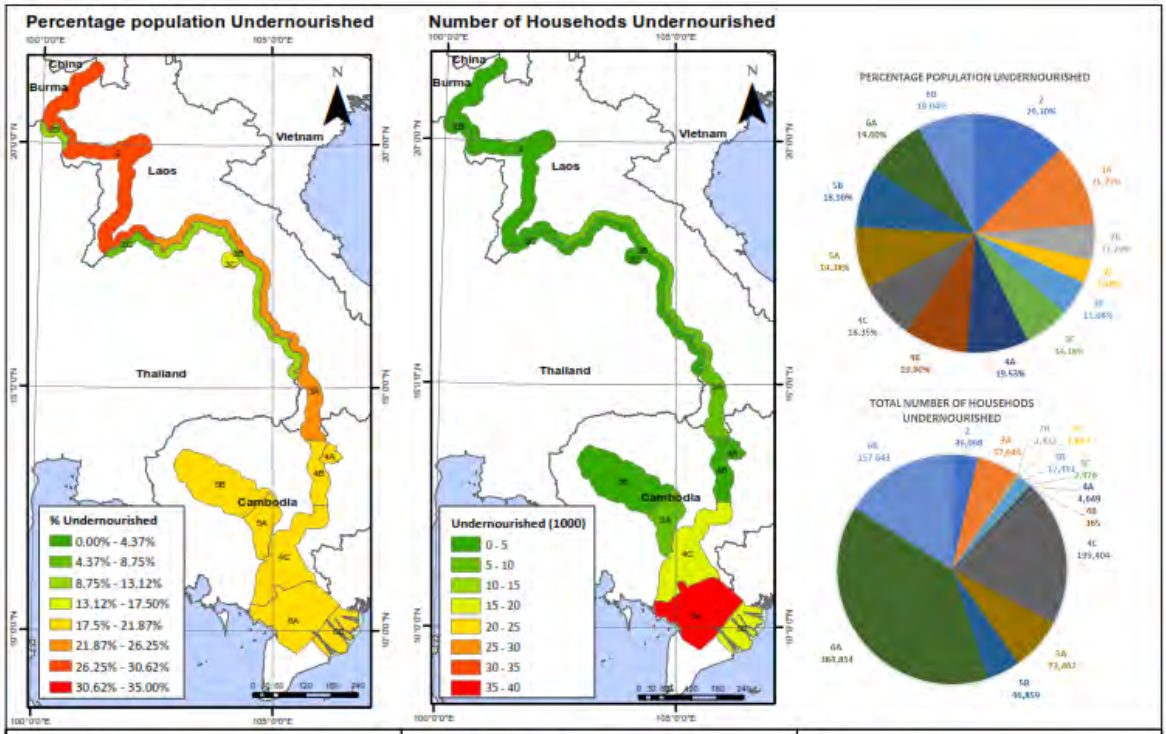




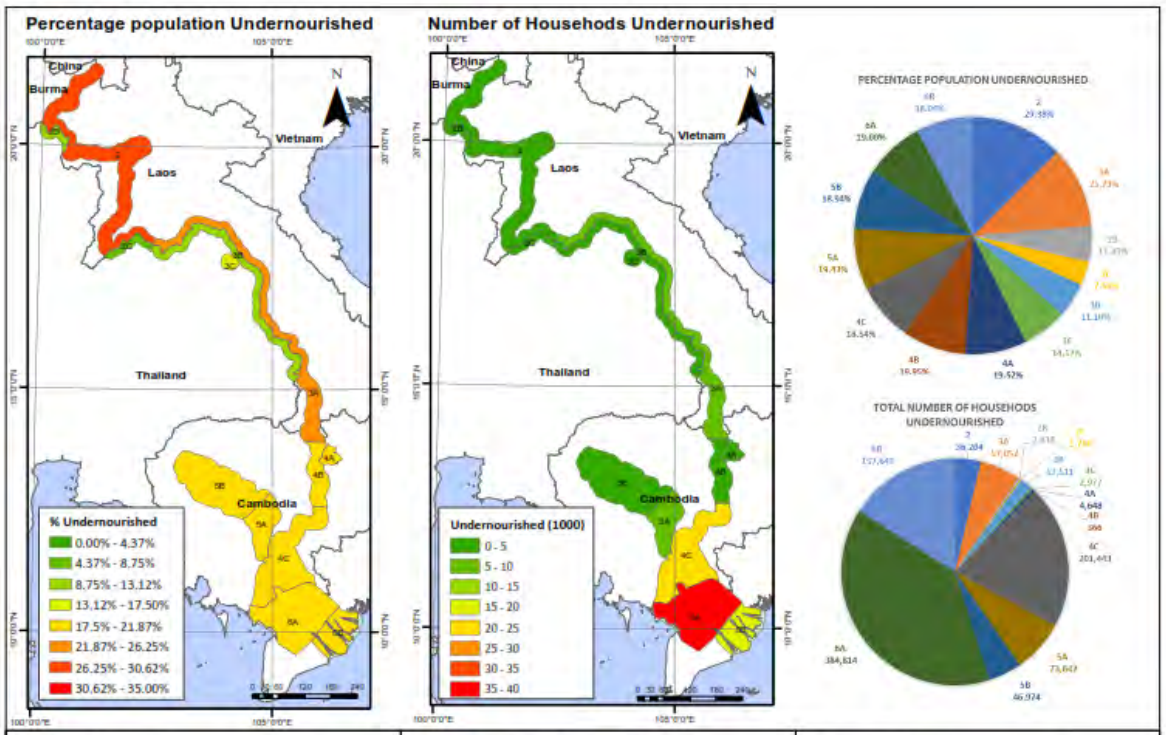
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario A1 for Year 24		**Scale:** 1:1'000.000



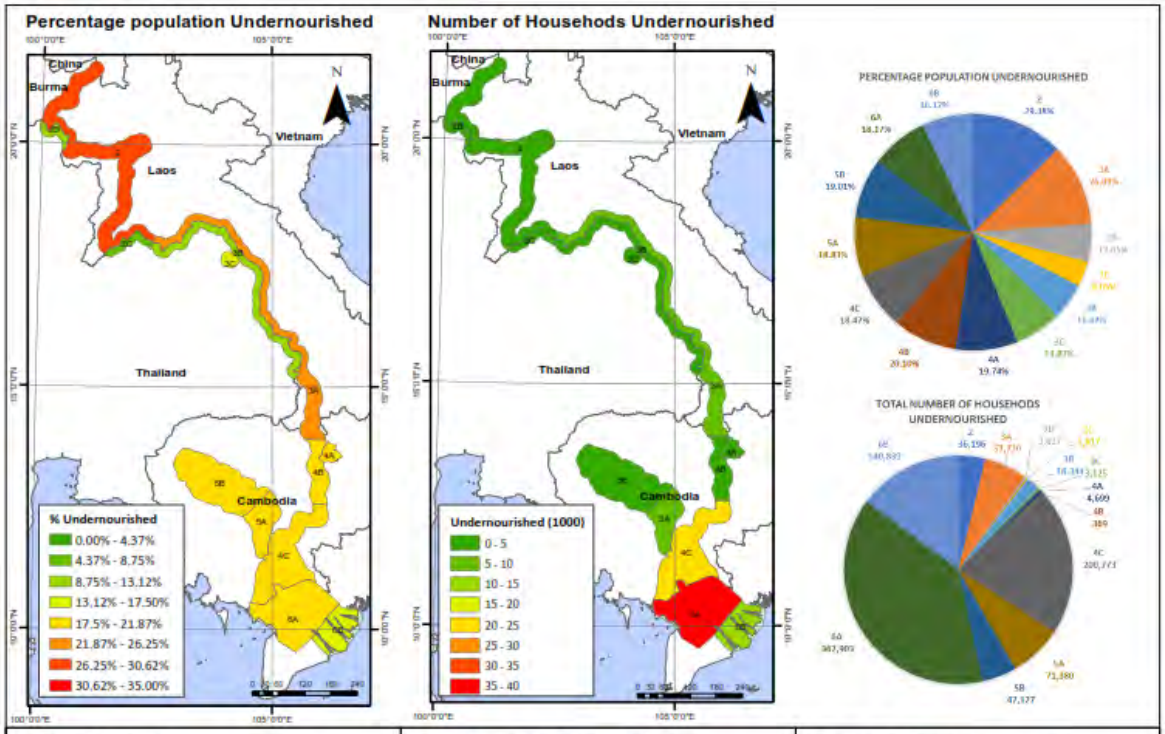
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario A2 for Year 24		**Scale:** 1:1'000.000



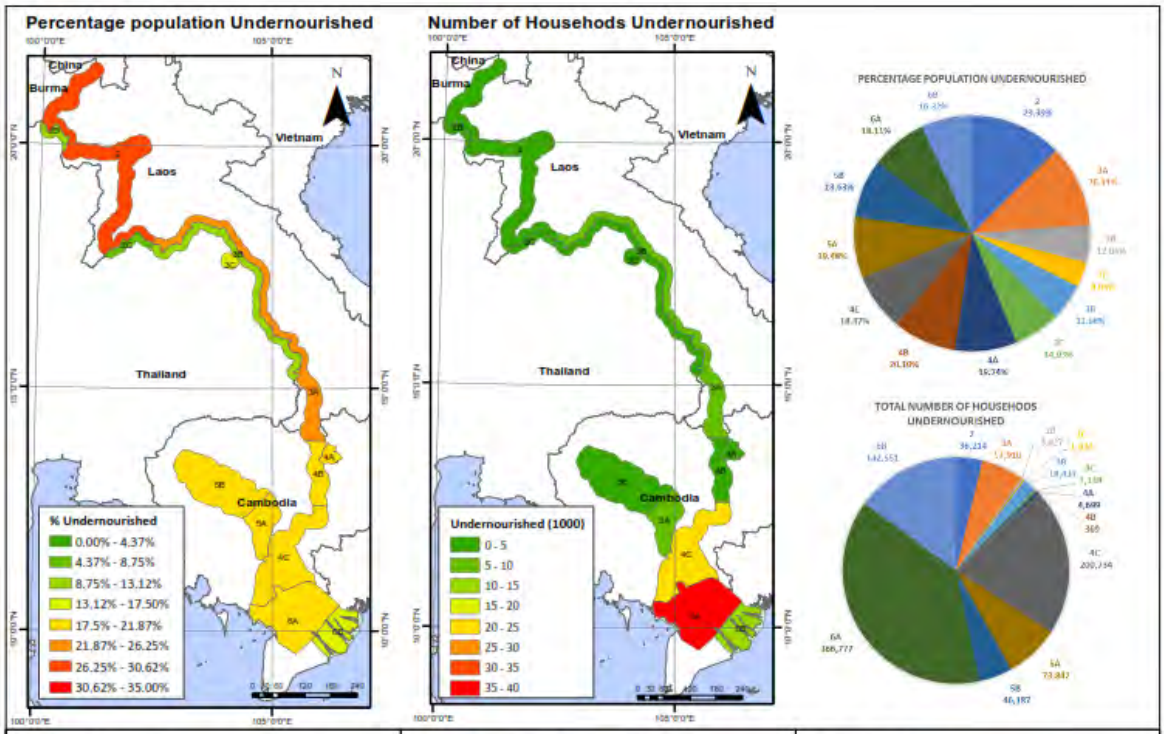
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario I1 for Year 24		**Scale:** 1:1'000.000



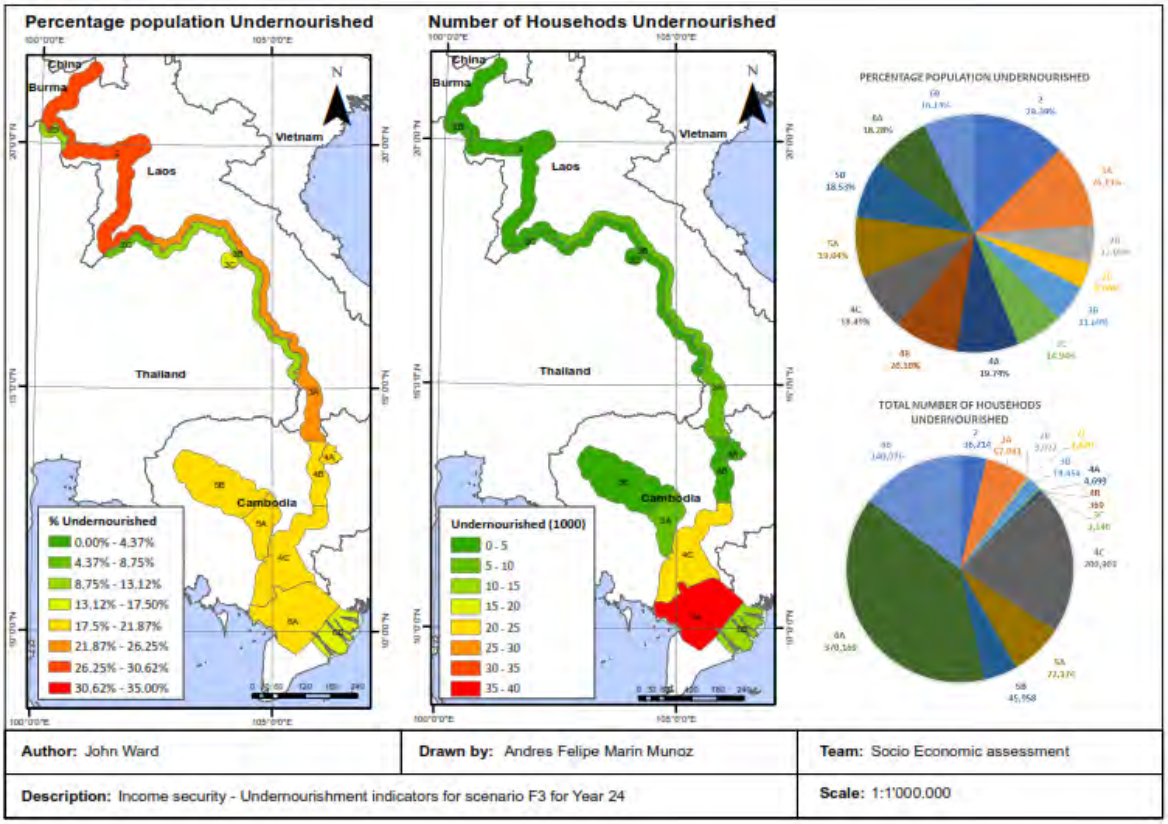
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario I2 for Year 24		**Scale:** 1:1'000.000



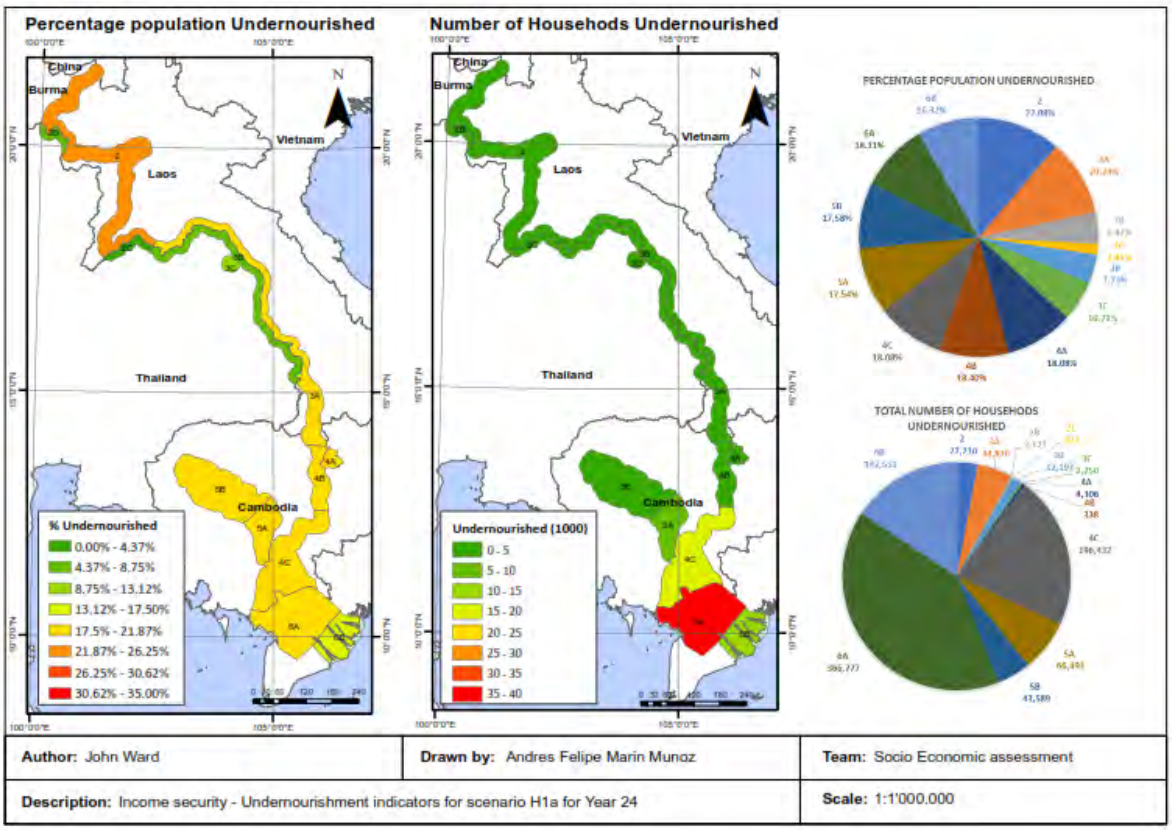
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario F1 for Year 24		**Scale:** 1:1'000.000



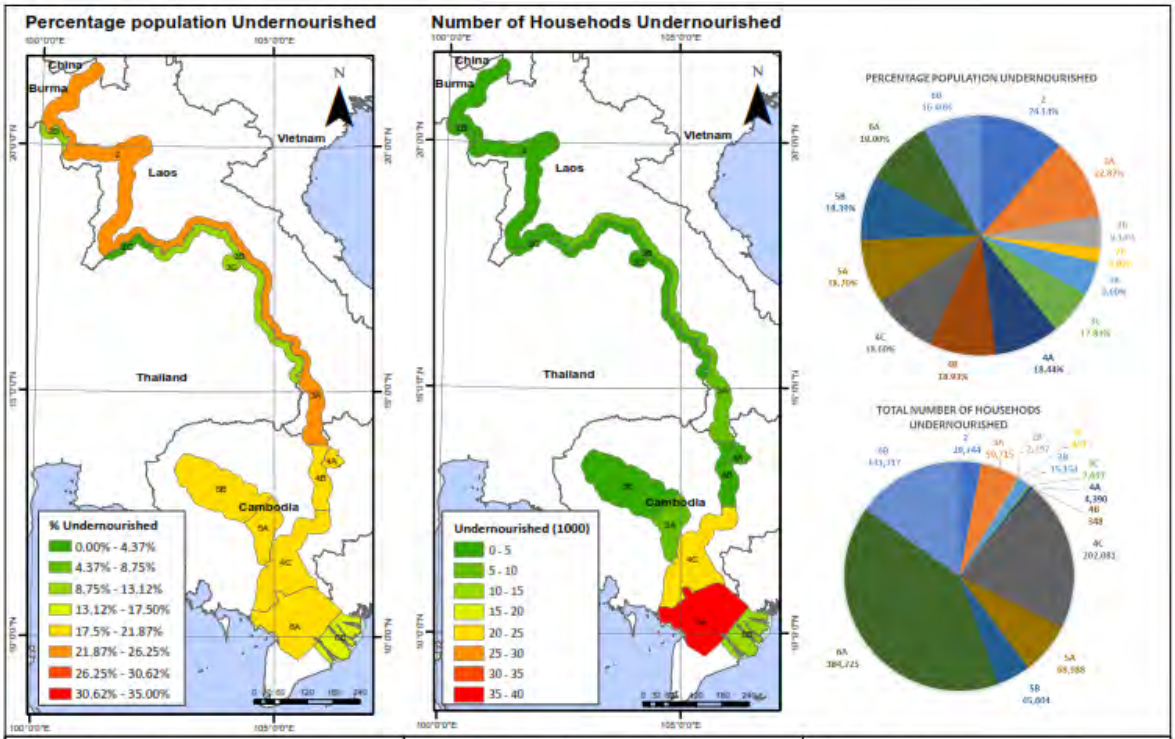
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario F2 for Year 24		**Scale:** 1:1'000.000



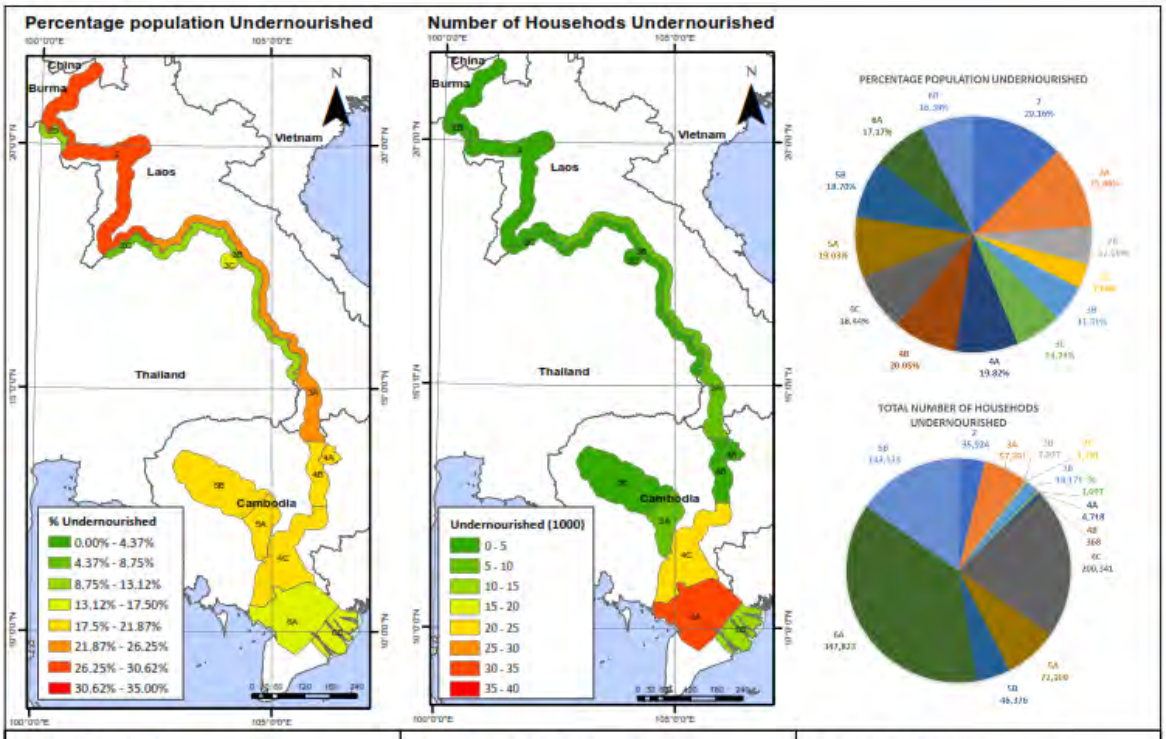
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario F3 for Year 24		**Scale:** 1:1'000.000



Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario H1a for Year 24		**Scale:** 1:1'000.000



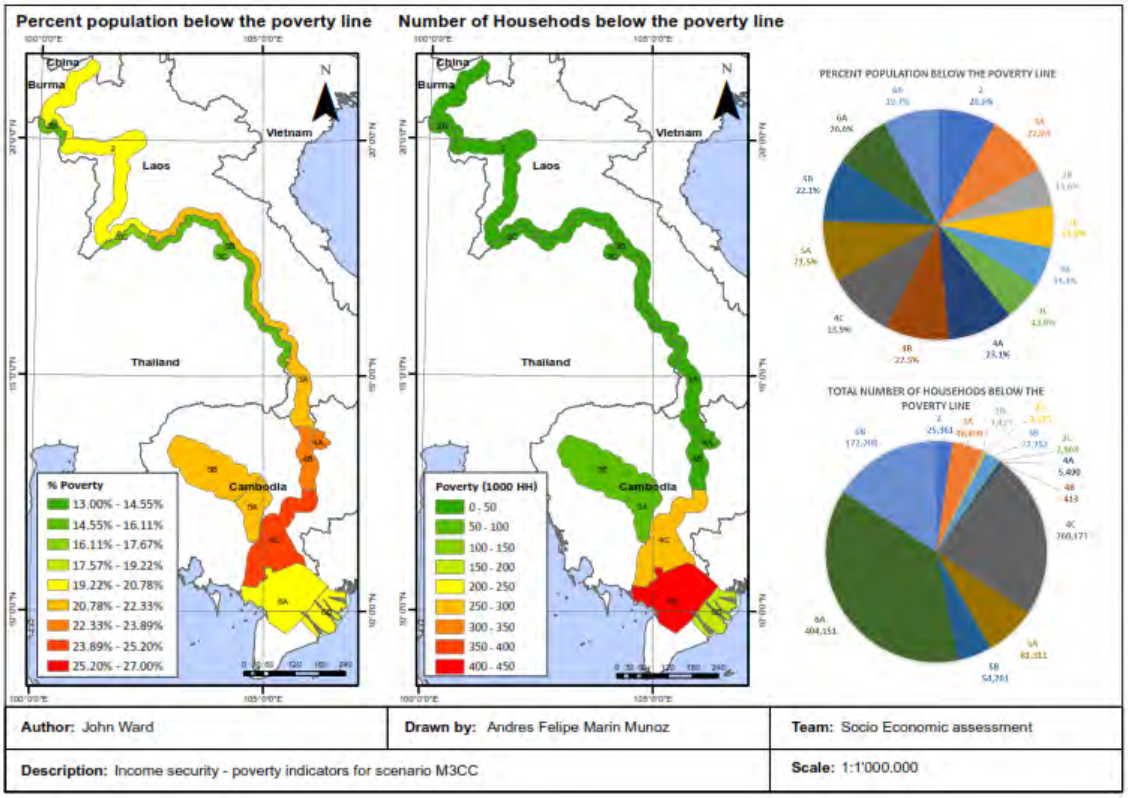
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario H1b for Year 24		**Scale:** 1:1'000.000

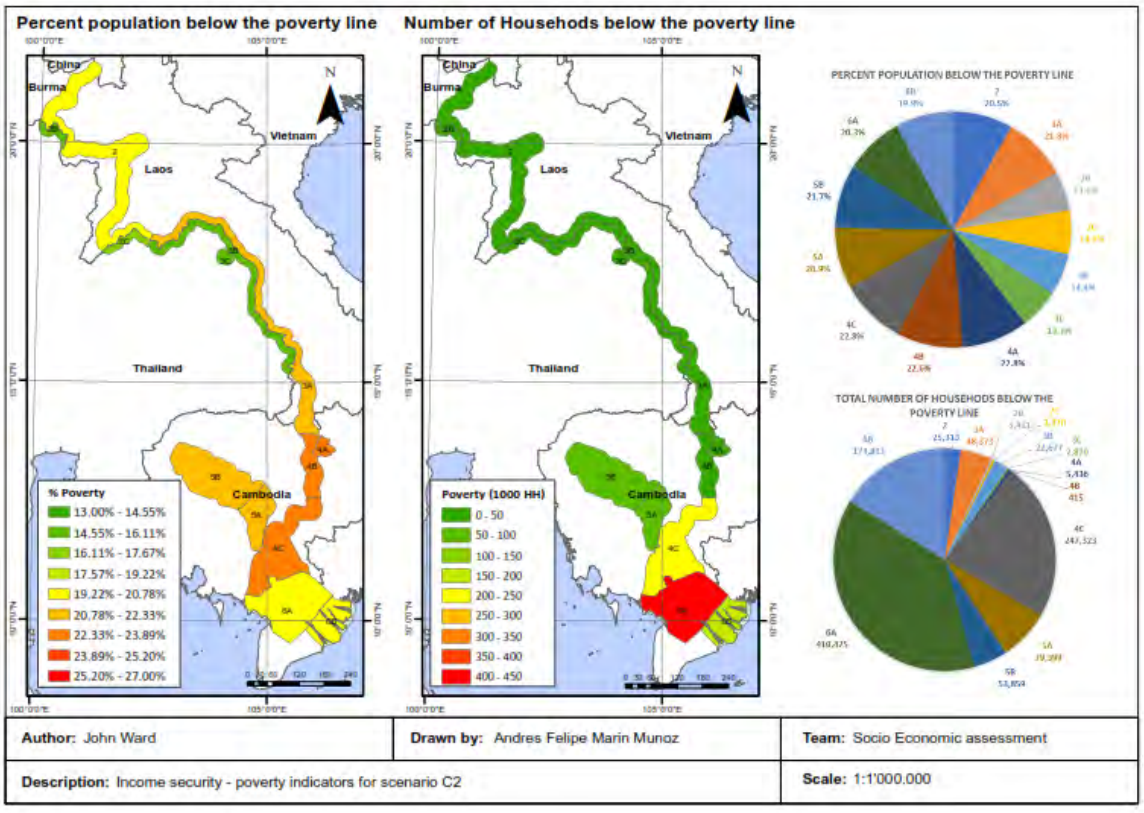


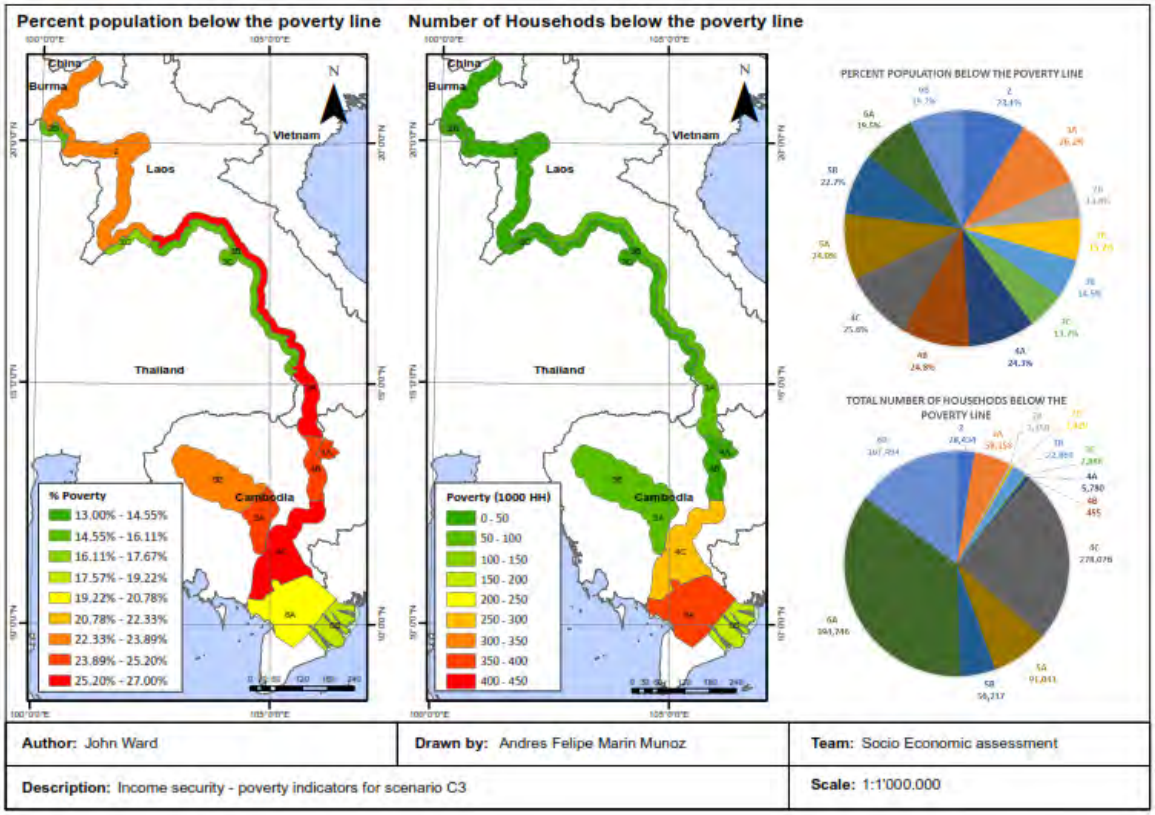
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - Undernourishment indicators for scenario H3 for Year 24		**Scale:** 1:1'000.000

9.6 Spatial representation of households below the national poverty lines (CS sub-scenarios)

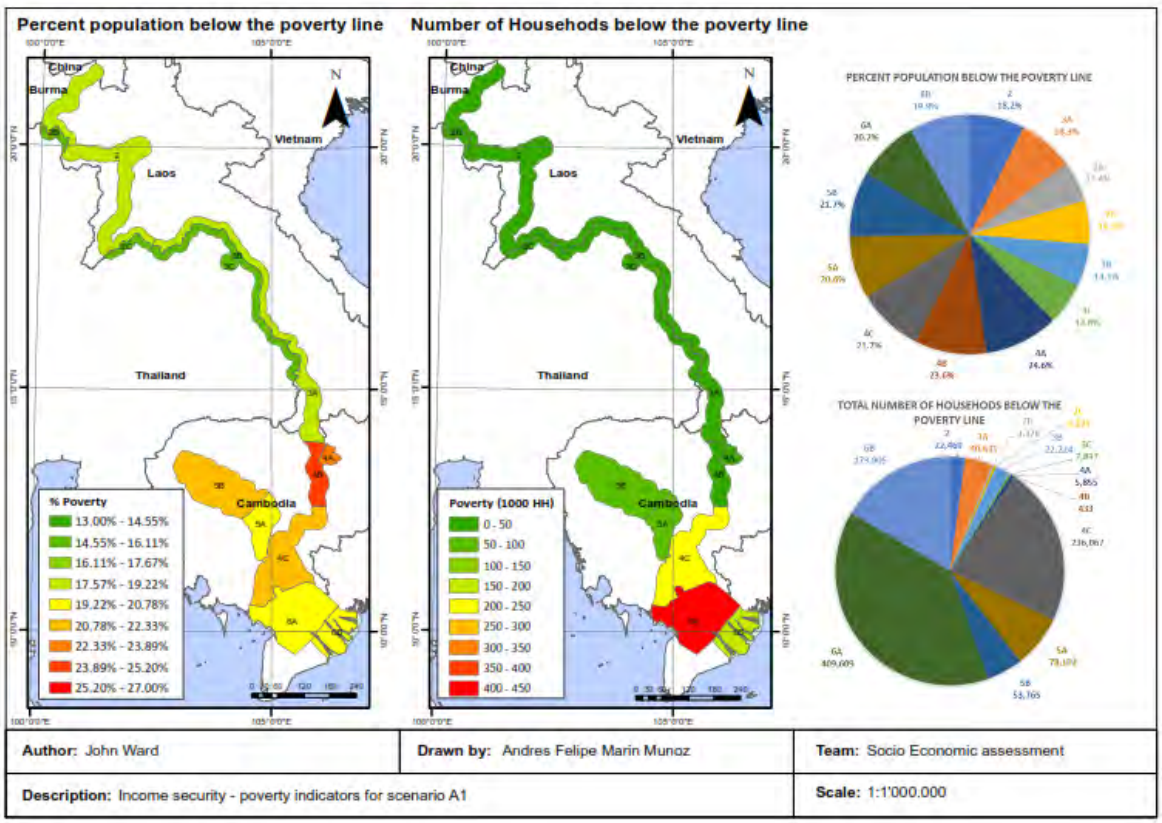
Figure 73 Maps of households below the poverty line: CS development sub-scenarios



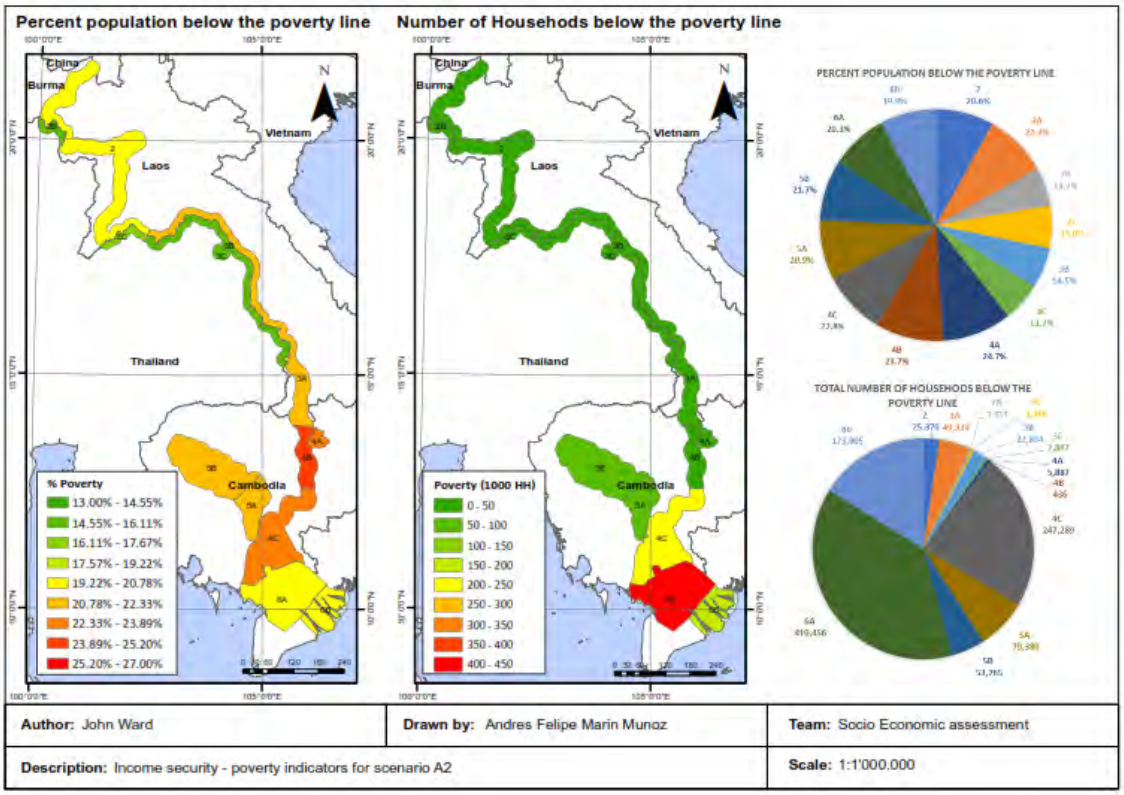




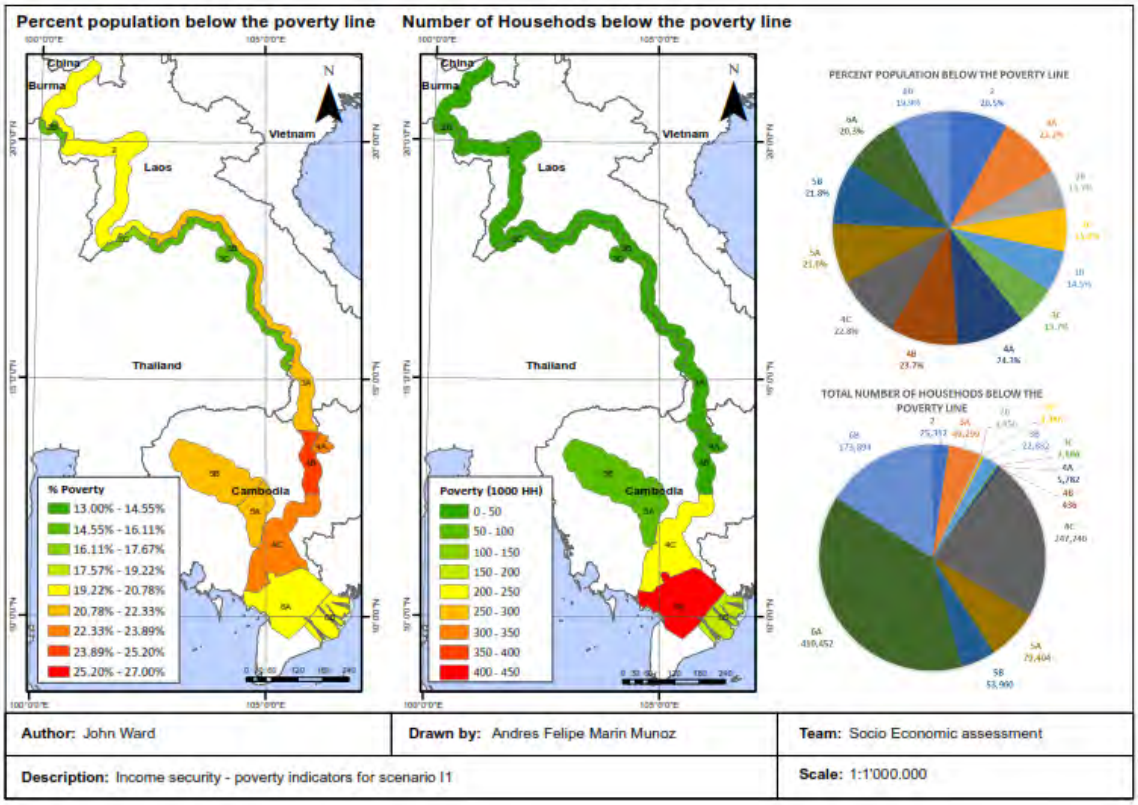
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario C3		**Scale:** 1:1'000.000



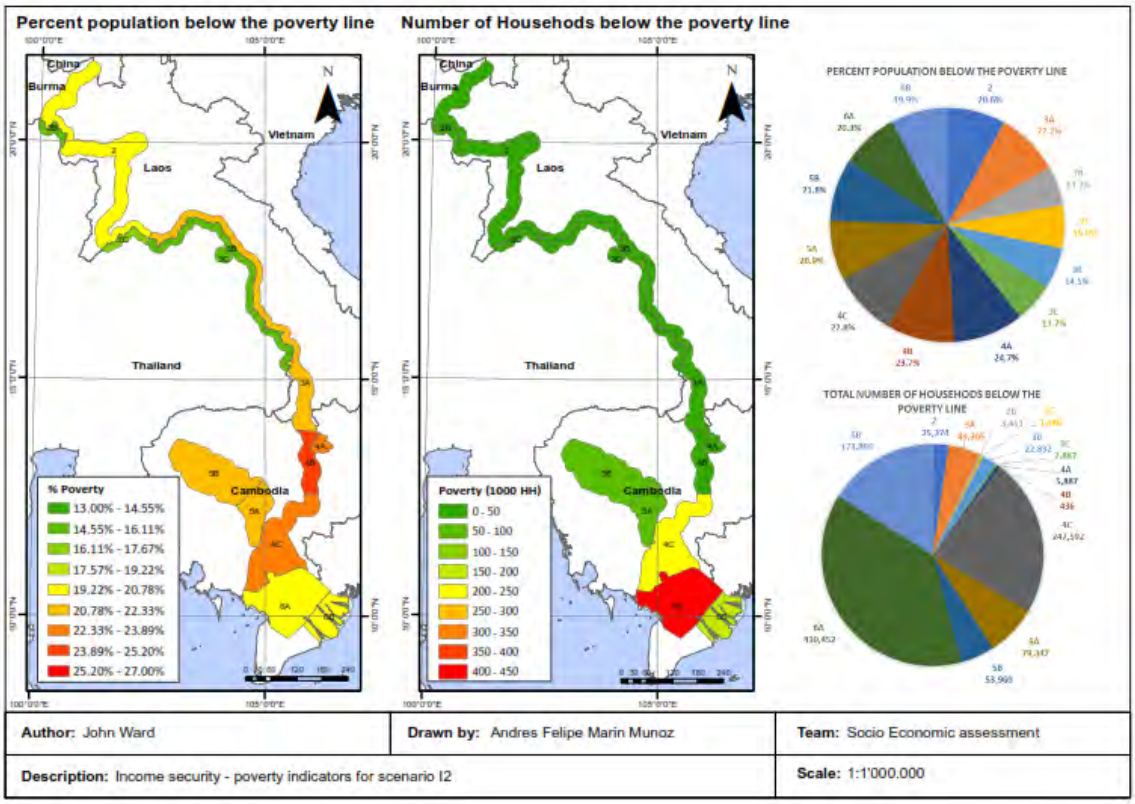
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario A1		**Scale:** 1:1'000.000



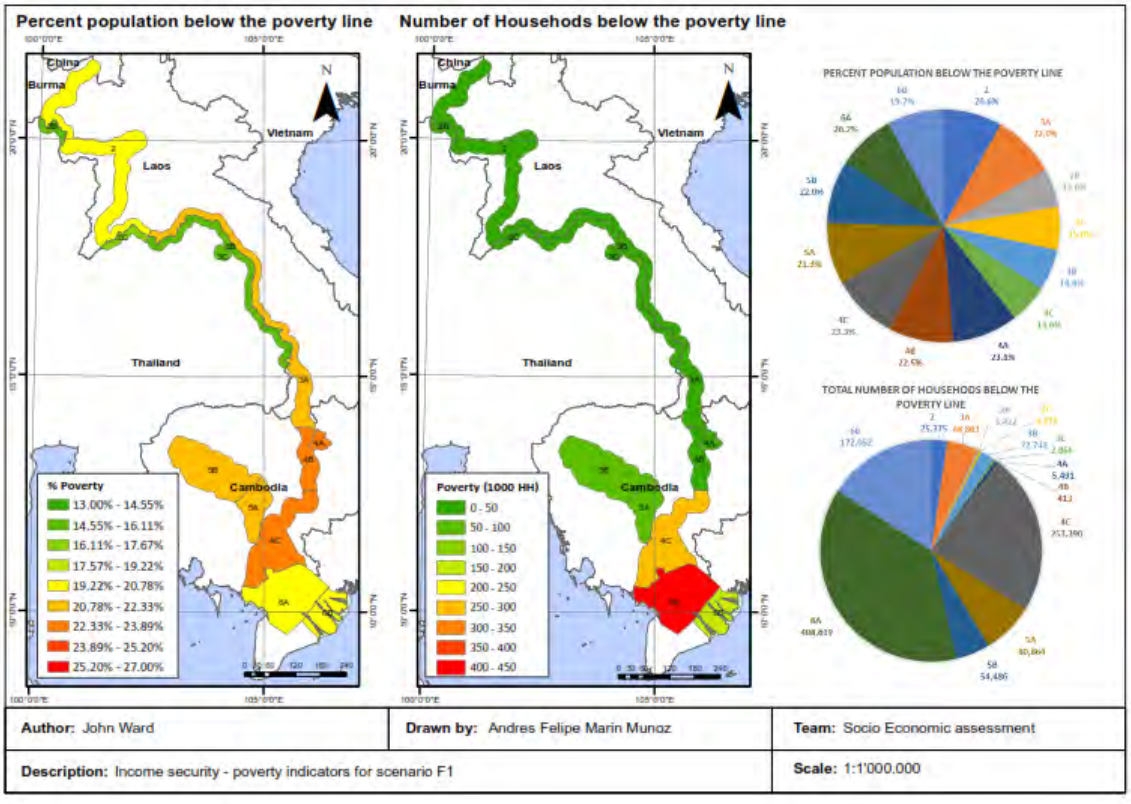
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario A2		**Scale:** 1:1'000.000



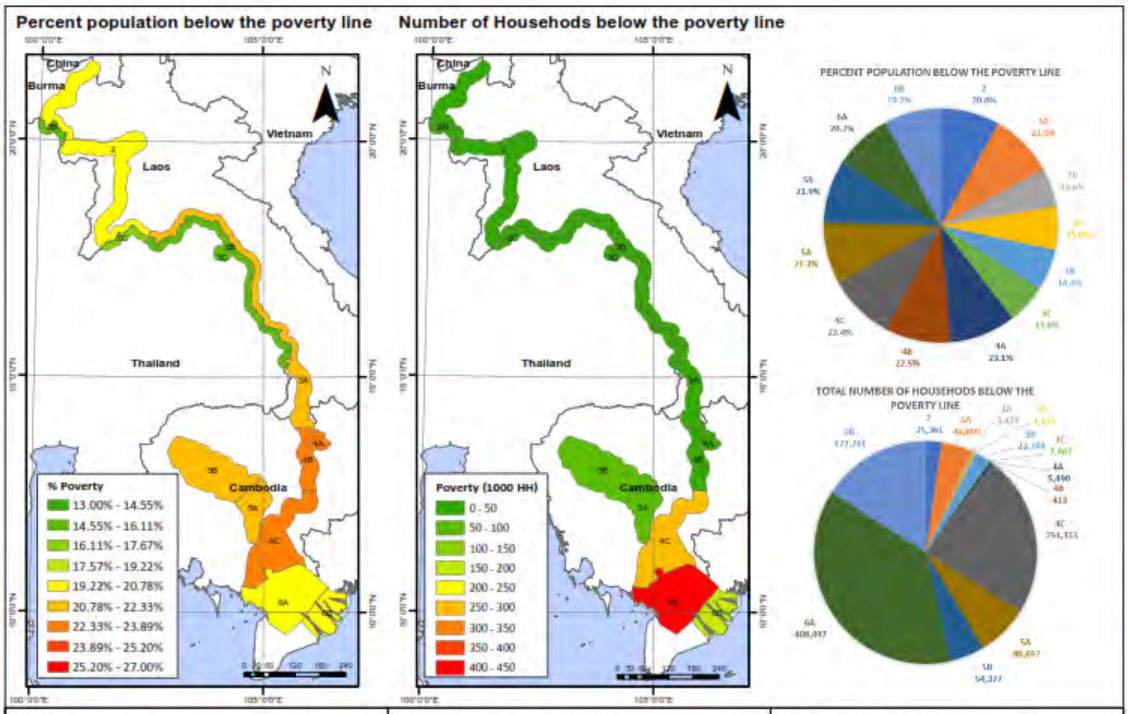
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario I1		**Scale:** 1:1'000.000



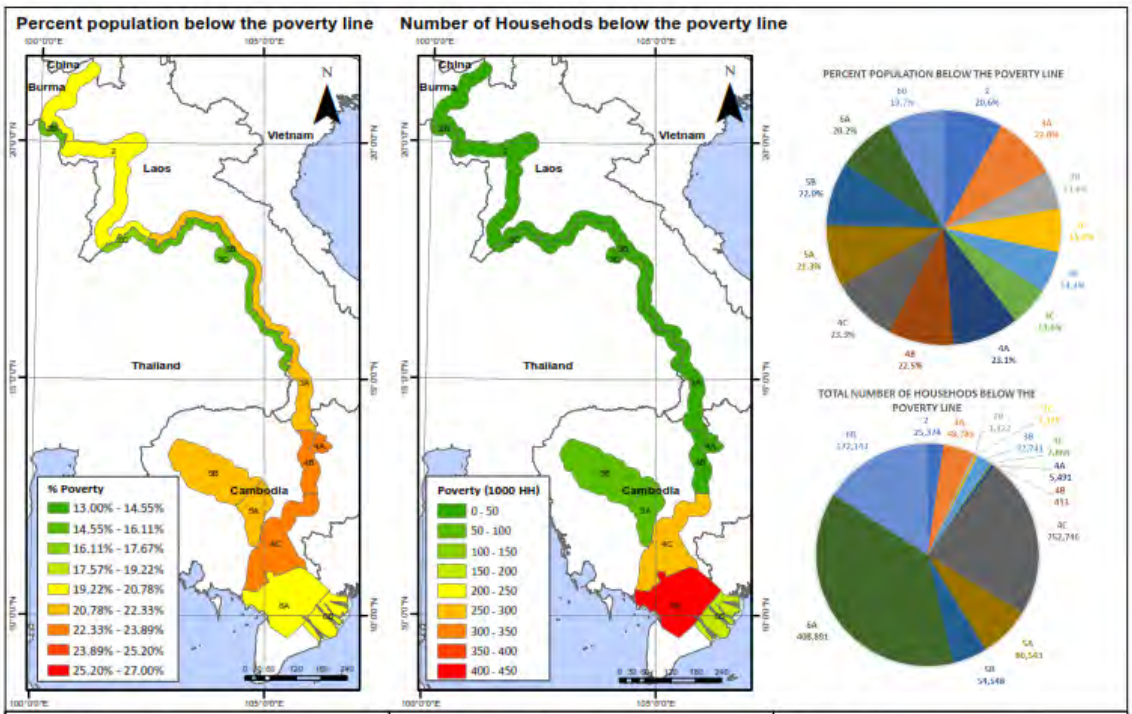
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario I2		**Scale:** 1:1'000.000



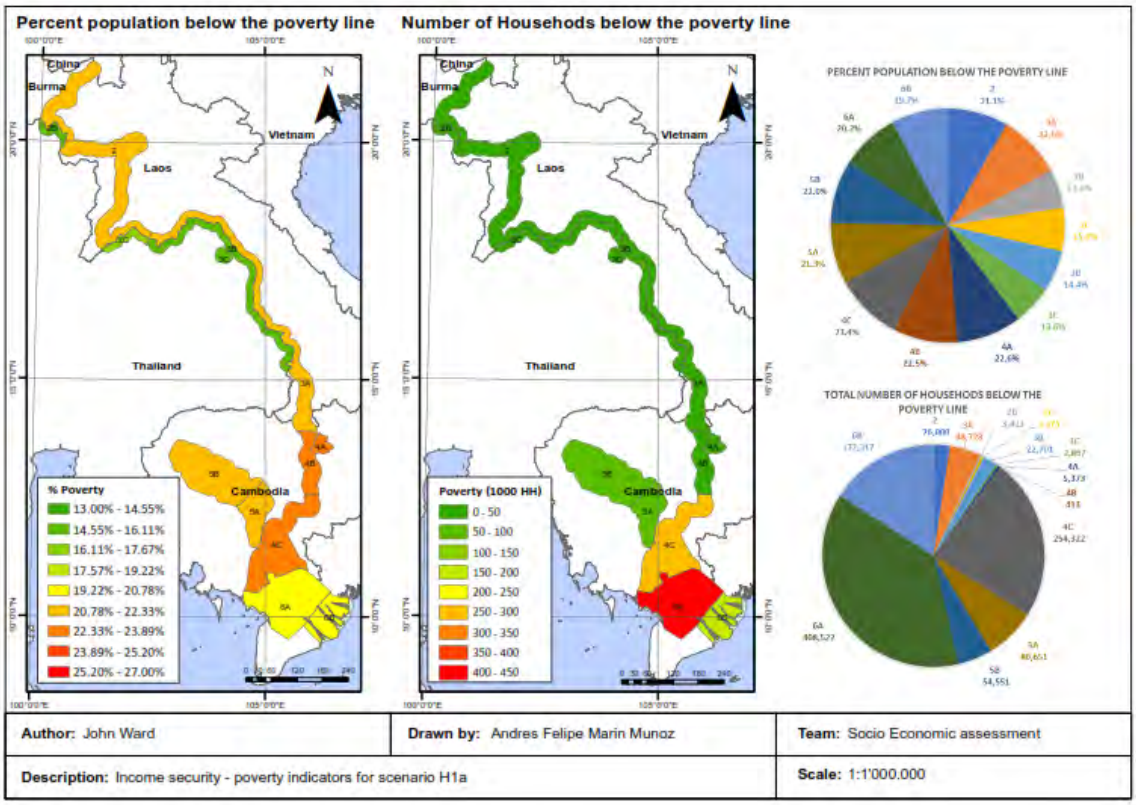
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario F1		**Scale:** 1:1'000.000



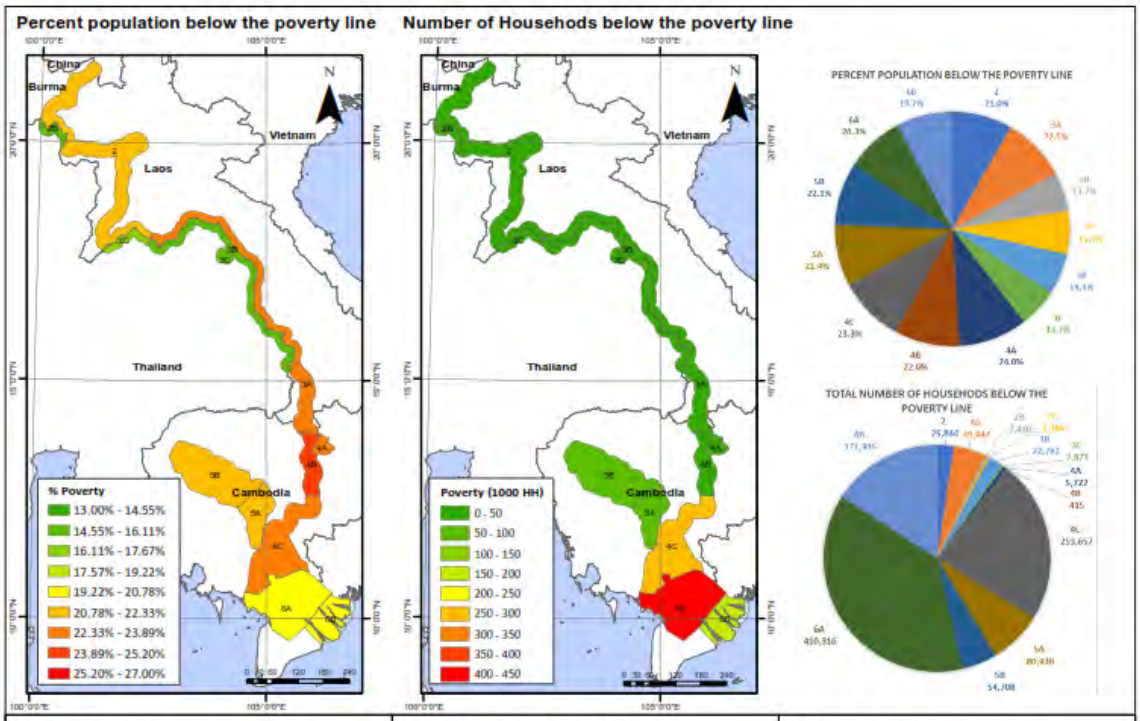
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario F2		**Scale:** 1:1'000.000



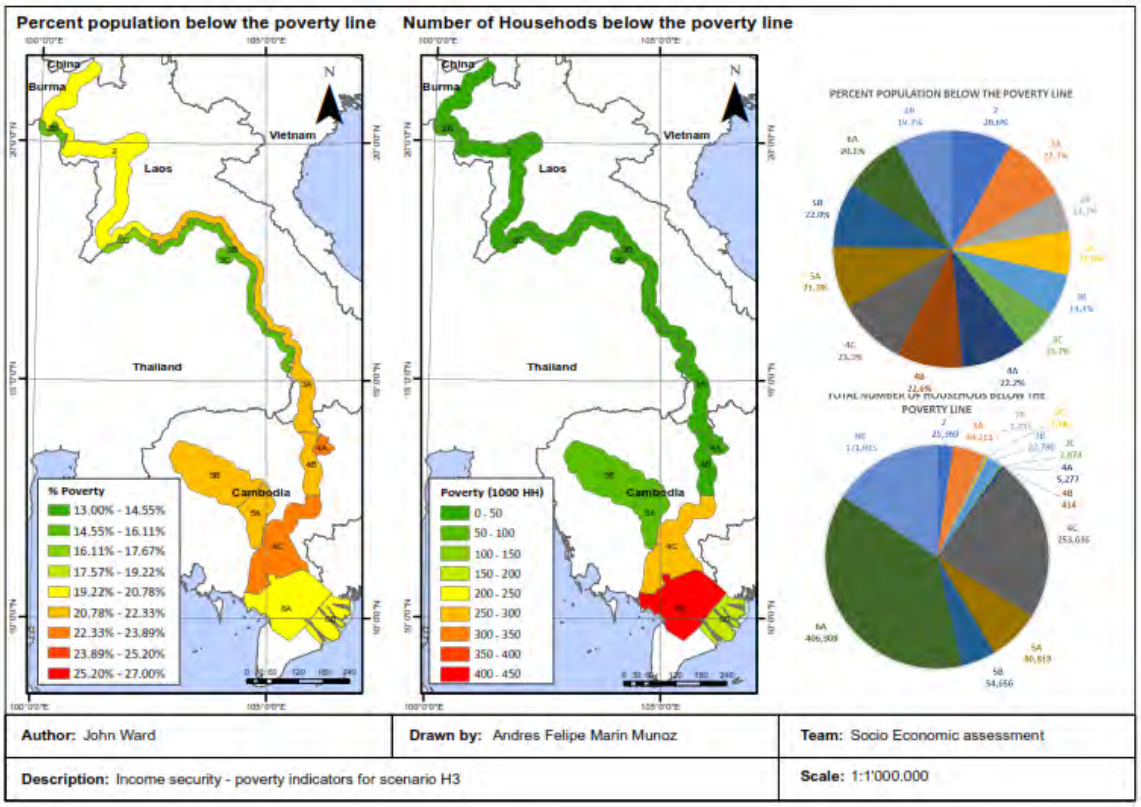
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario F3		**Scale:** 1:1'000.000



Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario H1a		**Scale:** 1:1'000.000

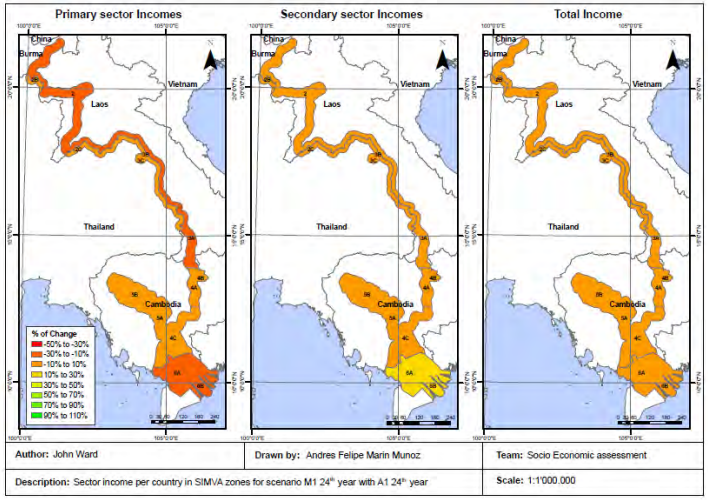


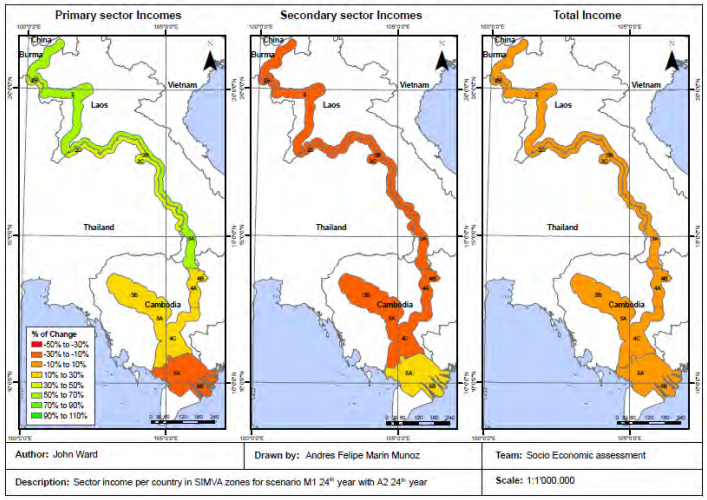
Author: John Ward	**Drawn by:** Andres Felipe Marin Munoz	**Team:** Socio Economic assessment
Description: Income security - poverty indicators for scenario H1b		**Scale:** 1:1'000.000

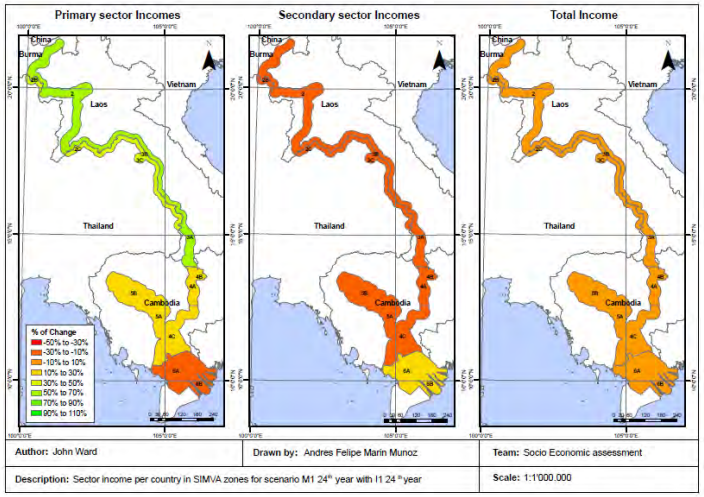

Percent population below the poverty line
Number of Households below the poverty line
China
Burma
Vietnam
Laos
Thailand
Cambodia
N
% Poverty
13.00% - 14.55%
14.55% - 16.11%
16.11% - 17.67%
17.57% - 19.22%
19.22% - 20.78%
20.78% - 22.33%
22.33% - 23.89%
23.89% - 25.20%
25.20% - 27.00%
Poverty (1000 HH)
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
350 - 400
400 - 450
PERCENT POPULATION BELOW THE POVERTY LINE
TOTAL NUMBER OF HOUSEHOLDS BELOW THE POVERTY LINE
Author: John Ward
Drawn by: Andres Felipe Marin Munoz
Team: Socio Economic assessment
Description: Income security - poverty indicators for scenario H3
Scale: 1:1'000.000

9.7 Spatial representation of sector incomes (CS development sub-scenarios compared to M1; M3)

Figure 74 Sector incomes across Corridor zones: A1-I2 sub-scenarios compared to M1 (% change)







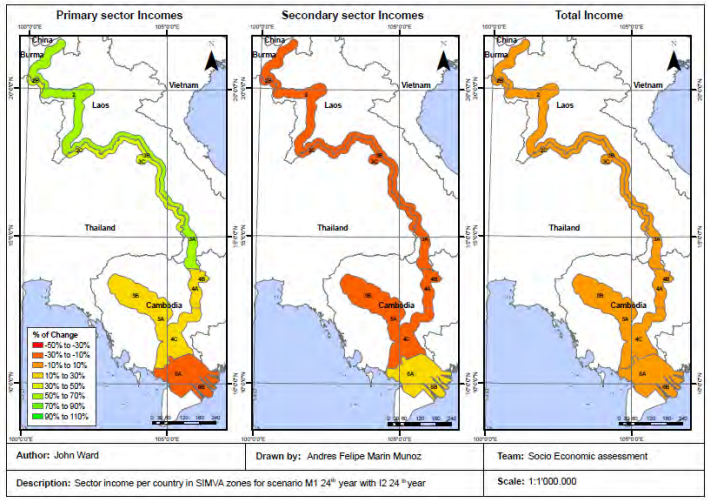
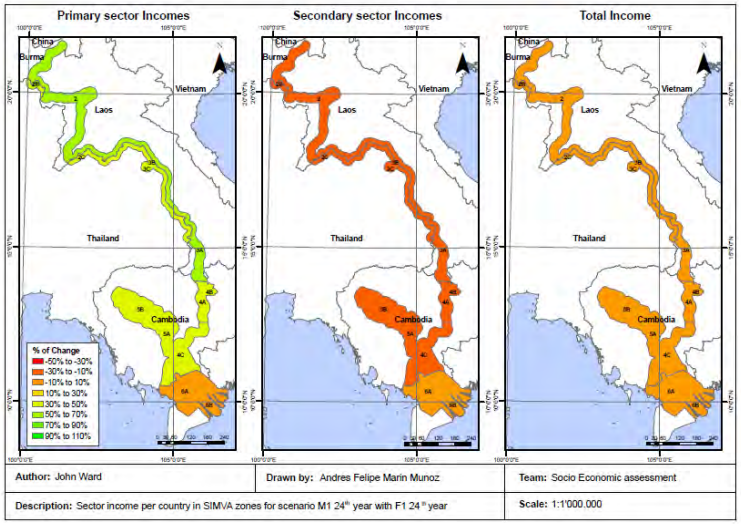
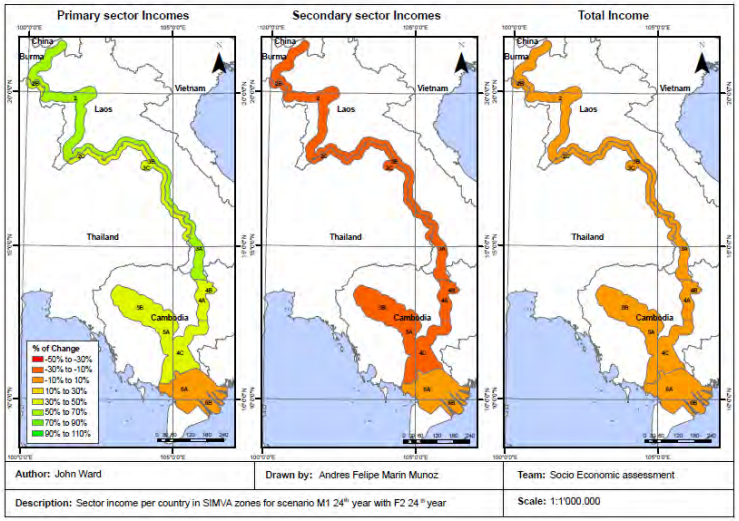
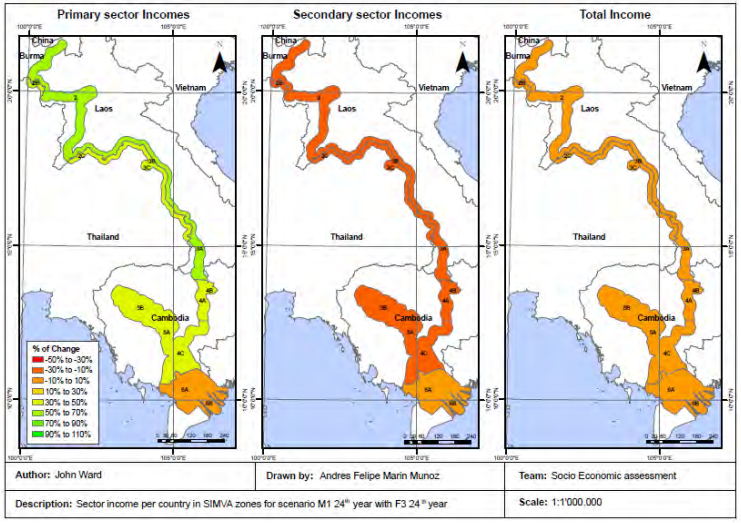


Figure 75 Sector incomes across Corridor zones: F1-H1a sub-scenarios compared to M1 (% change)







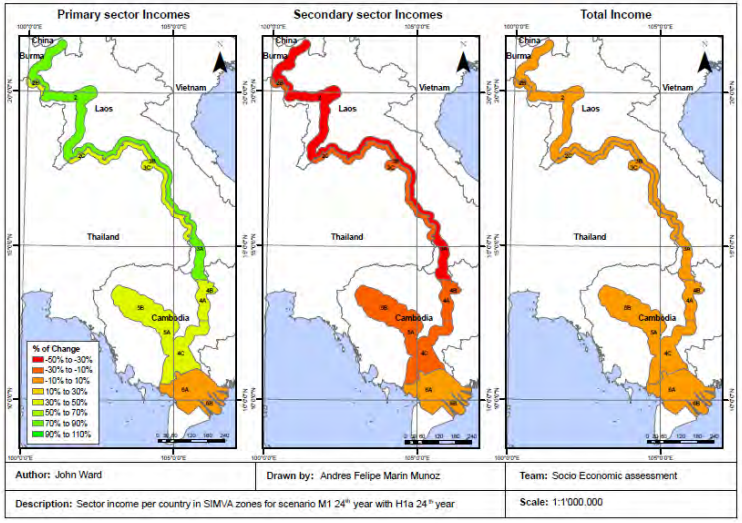
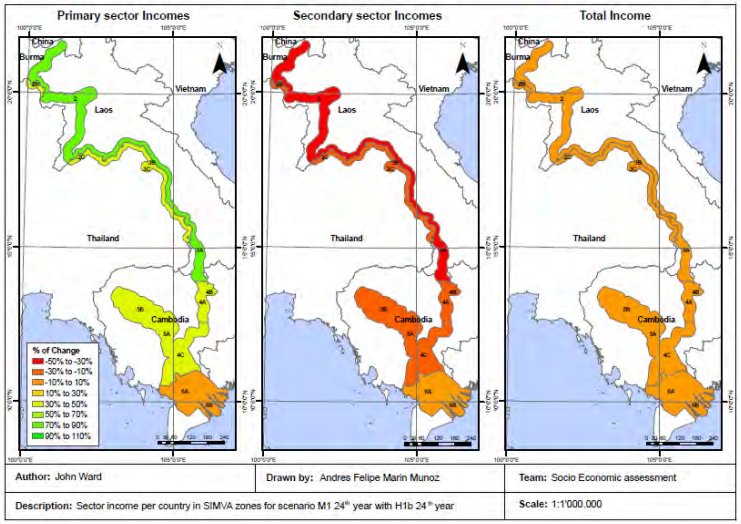
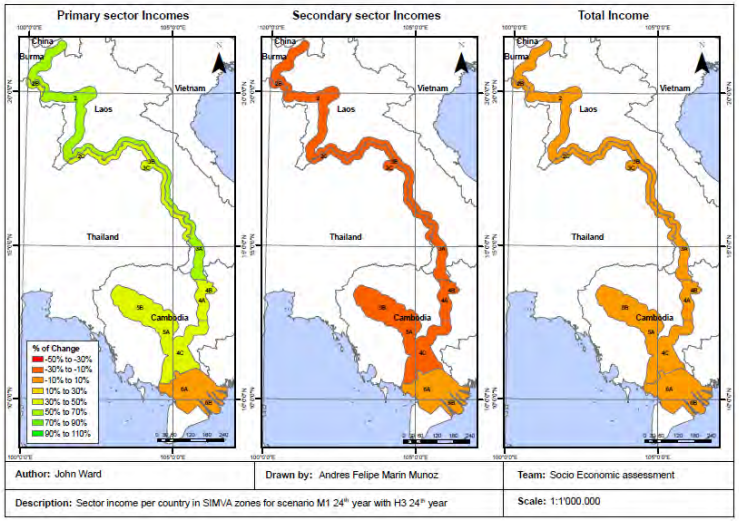
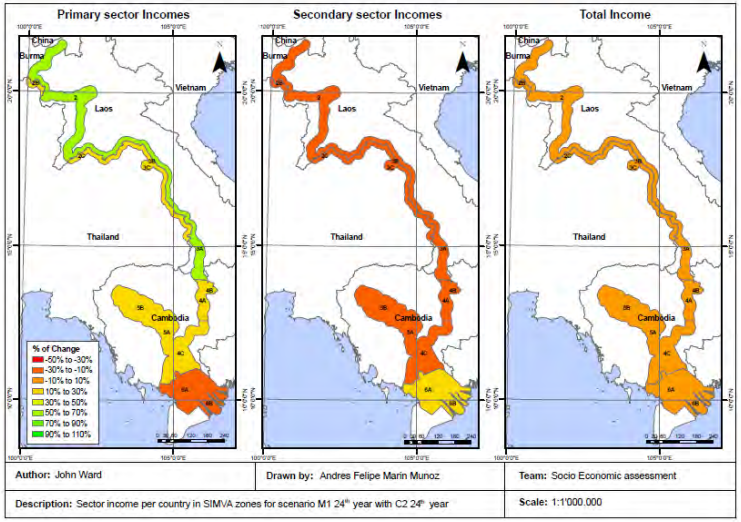


Figure 76 Sector incomes across Corridor zones: H1b-C3 sub-scenarios compared to M1 (% change)







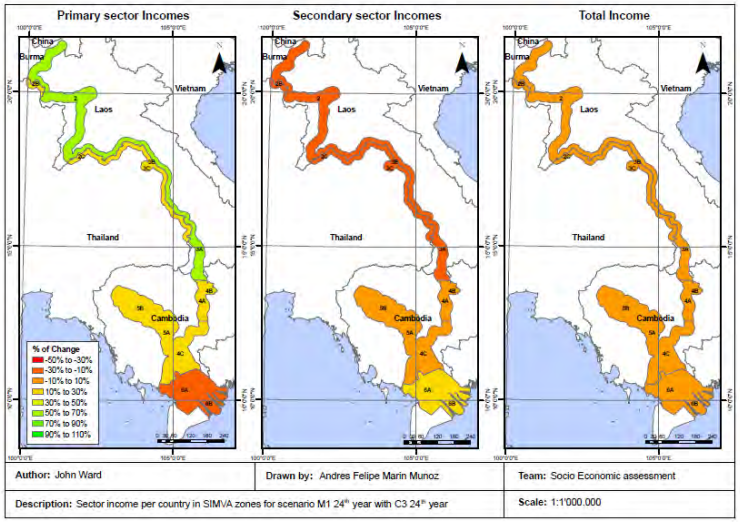
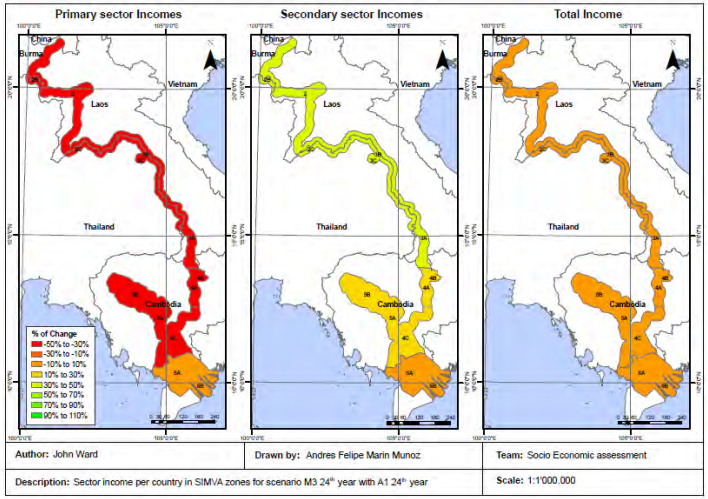
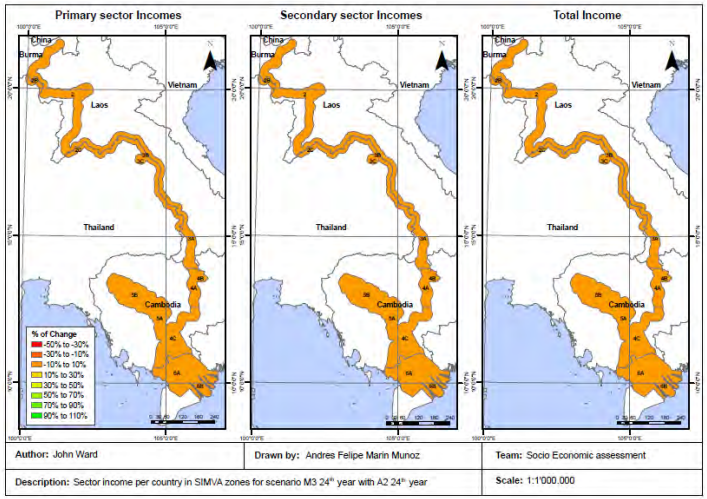
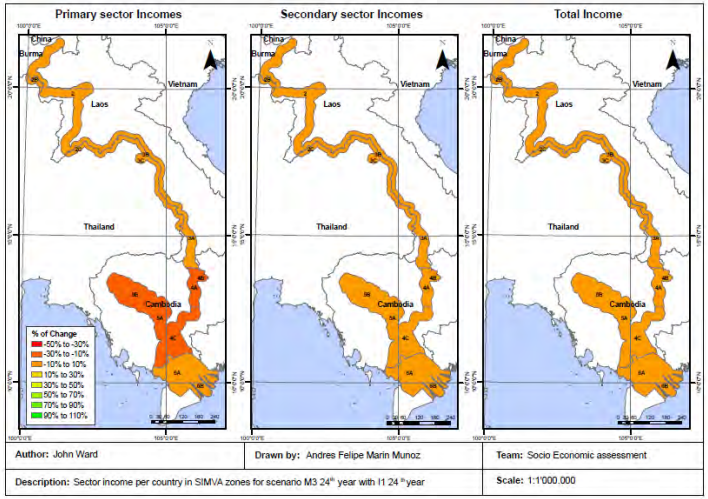


Figure 77 Sector incomes across Corridor zones: A1-I2 sub-scenarios compared to M3 (% change)







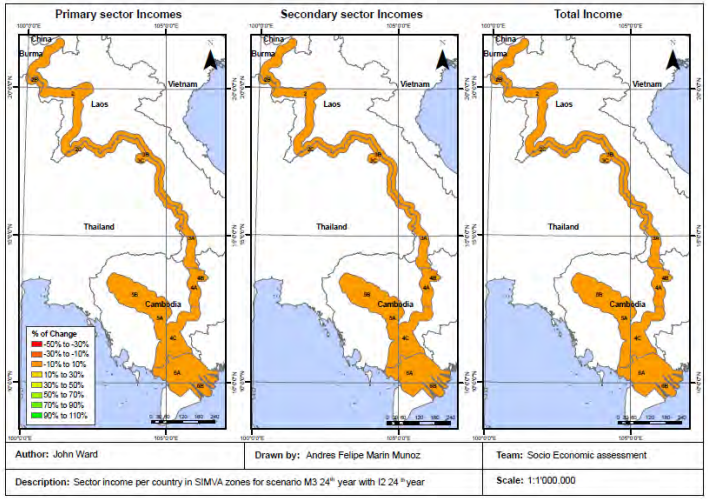
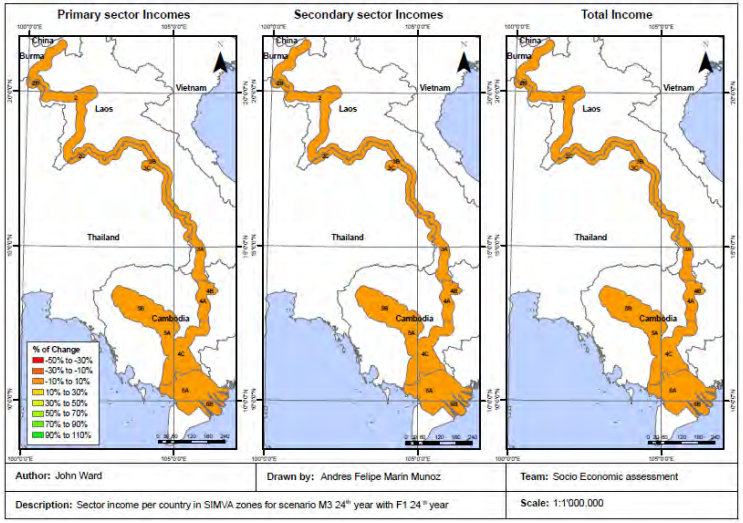
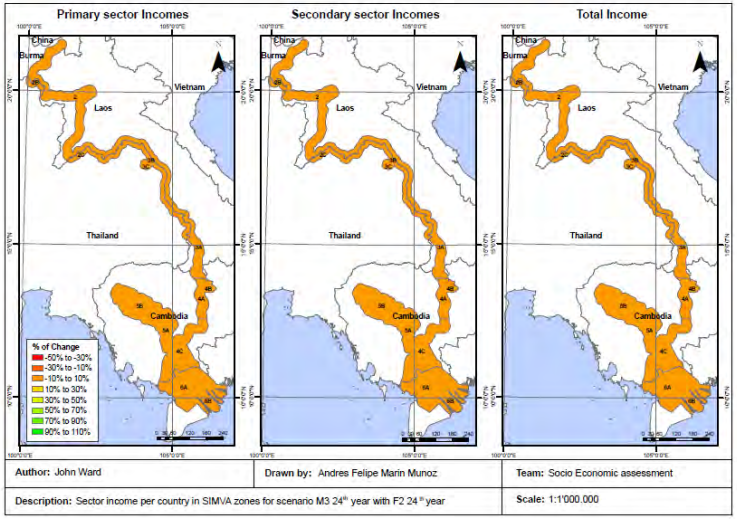
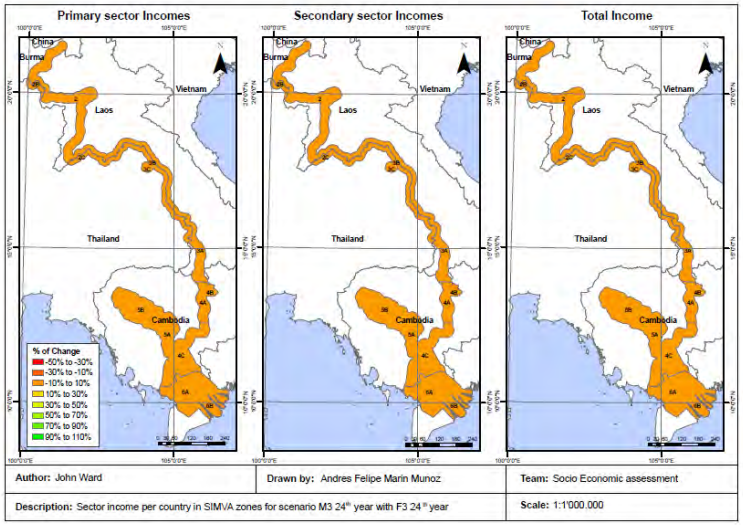


Figure 78 Sector incomes across Corridor zones: F1-H1a sub-scenarios compared to M3 (% change)







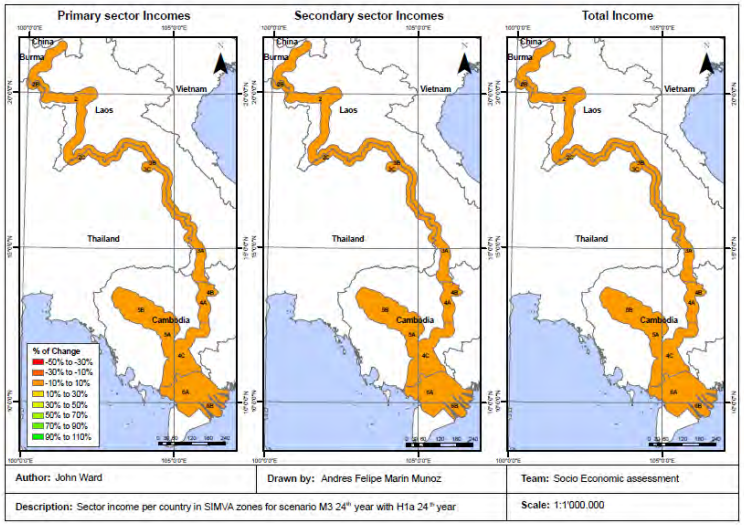
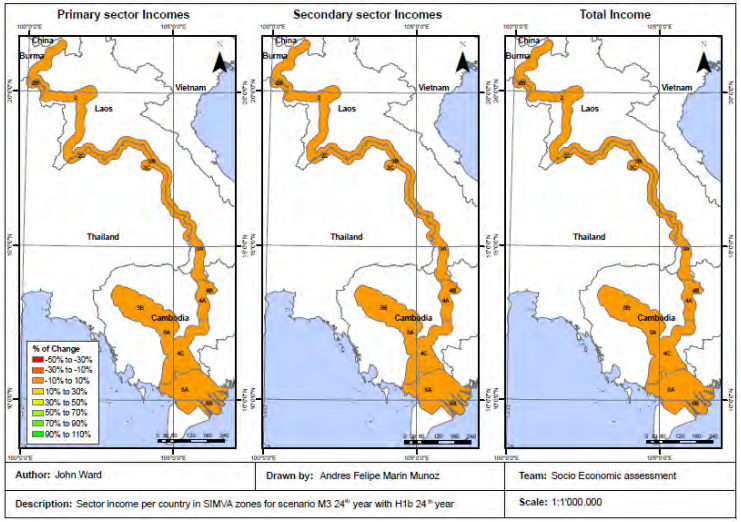
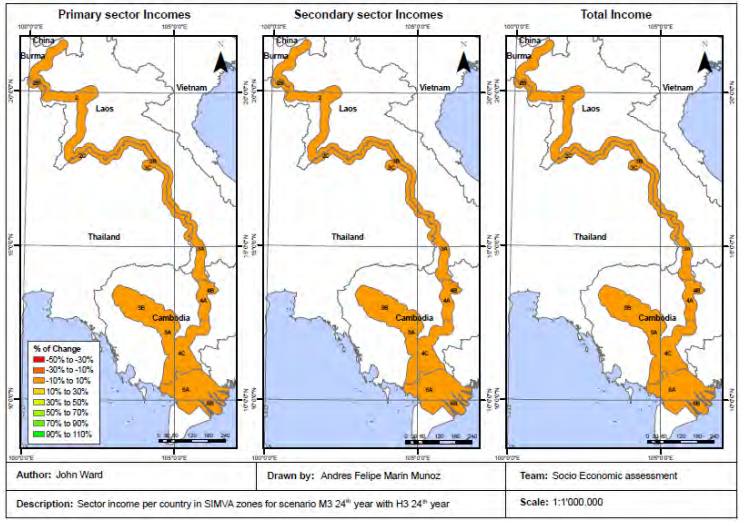
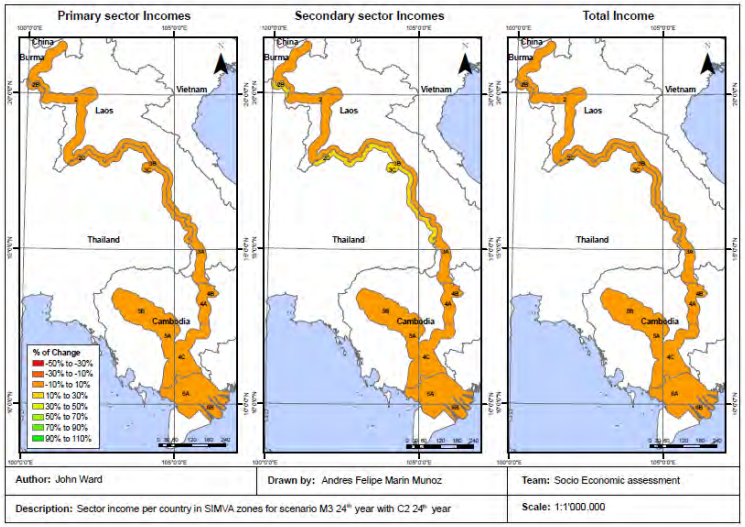
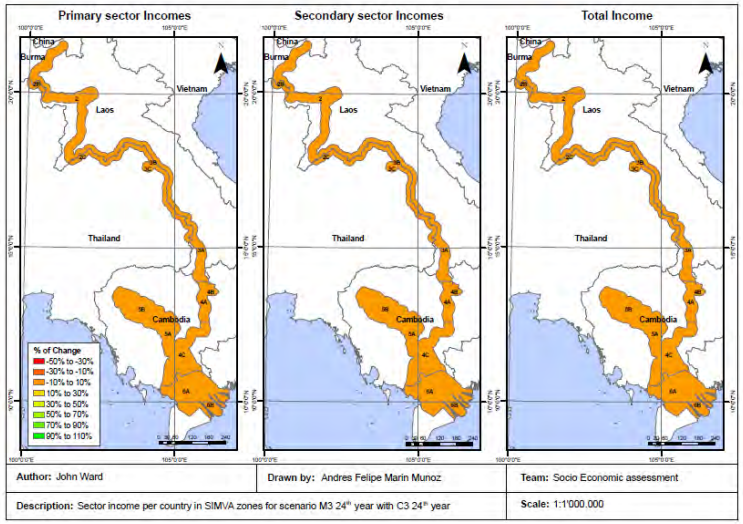


Figure 79 Sector incomes across Corridor zones: H1b-C3 sub-scenarios compared to M3 (% change)









10 Annex B: Assessment Tools

10.1 Social and Economic impact assessment indicators: linkages

Table 54 Relationships between Thematic and Discipline team outputs and socio-economic discipline specific indicators and assessment indicators

Strategic indicator	Living conditions and well-being				Employment in MRC sectors	
	Relating to access to safe water supplies, water availability for domestic and agricultural use and flood exposure	*Relating to ability to meet food grain and protein requirements through home production and/or having sufficient income to pay for food*	*Relating to being above the poverty rate and having sufficient monthly income*	*Relating to access to safe water, safe sanitation and health facilities*	*Relating to employment in MRC-related sectors*	*Relating to equity conditions associated with water, food, income & health security*

	Assessment indicator	Water security				Food security			Income security			Health security			Employment	Gender
	Discipline specific indicators	HHs with access to safe water supply system	HHs with secure supply for domestic use	HHs with secure supply for agricultural use	HHs exposed to flood damage risk	Total rice production	Total protein production (fish, livestock etc.)	HH expenditure on food	HH income	Alternative HH income source	HH income and expenditure	HH with access to secure safe water supply	HH with access to improved sanitation	HH with access to improved health facilities	No. of FTE jobs in MRC sectors	No. of females and males in water, food, income and health secure communities;
CS team	*CS themes and information requirements*	*Relevance to socio-economic assessment indicators*														
	Water resource developments															
1	**Irrigation**															*Note that gender assessment is based on water, food, income and health security assessment results and is not directly related to WR*
	Irrigation area and location (mapped and size, ha)															
	Irrigated agricultural production (tons of rice/ha)															
	Irrigated agricultural production (tons of in field fish/ha)															
	Irrigated agricultural production (tons of in field OAA/ha)															
	Irrigated agriculture employment (fte labour/year)															
2	**Forestry and catchment area**															
	Forest area and location (mapped and size, ha)															
	Forestry employment (fte labour/year)															

Assessment indicator		Water security				Food security			Income security			Health security			Employment	Gender
Discipline specific indicators		HHs with access to safe water supply system	HHs with secure supply for domestic use	HHs with secure supply for agricultural use	HHs exposed to flood damage risk	Total rice production	Total protein production (fish, livestock etc.)	HH expenditure on food	HH income	Alternative HH income source	HH income and expenditure	HH with access to secure safe water supply	HH with access to improved sanitation	HH with access to improved health facilities	No. of FTE jobs in MRC sectors	No. of females and males in water, food, income and health secure communities;
CS team	*CS themes and information requirements*	*Relevance to socio-economic assessment indicators*														
	Income derived from social forestry (US$/ha)															*development drivers*
3	**Urban and rural water supply and sanitation**															
	Urban water supply coverage (location, population served)	☐														
	Rural water supply coverage (location, population served)	☐														
	Rural improved sanitation coverage (location, population served)															
4	**Flood management**															
	Full flood protection area and location (mapped and size, ha)															
	Partial flood protection area and location (mapped and size, ha)															
	Areas exposed to flash flooding (mapped and size, ha)															
5	**Hydropower**															
	Reservoir area (mapped and size, ha)															
	Reservoir fisheries production (tons of in field fish/ha)															
	Employment in reservoir fisheries (fte labour/year)															
	Employment in hydropower generation (fte labour/year)															
6	**Navigation (mainstream)**															
	Mainstream employment centres (mapped)															
	Urban employment in navigation (fte labour/year)															
	Rural employment in navigation (fte labour/year)															
IKMP	**Water resource availability and status**															
	Annual mean minimum water level at selected mainstream locations															

Assessment indicator		Water security				Food security			Income security			Health security			Employment	Gender
Discipline specific indicators		HHs with access to safe water supply system	HHs with secure supply for domestic use	HHs with secure supply for agricultural use	HHs exposed to flood damage risk	Total rice production	Total protein production (fish, livestock etc.)	HH expenditure on food	HH income	Alternative HH income source	HH income and expenditure	HH with access to secure safe water supply	HH with access to improved sanitation	HH with access to improved health facilities	No. of FTE jobs in MRC sectors	No. of females and males in water, food, income and health secure communities;
CS team	*CS themes and information requirements*	*Relevance to socio-economic assessment indicators*														
	Flooded area (at selected depth-duration) (mapped and size, ha)															
	Extent of saline intrusion (mapped and size, ha)															
	Compliance with WHO water quality at selected mainstream locations															

	Exogenous developments															
2	**Non-irrigated agriculture including livestock**															
	Rainfed rice area and location (mapped and size,ha)															
	Rainfed rice production (tons of rice/ha)															
	Irrigated agricultural production (tons of in field fish/ha)															
	Rainfed rice area production (tons of in field OAA/ha)															
	Rainfed rice employment (fte labour/year)															
	Livestock production by District (tonnes/year)															
2	**Aquaculture**															
	Aquaculture area and location (mapped and size, ha)															
	Aquaculture production (tons of fish/ha)															
	Aquaculture employment (fte labour/year)															
3	**Mining, sand mining and other industrial water use and discharge**															
	Location and nature of industrial facilities (mapped by type)															
	Location and size of sand mining facilities (mapped and tonnes/year)															
	Rural employment from sand mining (fte labour/year)															

	Assessment indicator	Water security				Food security			Income security			Health security			Employment	Gender
	Discipline specific indicators	HHs with access to safe water supply system	HHs with secure supply for domestic use	HHs with secure supply for agricultural use	HHs exposed to flood damage risk	Total rice production	Total protein production (fish, livestock etc.)	HH expenditure on food	HH income	Alternative HH income source	HH income and expenditure	HH with access to secure safe water supply	HH with access to improved sanitation	HH with access to improved health facilities	No. of FTE jobs in MRC sectors	No. of females and males in water, food, income and health secure communities;
CS team	*CS themes and information requirements*	*Relevance to socio-economic assessment indicators*														
4	**Changes in flood plain land use including urban sprawl, roads etc**															
	Flood plain land use by type (mapped and size,ha)															
	Annual value of flood damages (mapped and amount US$/year)															
BioRA	**Capture fisheries and OAAs**															
	Capture fisheries production per SIMVA sub-zone (tonnes/year: needs conversion)															
	OAA production per SIMVA sub-zone (tonnes/year: needs conversion)															
BioRA	**Other environmental assets**															
	River bank garden area and location (mapped and size, ha)															
	River bank garden productivity value (US$/ha/year)															
	River bank garden employment (fte labour/ha/year)															
	Inundated forest area and location (mapped and size, ha)															
	Inundated forest areas productivity value (US$/ha/year)															
	Inundated forest areas employment (fte labour/ha/year)															
	Marshes and inundated grasslands area and location (mapped and size, ha)															
	Marshes and inundated grasslands productivity value (US$/ha/year)															
	Marshes and inundated grasslands (fte labour/ha/year)															

Assessment indicator		Water security				Food security			Income security			Health security			Employment	Gender
Discipline specific indicators		HHs with access to safe water supply system	HHs with secure supply for domestic use	HHs with secure supply for agricultural use	HHs exposed to flood damage risk	Total rice production	Total protein production (fish, livestock etc.)	HH expenditure on food	HH income	Alternative HH income source	HH income and expenditure	HH with access to secure safe water supply	HH with access to improved sanitation	HH with access to improved health facilities	No. of FTE jobs in MRC sectors	No. of females and males in water, food, income and health secure communities;
CS team	*CS themes and information requirements*	*Relevance to socio-economic assessment indicators*														
	Mangrove areas area and location (mapped and size, ha)															
	Mangrove areas productivity value (US$/ha/year)															
	Mangrove areas (fte labour/ha/year)															
	Coastal areas exposed to erosion/accretion (mapped and size, ha)															
	Areas exposed to bank erosion (mapped & size, ha)															
CCAI	**Climate change**															
	Impacts of CC on agricultural productivity (Percent change on yields)															
	Location and nature of CC adaption interventions (mapped by type)															
CIA	**Social development**															
	Access to electricity supply coverage (mapped, population served)															
	Access to health facilities (mapped, population served)															
	Poverty reduction support (location, impact on poverty rate)															
	Remittance income (location, impact on poverty rate)															
	Migration and demographic change at District/Provincial level)															
	Commodity prices															

Highlighted indicators describe indicators confirmed by Thematic Teams;
Highlighted indicators describe indicators calibrated to external datasets;

10.2 Food and nutritional security assessment tool

The rice yield estimates and sustainable rice growing area results from IWRM WUP-FIN model were used to develop the socio-economic tool. The IWRM model results were combined with the BioRA fish biomass estimates, population growth forecasts, livestock production and nutritional inputs of other food sources derived from FAO data to develop food balances for the 13 corridor zones across all development scenarios.

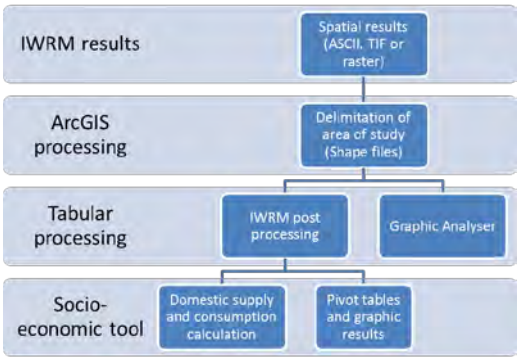
The spreadsheet tool addresses the lack of connection between the suite of CS modelling outputs and the necessary socio-economic inputs. Initially, the model had two limitations in information processing; first, the time series information could only be defined for rice production as the singular land use, applied across the entire study area; second estimates were expressed as the averaged outputs within the modelled cell limiting ex post analysis of annual variance and at resolutions demanded by the Council Study. The limitations constrained the input and evaluation of revised area and associated land use, and increasing spatial resolution when required. Addressing the combination of revisions required extensive manual changes to the model specifications resulting in increased processing demands and reduced analytical assessments.

The development of the revised socio-economic tool focused on:

1. Processing the spatial output information independently of the variable class (sediments, fish, irrigated rice, non-irrigated rice, water depth, etc.)
2. Allowing the possibility of changes in the study areas.
3. Automation with rapid processing.
4. Producing outputs for food security analysis and inputs for employment and income estimates for the social and economic assessmsnt and the macroeconomic assessment across the full set of development scenarios and sub scenarios.

The socio-economic tool optimizes socio-economic data processing and automation, enabling more effective ex post analysis by minimizing manual information processing. The model uses a modular architecture that allows the rapid imputation of revised data sets and additional variables and scenario modelling. A schematic of the main elements of the IWRM post processing and the associated socio-economic tool is illustrated in Figure 80.

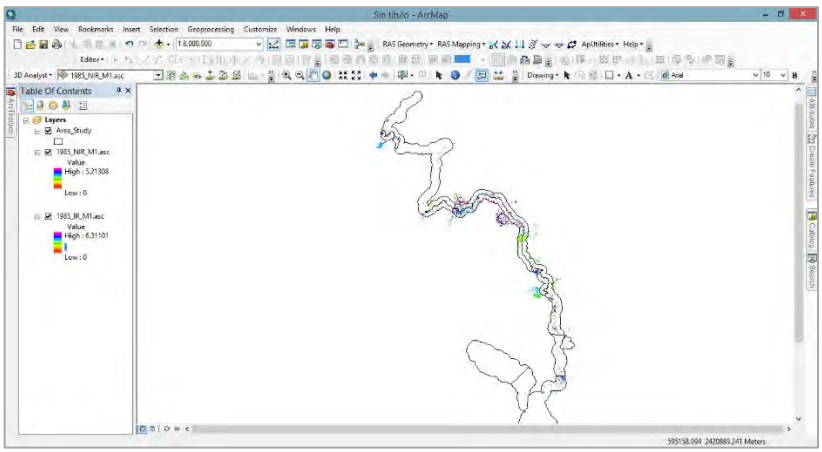
Figure 80 Main elements of the IWRM post processing and socio-economic assessment tool



The processing tool uses spatial information derived from the IWRM model outputs and manages the translation of raster format (ASCII, TIFF or Raster) into polygon shape files used to define the corridor zones of the Council Study. The tabular processing and socio-economic processing was developed using table and graphic information that can be readily interpreted and understood. The tool was developed combining the ArcGIS model builder toolbox and Excel Vba (Visual basic for applications).

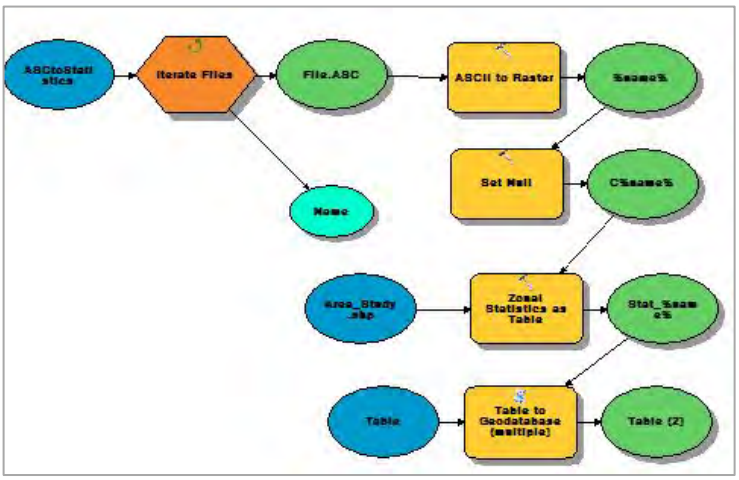
The process creates an ASCII file with the following format: YYYY_OUTPUT_SCENARIO.asc. Where: YYYY represents the code of the year that could vary from 1985 to 2008 for this project. OUTPUT represents the code of the type of output that can be FI (fish), NIR (non-irrigated), IR (irrigated), etc. And SCENARIO represents the scenario code which can be M1, M2, M3 or M3CC. An example of the information with the area of study is shown in Figure 81. It shows the area of study with the results 1985_NIR_M1 and 1985_IR_M1.

Figure 81. ArcGIS screenshot and raster information of the outputs of IWRM WUP-FIN model



The model builder toolbox shown in Figure 82 was created to automate the iterative statistical analysis of the time series, land use and scenario specifications (Figure 81). The process extracts the statistic tables from an ASCII raster and a delimitated shape file. The final output of this toolbox is a DBF file with the same code as the GIS map input with information of the area, average, minimum, maximum and standard deviation for each region of the studied area, for the 13 SIMVA zones.

Figure 82. Model builder tool created to process the raster information into statistical information



Extraction and conversion of spatial information was developed n ArcGIS, and calculation and graphical outputs in Microsoft Excel. The three main processing modules are shown in Figure 83.

Figure 83. main screen of post processing tool of IWRM WUP-FIN and Socio-economic impact assessment

The sequential modules represent a process initially implemented in the socio-economic analysis, revised and automated with Vba coding to facilitate rapid and accurate food security analyses. The

sequential modules input information from specified conditions (rice yields, fish catch, livestock growth rates, population growth functions). Spatial processing and scenario definitions are relatively unconstrained: the number of areas and scenarios can be readily amended by imputing new conditions and specifications. There is no limit to the number of scenarios and regions the model can manage, although increases will increase processing times. The model platform remains based on a Microsoft Excel configuration.

10.2.1 IWRM post processing

The post processing tool was design to extract the statistic information from the DBF files created from the spatial processing. The data extraction process relies on consistent formatting and identification of the information processed. The identification starts filling the tables from the ID and name of the area and ID and name of the scenario shown in Figure 84.

Figure 84. Interface of IWRM post processing tool definition window of regions and scenarios

ID	Name area	rice factor
1	Zone 2-Mainstream - Lao	1
2	Zone 3 A - Lao - Mainstream	1
3	Zone 2 B-Upper Thailand	1
4	Zone 2 C-Lower Thailand	1
5	Zone 3 B Thailand-Mainstream	1
6	Zone 3 C Thailand-Songkhram	1
7	Zone 4 A Cambodia-Khone Falls to Kratie	1
8	Zone 4 B Cambodia-3S	1
9	Zone 4 C Cambodia Kratie to Viet Nam border	1
10	Zone 5 A Cambodia-Tonle Sap river	1
11	Zone 5 B Cambodia Tonle Sap lake	1
12	Zone 6 A VietNam Delta - freshwater	1.3
13	Zone 6 B VietNam Delta - saline	1.3

ID	scenario	year
1	M1	2007
2	M2	2007
3	M3	2007
4	CC	2007
5	C2	2007
6	C3	2007
7	A1	2007
8	A2	2007
9	I1	2007
10	I2	2007
11	F1	2007
12	F2	2007
13	F3	2007
14	H1a	2007
15	H1b	2007
16	H3	2007

ID	Code	Output	units
1	FLD	Flood depth	m
2	FI	Fish	kg/ha
3	NIR	Non Irrigated	Ton/ha
4	IR	Irrigated	Ton/ha
5	CLAY	Clay	g/m2

Go Back

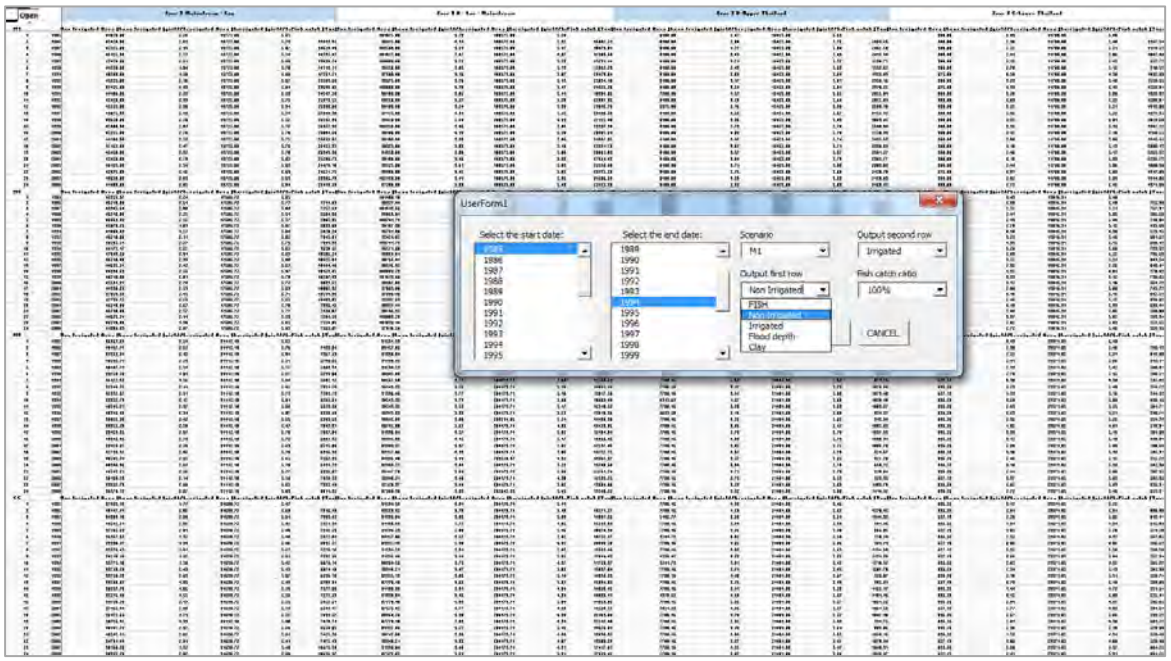
Go to Zones

Go to Description

Go to notes

The iterative process continues to impute the selected years, scenario, and outputs filled as shown in Figure 85.

Figure 85. Input information of statistic values for IWRM WUP FIN statistic files



Both tables shown in Figure 84 and Figure 85 show the main process of reading of information. Initially it is important to fill the ID of the region according to the ID of the shape file of the area of study: the name of the scenario must match with the scenario name given in the ASCII file or later

DBF file. The process continues by selecting the years and outputs requested for the process. When the process starts, information is automatically imputed for each element in the correct position to fit with the properties described. If the regions or scenarios increase or decrease, the tables will adjust to the new values as they have been defined with dynamic vectors.

An automatic graphic generator facilitates the visual identification of model errors and incorrect input information, allowing the user to create graphs from the tables shown in Figure 85 to identify trends or abnormal values. The graphic results are shown in Figure 86.

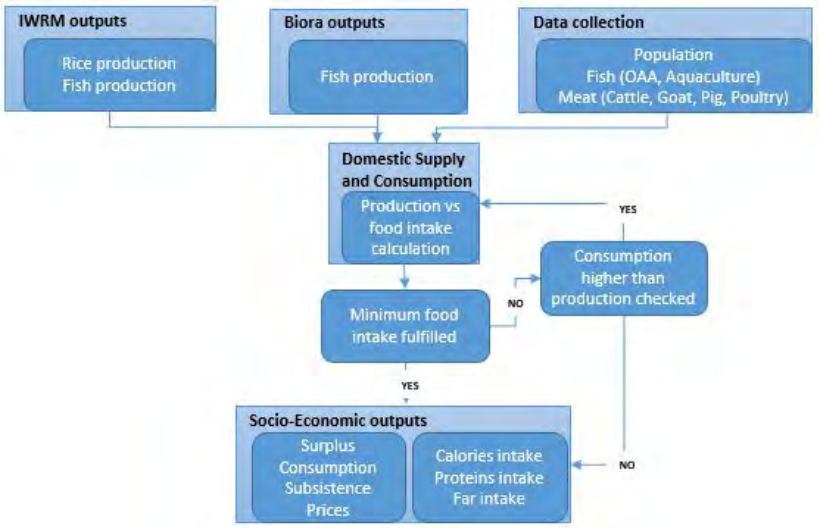
Figure 86. Graphic results of the IWRM WUP-FIN inputs to be created automatizing the process

The graphic generator creates default graphs of the initial conditions which can be readily modified in Microsoft Excel.

10.2.2 Socio-economic tool

The socio-economic assessment related to the results from the modelling teams which uses the input information from multiple sources to develop a domestic food supply, food balance and consumption analysis to evaluate changes in regional food security across the water development scenarios. The methodological process with their main elements of the socio-economic assessment is shown in Figure 87.

Figure 87. Flow chart of socio-economic methodology

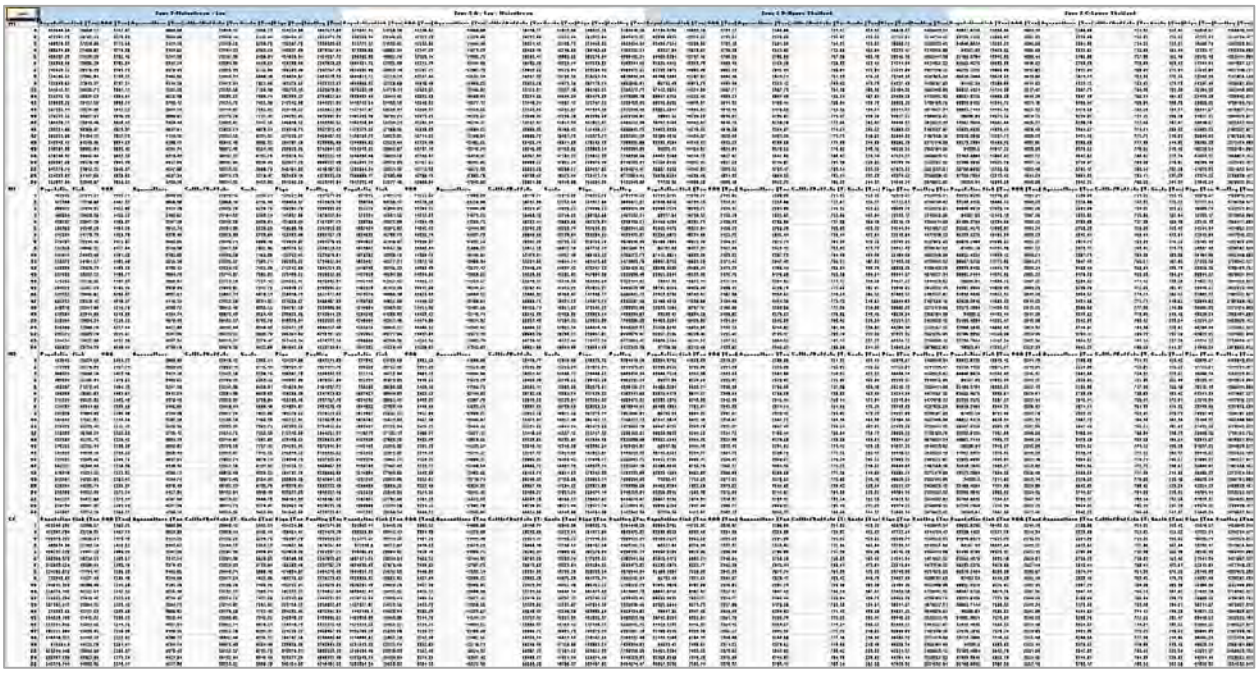


The socio-economic assessment involves input information and output information generated via a central processing calculator. The process is relatively simple when applied to individual spatial units and only for one specific condition. The complexity within the methodology is to account for and automate multiple social and economic variables and adjust the food balance inputs and conditions to run the model.

10.2.3 Socio-economic inputs

The first part of the tool processes the input information specific to each SIMVA zone, collected from BioRA team (environmental team), population estimates, livestock estimates and aquaculture. An example of the input information is shown in Figure 88.

Figure 88. Output table of Socio-economic input variables according to input information collected.

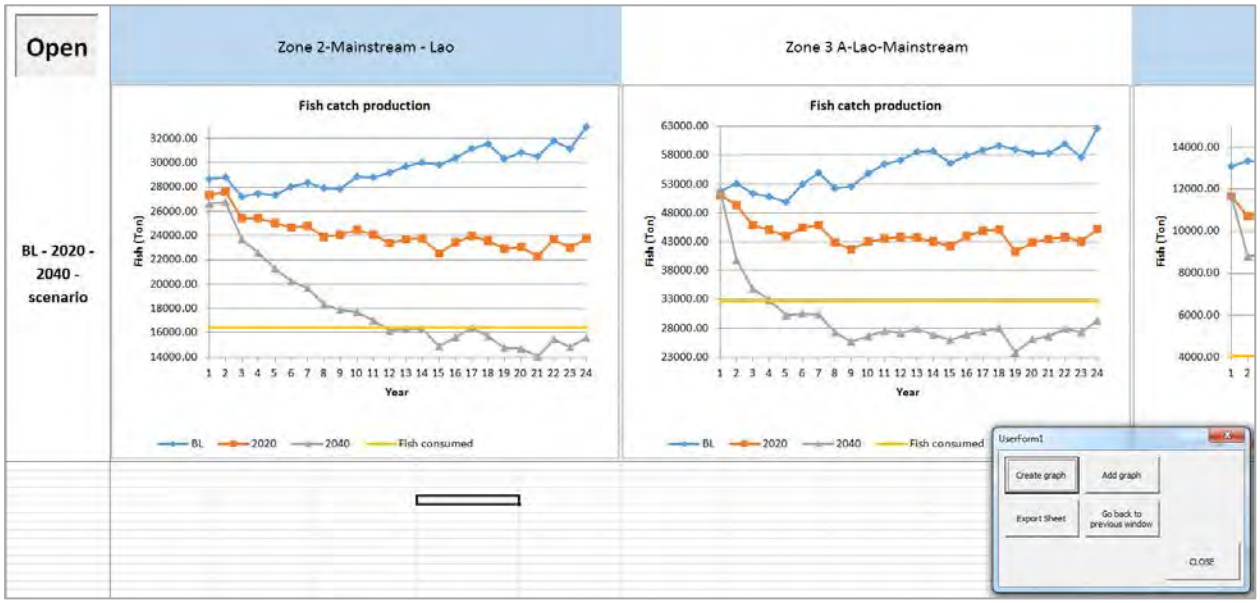


The elements that compose the socio-economic inputs are:

- ✓ Population: calculated from projections of population for each region (it can be adjusted according to the year that the model wants to represent)
- ✓ Fish production (Ton): it comes from Biora results of the projected fish production and environmental assumptions.
- ✓ OAA (Other Aquatic Animals), Cattle/Buffalo, Goats, Pigs, Poultry (Ton): This information comes from historical data collection of Fish and meat production within each region.

All the information shown in the input table is automatically processed and added to each year of the defined projection horizon. The projection can be specified as a single year or any combination form 1-24-years. Graphic outputs (rice fish, OAAs, livestock) derived from the table information are shown in Figure 89.

Figure 89. Output of fish coming from Socio-economic and Biora assessment



The central process of the socio-economic input methodology is the food and nutritional balance calculator (Figure 90).

Figure 90. Domestic supply and consumption calculator for each zone, each year and each scenario.

Food Balance Sheet	Pop.	Domestic Supply and consumption Per Capita Supply Prod. (tonnes	Food	Total Kg/Yr	Total KCal/Da	Prot. g/Day	Fat	% production	Coefficient KCal/	Coefficient Protei	Coefficient fat	max step	importance
Population	1711003												
Grand Total					2225	59.15	32.10						
Rice (Milled Equivalent)		1666877	235941	139.79	1334	27.2	4.4	15.55%	9.5	0.2	0.0	8.99121	0.01%
Meat		25177	11576	6.86	50	2.32	4.50	47.57%	7.36	0.34	0.66	0.14418	0.01%
Fish		136567	93025	55.12	104	16.5	3.8	74.94%	1.9	0.3	0.1	0.73545	0.01%
Aquatic Products, Other		103533	46210	27.38	52	8.18	1.88	44.68%				0.61282	0.01%
all other FAO food sources					684	5.00	17.53						

	Total	Prot.	Fat	Total	Prot.	Fat	Rice		Meat			Fish			Initial conditions for approximation			
Name area	KCal/Dag	g/Dag		KCal/Dag	g/Dag		Coefficient KCal/Da	Coefficient Protein	Coefficient fat	Coefficient KCal/	Coefficient Protei	Coefficient fat	Coefficient KCal/	Coefficient Protei	Coefficient fat	Rice	Meat	Fish	OAA
Zone 2-Mainstream - Lao	2250.00	59.85	34.26	684.00	14.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	140.00	13.00	34.00	7.00
Zone 3 A - Lao - Mainstream	2253.00	61.90	34.66	684.00	14.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	140.00	13.00	34.00	7.00
Zone 2 B-Upper Thailand	2818.00	62.13	64.35	1280.00	11.00	41.16	9.93	0.17	0.02	6.49	0.32	0.57	2.20	0.34	0.02	122.00	27.00	40.00	22.00
Zone 2 C-Lower Thailand	2817.00	61.94	64.32	1280.00	11.00	41.16	9.93	0.17	0.02	6.49	0.32	0.57	2.20	0.34	0.02	122.00	27.00	40.00	18.00
Zone 3 B Thailand-Mainstream	2827.00	62.51	64.43	1280.00	11.00	41.16	9.93	0.17	0.02	6.49	0.32	0.57	2.20	0.34	0.02	125.00	26.00	47.00	14.00
Zone 3 C Thailand-Songkhram	2827.00	54.63	65.09	1280.00	11.00	41.16	9.93	0.17	0.02	6.49	0.32	0.57	2.20	0.34	0.02	122.00	26.00	60.00	6.00
Zone 4 A Cambodia-Khone Falls t	2311.00	63.31	34.71	684.00	5.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	143.00	9.00	63.00	18.00
Zone 4 B Cambodia-3S	2308.00	64.15	34.91	684.00	5.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	143.00	8.00	62.00	20.00
Zone 4 C Cambodia Kratie to Viet	2308.00	63.63	34.92	684.00	5.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	143.00	7.00	56.00	28.00
Zone 5 A Cambodia-Tonle Sap riv	2308.00	62.67	34.58	684.00	5.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	143.00	8.00	60.00	24.00
Zone 5 B Cambodia Tonle Sap lak	2289.00	63.90	34.88	684.00	5.00	17.53	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	142.00	8.00	60.00	26.00
Zone 6 A YietNam Delta - freshwa	2593.00	72.78	53.21	791.00	18.00	23.62	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	148.00	31.00	28.00	11.00
Zone 6 B YietNam Delta - saline	2644.00	74.49	54.49	791.00	18.00	23.62	9.55	0.19	0.03	7.36	0.34	0.66	1.89	0.30	0.07	148.00	31.00	34.00	29.00

The calculator works by replacing the input information from the model to estimate the daily food intake balance; meet the specified nutritional daily intake for kcals, protein and fat; and calculate the difference between the total agricultural production and the total consumption demand (hereby referred to as surplus).

The ranges of variation per region:

- ✓ Minimum calories intake: 2250 – 2650 Kcal/day
- ✓ Minimum Proteins intake: 61 – 74 g/day
- ✓ Minimum Fat intake: 34 – 55 g/day

The food intake depends on rice, meat, fish and OAA needs and each condition affects the balance of the equations. Increased rice intake with less meat intake creates more calories and declining protein intake: the same applies for fish and OAA consumption. The calculator "balances" the model inputs by calibrating the initial conditions so as the daily intake requirements are met for each zone.

Initially, this process was developed manually for each year, each scenario and each region and changes in the input conditions could substantially alter the balance of supply vs. consumption achieved. Automating this process allows users to focus more on output generation than the actual process of nutritional security calibration.

Despite process automation, the calculator is sensitive to the input information. To achieve reliable results, we recommend that the user understands how calculator solves the equations and input information as well as key socio-economic parameters.

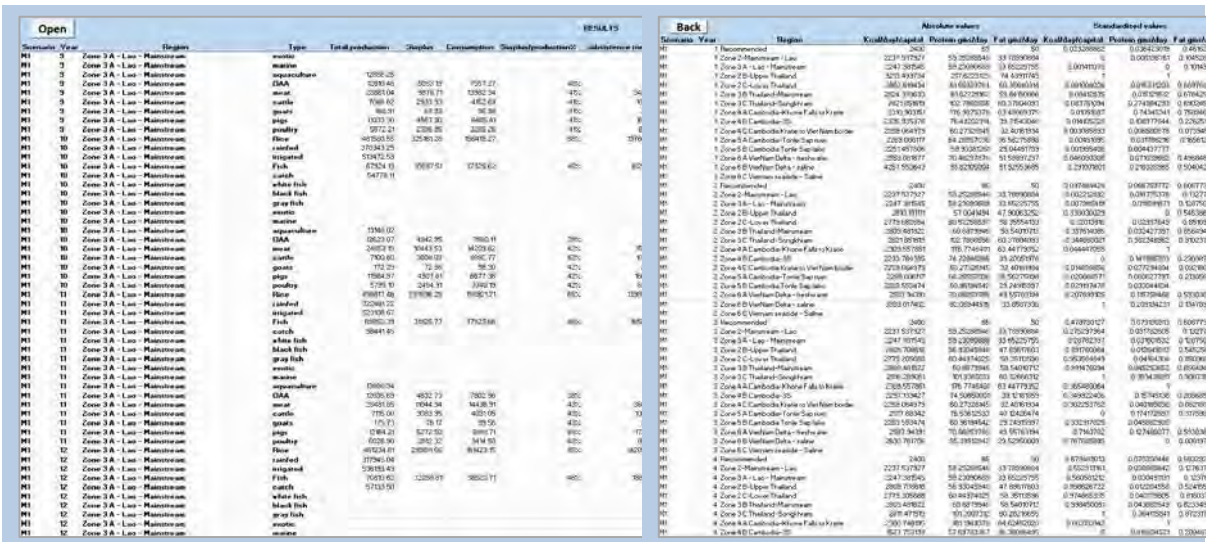
10.2.4 Socio-economic outputs

The socio-economic output windows are composed by two parts; the first output content is the solution of the supply and consumption calculation and associated per unit prices; the second output screen reports the level of calories, proteins and fat.

The model was set to allow calculation for three different output classes: the first and last year of simulation, the whole period of simulation and specific time periods and/or zones.

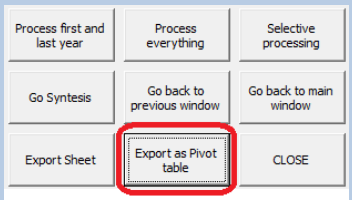
Figure 91 shows the full 24-year Council Study projection horizon: outputs can be modified to any year periods required for analysis.

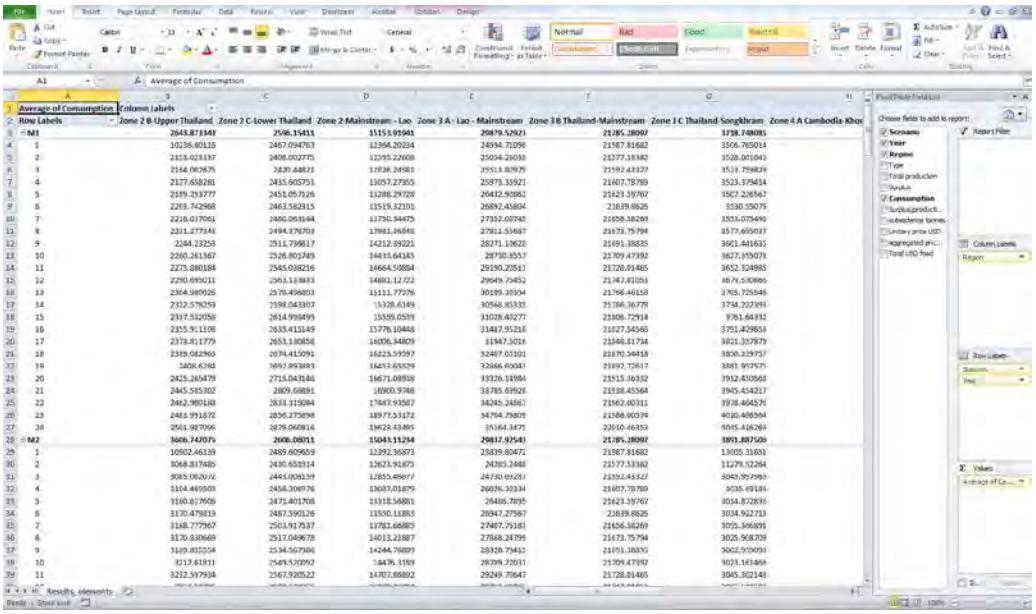
Figure 91. Domestic supply and consumption for every zone and every scenario; first and last year of simulation



Finally, the table outputs were modified to support the creation of a pivot table exported to a new workbook as shown in Figure 92.

Figure 92. Pivot table exported from final results of domestic supply and consumption





The pivot table shown in Figure 93 is the final output of the socio-economic tool. The pivot table supports the analysis and independent management of the columns, rows and values shown in the table. It is possible to show some specific values, filter conditions or group them.

That is the model user can decide which output has more importance for the specific case of interest and identify and assess variable and time series variation, and rapidly produce graphs and tables from key outputs. The tables act as dbf inputs for further GIS representation and analysis.

A tutorial guide is currently being written to assist Member Country users.

10.3 Employment and Income spreadsheet tool

The tool enables estimates of sectoral employment and income aggregated to the CS corridor and Member Country levels. The primary inputs are the SIMVA and EMRF survey data referenced against the MRC social and economic database where data are available; and the social and economic assessment tool used to estimate food security and agricultural surpluses for each of the CS development scenarios. The schematic illustrates the input data sources, spreadsheet analysis and sector employment and income outputs.

The employment and income estimates rely on six sequenced methodological steps:

Step one establishes the relative proportions of existing sectoral employment from the survey data, apportioned to agriculture, fishing, navigation, secondary and tertiary sectors. The majority of survey respondents indicated they have at least two livelihood occupations, mostly involved in agriculture. Sector employment proportions for each corridor zone were calculated by using scaling factors of 0.2 for fishing (the majority of respondents indicated they were part time fishers) and 0.62-0.71 for agriculture, applied to the raw primary and secondary scores to address livelihood diversity. Secondary occupations were scaled down by a factor of 0.3 to calculate Full time employment (FTE) equivalence. Final employment estimates for each corridor were estimated by applying the FTE sector proportions to the zone population estimates for years one and 24 (see Section 5.2). The proportion of working people for each zone were derived from the ADB national estimates (ADB 2017, national statistics available online).

SIMVA 2014 Sectors		q17_subsone_code																											
ONLY Household Head		1.00 Zone 2 A - Mainstream-Lao		2.00 Zone 2 C Subzone Lower Thailand		3.00 Zone 2 B Subzone Upper Thailand		4.00 Zone 3 A - Subzone Lao - Mainstream		5.00 Zone 3 C - Subzone Thailand - Songkhram		6.00 Zone 3 B - Subzone Thailand - Mainstream		7.00 Zone 4 A Subzone Cambodia - Khone Falls to Kratie		8.00 Zone 4 B - Subzone Cambodia - 3Sr		9.00 Zone 4 C - Subzone Cambodia - Kratie to Vietnam border		10.00 Zone 5 A - Subzone Cambodia - Tonle Sap river		11.00 Zone 5 B - Subzone Cambodia - Tonle Sap lake		12.00 Zone 6 A - Subzone Vietnam - Mekong Delta - freshwater		13.00 Zone 6 B - Subzone Vietnam - Mekong Delta - saline	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
$Agg_fishing	1.0 Main occupation	6	1.4%	1	8%	0	0.0%	5	1.2%	3	2.4%	0	0.0%	6	2.7%	0	0.0%	15	8.3%	8	6.8%	57	34.3%	5	4.8%	63	60.6%		
	2.0 Secondary occupation	410	98.8%	123	100.0%	87	100.0%	414	99.0%	122	97.6%	107	100.0%	216	97.7%	51	100.0%	175	96.7%	114	94.2%	140	84.3%	100	95.2%	42	40.4%		
$Agg_LH	1.0 Main occupation	655	97.6%	330	99.1%	326	97.3%	640	96.4%	321	98.8%	312	98.4%	339	99.4%	63	100.0%	282	99.6%	327	97.9%	337	98.5%	613	98.7%	648	99.5%		
	2.0 Secondary occupation	575	85.7%	214	64.3%	241	71.9%	579	87.2%	271	83.4%	221	69.7%	319	93.5%	62	98.4%	259	91.5%	306	91.6%	300	87.7%	278	44.8%	298	45.8%		
$Agg_Nav	1.0 Main occupation	3	33.3%	1	0.0%	1	50.0%	1	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	0.0%	1	0.0%	1	0.0%	2	33.3%	2	100.0%		
	2.0 Secondary occupation	6	66.7%	0	0.0%	1	50.0%	0	0.0%	3	100.0%	1	100.0%	1	100.0%	0	0.0%	2	0.0%	2	0.0%	3	100.0%	4	66.7%	4	0.0%		
$Agg_primary	1.0 Main occupation	508	86.5%	274	95.5%	227	81.7%	486	85.3%	282	94.0%	244	90.4%	283	89.3%	58	95.1%	224	86.8%	262	85.3%	209	81.6%	560	95.2%	573	93.2%		
	2.0 Secondary occupation	454	77.3%	67	23.3%	88	31.7%	421	73.9%	119	39.7%	104	38.5%	219	69.1%	52	85.2%	184	71.3%	221	72.0%	195	76.2%	143	24.3%	168	27.3%		
$Agg_secondary	1.0 Main occupation	67	59.3%	10	35.7%	35	50.0%	86	51.5%	23	33.8%	21	41.2%	18	14.1%	2	8.0%	18	40.0%	36	39.1%	41	45.6%	69	83.1%	64	81.0%		
	2.0 Secondary occupation	46	40.7%	18	64.3%	36	51.4%	83	49.7%	46	67.6%	30	58.8%	110	85.9%	23	92.0%	28	62.2%	57	62.0%	49	54.4%	14	16.9%	15	19.0%		
$Agg_tertiary	1.0 Main occupation	81	46.0%	45	37.8%	64	40.5%	65	36.3%	15	16.7%	49	40.2%	34	44.2%	4	36.4%	29	32.2%	34	34.0%	35	28.9%	173	79.7%	109	57.4%		
	2.0 Secondary occupation	97	55.1%	74	62.2%	97	61.4%	118	65.9%	76	84.4%	75	61.5%	43	55.8%	7	63.6%	65	72.2%	72	72.0%	88	72.7%	54	24.9%	90	47.4%		
fishing effort	0.2		21%		21%		20%		21%		22%		20%		22%		20%		26%		25%		43%		24%		68%		
Agricultural effort	0.57	62.00%	56.34%	71.00%	66.87%	71.00%	70.72%	62.00%	51.79%	71.00%	64.77%	71.00%	58.75%	71.00%	57.48%	71.00%	61.07%	71.00%	61.53%	71.00%	56.82%	71.00%	51.21%	81.00%	76.73%	81.00%	78.51%		
Primary	Total	962	0.44	341	0.42	315	0.39	903	0.39	401	0.44	348	0.38	502	0.44	110	0.54	408	0.46	483	0.43	404	0.32	703	0.61	741	0.61		
Fishing	Total	416	0.07	124	0.05	87	0.03	419	0.07	125	0.05	107	0.04	222	0.07	51	0.08	190	0.09	122	0.05	197	0.13	105	0.03	105	0.08		
secondary	Total	90	0.19	15	0.10	57	0.34	128	0.28	41	0.24	27	0.17	51	0.27	9	0.25	26	0.17	47	0.26	51	0.27	83	0.09	79	0.08		
Navigation	Total	9	0.01	1	0.00	2	0.00	1	0.00	3	0.01	1	0.00	1	0.00	0	0.00	3	0.01	3	0.00	4	0.01	6	0.01	6	0.01		
Tertiary	Total	130	0.28	67	0.43	127	0.22	124	0.27	45	0.26	64	0.41	43	0.22	5	0.15	42	0.23	48	0.26	53	0.28	227	0.25	199	0.21		
			0.99		0.99		1.00		1.00		1.00		1.01		1.01		1.01		1.00		1.01		1.02		0.99		0.99		

2007

M1	Population	Working population	% working population	Primary	Fishing	Secondary	Navigation	Tertiary	Note Primary +secondary	ratio of total employment to working population
Zone 2-Mainstream - Lao	466848	233424	0.5	102851	16700	44947	1708	64674	230879	99%
Zone 3 A-Lao-Mainstream	935282	467641	0.5	180197	33682	128717	384	125183	468164	100%
Zone 2 B-Upper Thailand	82118	46807	0.57	18390	1436	16112	165	10488	46592	100%
Zone 2 C-Lower Thailand	83025	47324	0.57	19838	2227	4620	87	20158	46930	99%
Zone 3 B Thailand-Mainstream	734376	418594	0.57	160558	16807	73119	785	173320	424589	101%
Zone 3 C Thailand-Songkhram	82242	46878	0.57	20566	2170	11304	238	12397	46674	100%
Zone 4 A Cambodia-Khone Falls to Kratie	84263	46345	0.55	20322	3465	12386	70	10346	46590	101%
Zone 4 B Cambodia-3S	6583	3621	0.55	1946	295	889	0	539	3670	101%
Zone 4 C Cambodia Kratie to Viet Nam border	3869504	2128227	0.55	987560	196694	358118	11802	569734	2123908	100%
Zone 5 A Cambodia-Tonle Sap river	1312422	721832	0.55	312931	35122	186386	3421	193318	728178	101%
Zone 5 B Cambodia Tonle Sap lake	891973	490585	0.55	159336	65463	134909	3081	139689	502478	102%
Zone 6 A VietNam Delta-freshwater	7893306	4657051	0.59	2819319	130669	433822	31361	1186476	4601647	99%
Zone 6 B VietNam Delta-saline	3155159	1861544	0.59	1144731	140501	155457	11807	391593	1844089	99%
Totals	19597101	11169873		5948546	645232	1560786	64908	2894916	11114388	100%

Household Head
Primary= farming+ forestry+ livestock
Fishing= fishing+ OAA + aquaculture
Seconday=sand mining + construction+ permanent work+ handicraft
Tertiary=tourism+casual work+house work+business+ self employed

		Cambodia	Lao PDR	Thailand	Vietnam
EMRF (2011-17)	Primary	0.651	0.704	0.843	0.739
	Secondary	0.053	0.047	0.033	0.073
	Tertiary	0.217	0.189	0.063	0.076

Step 2: Rice and fish production estimates for each development scenario by corridor zone were imported from the social and economic assessment tool.

Row Labels	Zone 2-Mainstream - Lao	Zone 3 A - Lao - Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Cambodia-Khone Falls to Kratie	Zone 4 B Cambodia-3S	Zone 4 C Cambodia Kratie to Viet Nam border	Zone 5 A Cambodia-Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta - freshwater	Zone 6 B VietNam Delta - saline
1	75510	432672	40621	36300	336293	53137	5875	738	868657	303067	844050	2507030	765491
Fish	34295	95605	9379	11224	101584	19953	7156	611	133843	111700	124642	1136333	292321
M1	35366	96823	9942	11522	102773	20206	19581	4458	112408	163304	167585	1140102	463393
M2	28183	96264	8880	9520	102227	20090	17396	3949	86993	141421	135007	1066537	385947
M3	14127	97447	6806	5602	103382	20335	11352	2541	83468	131317	114933	1046299	364641
CC	13274	97130	6833	5364	103073	20270	11600	2599	83975	132925	118084	1051503	370120
Rice	116726	769740	71863	61377	571002	86320	4593	864	1603470	494434	1563458	3877727	1238662
M1	92905	491349	64110	37784	448720	91604	12286	868	1587971	488385	1560751	3953331	1207366
M2	105144	648557	70894	62691	578966	88750	12460	863	1643877	524253	1561196	3943127	1208559
M3	139663	991677	79634	73624	648014	87364	10911	925	2031985	549722	1561292	3852348	1208075
CC	129190	947375	72813	71409	608309	77563	4935	802	2015530	550135	1548267	3845670	1194108
24	73096	419864	42588	35532	310970	51965	7099	625	840335	177926	791739	2490649	731911
Fish	27854	77893	8329	9428	84296	16278	7055	603	190030	124530	142038	1240952	344111
M1	41734	121168	11390	13838	128662	25287	21324	4838	151285	187198	182389	1233980	545087
M2	22182	74928	8768	8388	83526	15694	18369	4149	117250	159670	158783	1144719	451117
M3	12527	56992	6268	5697	66019	11972	10609	2341	105982	133769	142311	1120997	426144
CC	11032	48362	5449	4739	55470	10152	10455	2332	105337	144948	126748	1102416	427068
Rice	118338	761834	76848	61635	537644	87652	7143	647	1490641	231323	1441440	3740345	1119712
M1	89815	452081	68617	37834	398515	92435	8197	721	1590780	176079	1481383	3754098	1087345
M2	103124	635493	75584	63030	547224	89554	9899	723	1649221	217133	1483349	3742774	1086921
M3	139791	993786	84725	74088	617274	88157	7633	775	1983997	246730	1483571	3657028	1087331
CC	140622	965975	78465	71588	587562	80462	4820	367	1987728	293066	1538957	3730068	1160859
Grand Total	74303	426268	41605	35916	323631	52551	6487	681	854496	240497	817894	2498839	748701

Step 3: productivity levels for rice production and fishing effort were estimated for each corridor zone for years 1 and 24 of the CS time horizon. Productivity was measured as the number of people required to produce one of tonne of rice and catch one tonne of fish. Productivity was assumed to constant across all development scenarios and for years 1 and 24. Productivity was calculated as the number of people stating their primary or secondary occupation was agriculture divided by the volume of rice -fish production. Several options for productivity levels were and can be investigated. The output estimates the number of people involved in agriculture or fishing for a given production level estimated for each development scenario

		Zone 2-Mainstream - Lao	Zone 3 A-Lao-Mainstream	Zone 2 B-Upper Thailand	Zone 2 C-Lower Thailand	Zone 3 B Thailand-Mainstream	Zone 3 C Thailand-Songkhram	Zone 4 A Khone Falls to Kratie	Zone 4 B 3S	Zone 4 C Kratie to Viet Nam border	Zone 5 A Tonle Sap river	Zone 5 B Cambodia Tonle Sap lake	Zone 6 A VietNam Delta-freshwater	Zone 6 B VietNam Delta-saline	
working population	Primary year1	102851	180197	18390	19838	160558	20566	20322	1946	987560	312931	159336	2819319	1144731	
	Primary Year23	160646	279178	21886	23458	164940	24279	28023	2703	1392308	441009	224575	3571552	1413678	
	Fishing year 1	16700	33682	1436	2227	16807	2170	3465	295	196694	35122	65463	130669	140501	
	Fishing Year 23	26085	52184	1709	2633	17265	2561	4778	410	277308	49497	92266	161258	173511	
	Fishing year 23	26085	52184	1709	2633	17265	2561	4778	410	277308	49497	92266	161258	173511	
M1 Year 1	**Rice**	92905	491349	64110	37784	448720	91604	12286	868	1587971	488385	1560751	3953331	1207366	
	year 1	1.107	0.367	0.287	0.525	0.358	0.225	1.654	2.242	0.622	0.641	0.102	0.713	0.948	
Productivity	proposed	1.20	0.60	0.40	0.79	0.60	0.40	2.50	2.50	0.80	1.10	0.20	1.06	1.50	Productivity estimates
	existing	1.107	0.367	0.287	0.525	0.358	0.225	1.654	2.242	0.622	0.641	0.102	0.713	0.948	
	M23 change	1.951	0.708	0.406	0.785	0.609	0.404	5.551	3.672	0.888	1.199	0.195	1.061	1.515	
	Fish	35366	96823	9942	11522	102773	20206	19581	4458	112408	163304	167585	1140102	463393	
	Year 1	0.47	0.35	0.14	0.19	0.16	0.11	0.18	0.07	1.75	0.22	0.39	0.11	0.30	
		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
M1 Year 23	Rice	89815	452081	68617	37834	398515	92435	8197	721	1590780	176079	1481383	3754098	1087345	
		99429	165796	19683	19864	142594	20753	13559	1618	989307	112822	151234	2677235	1030936	
		-61217	-113382	-2203	-3594	-22346	-3526	-14463	-1085	-403001	-328188	-73341	-894316	-382742	
		-38%	-41%	-10%	-15%	-14%	-15%	-52%	-40%	-29%	-74%	-33%	-25%	-27%	
	Fish	41734	121168	11390	13838	128662	25287	21324	4838	151285	187198	182389	1233980	545087	
		19707	42152	1646	2675	21040	2715	3774	321	264722	40261	71245	141429	165271	
		-6378	-10032	-64	41	3775	154	-1005	-90	-12586	-9236	-21020	-19830	-8240	
		-81%	-86%	-31%	10%	137%	66%	-164%	-458%	-4%	-122%	-82%	-132%	-19%	
M2 Year 1	Rice	105144	648557	70894	62691	578966	88750	12460	863	1643877	524253	1561196	3943127	1208559	
		116400	237851	20336	32916	207162	19925	20611	1936	1022328	335913	159382	2812041	1145862	
		13549	57654	1946	13078	46604	-641	289	-10	34768	22982	45	-7277	1131	
		13%	32%	11%	66%	29%	-3%	1%	-1%	4%	7%	0%	0%	0%	
	Fish	28183	96264	8880	9520	102227	20090	17396	3949	86993	141421	135007	1066537	385947	
		13308	33488	1283	1840	16717	2157	3079	262	152222	30416	52737	122238	117020	
		-3392	-195	-153	-387	-89	-12	-387	-34	-44472	-4706	-12726	-8431	-23482	
		-43%	-2%	-74%	-90%	-3%	-5%	-63%	-172%	-13%	-62%	-50%	-56%	-55%	

Step 4: The agriculture and fishing employment levels were imported into a calculator specific for each development scenario for the population levels estimated for years 1 and 24. Secondary and tertiary employment numbers were calculated as the residual number of working population after agriculture and fishing employment estimates were subtracted.

	1.00 Zone 2 A - Mainstream-Lao	2.00 Zone 2 C Subzone Lower Thailand	3.00 Zone 2 B Subzone Upper Thailand	4.00 Zone 3 A - Subzone Lao - Mainstream	5.00 Zone 3 C - Subzone Thailand - Songkhram	6.00 Zone 3 B - Subzone Thailand - Mainstream	7.00 Zone 4 A Subzone Cambodia - Khone Falls to Kratie	8.00 Zone 4 B - Subzone Cambodia - 3Sr	9.00 Zone 4 C - Subzone Cambodia - Kratie to Vietnam border	10.00 Zone 5 A - Subzone Cambodia - Tonle Sap river	11.00 Zone 5 B Subzone Cambodia - Tonle Sap lake	12.00 Zone 6 A - Subzone Vietnam Mekong Delta - freshwater	13.00 Zone 6 B - Subzone Vietnam - Mekong Delta - saline
										SIMVA sector proportions			
	0.44	0.42	0.39	0.39	0.44	0.38	0.44	0.54	0.46	0.43	0.32	0.61	0.61
	0.07	0.05	0.03	0.07	0.05	0.04	0.07	0.08	0.09	0.05	0.13	0.03	0.08
	0.19	0.10	0.34	0.28	0.24	0.17	0.27	0.25	0.17	0.26	0.27	0.09	0.08
	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
	0.28	0.43	0.22	0.27	0.26	0.41	0.22	0.15	0.27	0.26	0.28	0.25	0.21

M2 Year 1	Population	% working population	working population	Primary to meet food security	Fishing to meet food security	Secondary	Navigation (25% increase)	Tertiary	Total	total occupation/working population
Zone 2-Mainstream - Lao	466848	0.50	233424	116400	28183	35727	1708	51407	233424	100%
Zone 3 A-Lao-Mainstream	935282	0.50	467641	237851	96264	67498	384	65645	467641	100%
Zone 2 B-Upper Thailand	82118	0.57	46807	20336	8880	10555	165	6871	46807	100%
Zone 2 C-Lower Thailand	83025	0.57	47324	32916	9520	895	87	3907	47324	100%
Zone 3 B Thailand-Mainstream	734376	0.57	418594	207162	21040	56257	785	133350	418594	100%
Zone 3 C Thailand-Songkhram	82242	0.57	46878	19925	20090	3160	238	3465	46878	100%
Zone 4 A Cambodia-Khone Falls to Kratie	84263	0.55	46345	20611	17396	4505	70	3763	46345	100%
Zone 4 B Cambodia-3S	6583	0.55	3621	1936	3949	-1410	0	-855	3621	100%
Zone 4 C Cambodia Kratie to Viet Nam border	3869504	0.55	2128227	1022328	86993	388707	11802	618397	2128227	100%
Zone 5 A Cambodia-Tonle Sap river	1312422	0.55	721832	335913	141421	119281	3421	121797	721832	100%
Zone 5 B Cambodia Tonle Sap lake	891973	0.55	490585	159382	135007	94877	3081	98239	490585	100%
Zone 6 A VietNam Delta-freshwater	7893306	0.59	4657051	2812041	1066537	200033	31361	547079	4657051	100%
Zone 6 B VietNam Delta-saline	3155159	0.59	1861544	1145862	385947	90346	11807	227581	1861544	100%

Step 5: median incomes for each sector were estimated from the SIMVA and EMRF datasets and referenced against International employment and income data. The current income estimates are illustrated immediately below followed by alternate reference incomes.

Year 1		Tonle Sap	Nam Ngum	Huai Sai Bart	Vietnam Delta
Median	agriculture	1760	1667	3104	4603
	m'facturing	1549	2780	3900	2262
	service	2002	1803	3900	2100
	mining	0	3432	0	0

Year 23		Tonle Sap	Nam Ngum	Huai Sai Bart	Vietnam Delta
Median	agriculture	4338	6368	14715	17582
	m'facturing	3818	10619	18488	8642
	service	4934	6886	18488	8021
	mining	0	13109	0	0

	Inflation rate	Cambodia	LaoPDR	Thailand	Vietnam
	AV 2004-10	0.057	0.076	0.036	0.111
Wages growth per annum 2012-2016		0.04	0.06	0.07	0.06
	Year 23	4338	6368	14715	17582
		3818	10619	18488	8642
		4934	6886	18488	8021
		0	13109	0	0
	Year 1	2147	2544	3868	3919
		1273	2077	2781	1691
		1645	1347	2781	1569
		0	2565	0	0

Year 12 reference data		Tonle Sap	Nam Ngum	Huai Sai Bart	Vietnam Delta
Median	agriculture	2613	3405	5425	5244
	m'facturing	1549	2780	3900	2262
	service	2002	1803	3900	2100
	mining	0	3432	0	0

Year 2016 reference data		Cambodia	Lao	Thailand	Vietnam Delta
Median	agriculture	2613	3405	5425	5244
	m'facturing	1836	1700	5400	3240
	service	1836	1800	5000	3240
	mining	0	3432	0	0

Year 12 reference data no subsistence		Tonle Sap	Nam Ngum	Huai Sai Bart	Vietnam Delta
Median	agriculture	1760	1667	3104	4603
	m'facturing	1549	2780	3900	2262
	service	2002	1803	3900	2100
	mining	0	3432	0	0

Step 6: Employment numbers and associated incomes were estimated for each sector by corridor zone and development scenario (years 1 and 24). The incomes were further scaled up to national level by aggregating the respective zones located in each of the four member countries.

M1	Primary	Fishing	Secondary	Navigation	Tertiary	Mining	Total	Sec and tert
Zone 2-Mainstream - Lao	199,291,589		124,952,257	2,732,769	116,589,277			
Zone 3 A-Lao-Mainstream	356,537,263		357,832,892	613,803	225,672,690		1,384,222,540	828,393,688
Zone 2 B-Upper Thailand	61,541,862		62,836,676	264,168	40,904,344			
Zone 2 C-Lower Thailand	68,489,548		18,016,572	139,189	78,617,770			
Zone 3 B Thailand-Mainstream	550,539,773		285,165,180	1,256,568	675,947,094			
Zone 3 C Thailand-Songkhram	70,571,926		44,087,326	380,091	48,346,971		2,007,105,060	1,255,961,951
Zone 4 A Cambodia-Khone Falls to Kratie	41,865,475		19,186,569	112,692	20,713,304			
Zone 4 B Cambodia-3S	3,944,736		1,376,956	-	1,079,783			
Zone 4 C Cambodia Kratie to Viet Nam border	2,084,287,373		554,725,424	18,882,607	1,140,607,151			
Zone 5 A Cambodia-Tonle Sap river	612,573,404		288,711,606	5,473,608	381,016,618			
Zone 5 B Cambodia Tonle Sap lake	395,646,064		208,973,924	4,928,956	279,657,702		6,063,763,953	2,925,446,901
Zone 6 A VietNam Delta-freshwater	13,578,794,851		981,483,210	50,176,976	2,491,600,440			
Zone 6 B VietNam Delta-saline	5,915,925,994		351,706,789	18,890,931	822,345,833		24,210,925,023	4,716,204,179
Totals	23,940,009,857	-	3,299,055,381	103,852,358	6,323,098,980	33,666,016,576	33,666,016,576	9,726,006,719

M1 Year 23	Primary	Fishing	Secondary	Navigation	Tertiary	Mining	Total	Sec and tert
Zone 2-Mainstream - Lao	198,600,597		276,746,349	4,268,410	258,223,882			
Zone 3 A-Lao-Mainstream	346,648,776		727,179,507	950,959	458,606,682		2,271,225,162	1,725,975,790
Zone 2 B-Upper Thailand	66,204,122		80,742,894	314,387	52,560,628			
Zone 2 C-Lower Thailand	69,961,560		24,301,561	-	106,043,176			
Zone 3 B Thailand-Mainstream	507,920,732		525,084,835	1,290,865	510,670,742			
Zone 3 C Thailand-Songkhram	72,844,355		58,766,211	448,709	64,444,106		2,141,598,884	1,424,668,114
Zone 4 A Cambodia-Khone Falls to Kratie	30,505,992		39,226,571	155,396	42,347,953			
Zone 4 B Cambodia-3S	3,411,425		1,847,590	-	3,798,950			
Zone 4 C Cambodia Kratie to Viet Nam border	2,207,091,805		1,034,180,184	26,621,565	2,126,445,376			
Zone 5 A Cambodia-Tonle Sap river	269,425,889		658,630,557	7,713,888	869,203,670			
Zone 5 B Cambodia Tonle Sap lake	391,562,851		353,590,563	6,947,060	473,189,777		8,545,897,063	5,643,899,101
Zone 6 A VietNam Delta-freshwater	12,974,311,238		1,750,525,447	61,923,241	4,443,896,678			
Zone 6 B VietNam Delta-saline	5,506,142,499		699,564,005	23,329,220	1,635,690,760		27,095,383,088	8,614,929,350
Totals	22,644,631,842	-	6,230,386,276	133,963,700	11,045,122,380		40,054,104,198	17,409,472,356

11 Annex C: Trends and Data assembly

11.1 Population distribution and projections 2007-2030

Projecting the situation with and without water resources development requires an estimation of the demographic situation in the LMB across the 24-year projection horizon years from 2007 to 2030. The population projections underpin both the assessment with and without water resources development. Whilst there is a probable feedback loop of demographic change brought about by future levels of water resources development, the MRC (2015)[22] considers that this may be a minor effect given the growing significance of other parts of the economy exogenous to the water resources sector.

The population projections were held constant for the M1 (current development), M2 (2020 definite future) and M3 (2040 planned future) and all sub-scenarios. The population and relative distribution projections represent the basis to estimate the total numbers of people, gender disaggregation and the number of households in each sub-assessment unit across each of the 24-years of the CS projection horizon.

The population projections have been made at the assessment sub-zone level using the spatial analysis described in Section 2.6, the SIMVA 2015 population baseline estimates (Table 56) and account for population growth trends and urban migration rates (Country estimates, WDI 2017, ESA 2015[23]). The sources for population data for the SIMVA 2015 sample frame were: Cambodia: CAMInfo 2011, Population Census 2008; Lao PDR: Agricultural Census 2010/11; Thailand: Population Census 2010; Viet Nam: Population Census, Agricultural Census 2011 (MRC 2015 p 17). The SIMVA 2015 population estimates have been used as the reference data to estimate and the 2007 population and future populations for each of the corridor sub-zones.

Table 55 Estimated population of the survey area in the LMB Corridor 2010-11 (SIMVA 2015)

		Total HH sub-zone	Mean number HH members	2010-11 population
Country	**Zone**			
Cambodia	Zone 4 A - Subzone Cambodia - Khone Falls to Kratie	18,380	4.88	89,655
	Zone 4 B - Subzone Cambodia - 3S	1,404	4.98	6,998
	Zone 4 C - Subzone Cambodia - Kratie to Viet Nam border	819,839	5.02	4,113,428
	Zone 5 A - Subzone Cambodia - Tonle Sap river	285,686	4.88	1,395,154
	Zone 5 B - Subzone Cambodia - Tonle Sap lake	187,089	5.07	948,201
	Total	***1,312,398***	***24.83***	***6,553,436***
Lao PDR	Zone 2 A - Mainstream - Lao	94,235	5.38	507,316
	Zone 3 A - Subzone Lao - Mainstream	170,971	5.94	1,016,355
	Total	***265,206***	***11.33***	***1,523,671***
Thailand	Zone 2 B - Subzone Upper Thailand	21,390	3.89	83,108
	Zone 2 C - Subzone Lower Thailand	19,318	4.35	84,025
	Zone 3 B - Subzone Thailand - Mainstream	155,580	4.78	743,228
	Zone 3 C - Subzone Thailand - Songkhram	18,020	4.62	83,233
	Total	***214,308***	***17.63***	***993,594***

[22] MRC (2015) Development trends and future outlook in the Lower Mekong Basin Countries

[23] .United Nations Economic and Social Affairs (2015) http://esa.un.org/unpd/ppp/. Accessed May 2017

Viet Nam	Zone 6 A - Subzone Viet Nam - Mekong Delta - freshwater	1,720,324	4.81	8,279,059
	Zone 6 B - Subzone Viet Nam - Mekong Delta - saline	742,443	4.46	3,309,355
	Total	***2,462,767***	***9.27***	***11,588,415***
Total	**Total**	**4,254,679**	**63.06**	**20,659,116**

Source (SIMVA 2015)

Note that SIMVA 2011 estimated the population living within the LMB corridor (as delineated at the time) to be 33.8 million people. This was based on extrapolation from LandScan GIS information in the absence of official statistical data on the number of households in the LMB Corridor. SIMVA 2015 revised the sample area and reduced the urban boundaries for the sampling regime (MRC 2015: SIMVA Final Report).

The annual growth rates derived for the BDP 2 (MRC 2010) were estimated using Autoregressive integrated moving average (ARIMA) forecasting models. The annual BDP 2 population growth estimates for the LMB were: Lao PDR; 2.1%, Thailand 0.3%; Cambodia 1.5% and Viet Nam 1.2% and cross referenced against the World Development Indicator database (WDI 2017).

Population projections for the CS were therefore estimated through a comparative analysis of ARIMA forecasts and probabilistic population projections (UNESA 2015).

ARIMA population modelling for the LMB countries

ARIMA modelling was applied to the World Bank Population statistics from 1950 to 2015 (World Bank 2017[24]) for the LMB countries and estimate population growth rates and levels from 2016 to 2030. ARIMA models are the most general class of models for forecasting a time series which can be modelled as stationary by analysing the differences between time steps in conjunction with nonlinear transformations if necessary. A time series is stationary if it's statistical properties are constant over time. A stationary series has no trend, variations around the mean have a constant amplitude and short-term random time patterns (wiggles) always look the same in a statistical sense. The latter condition means that the time series autocorrelations (i.e. correlations with own prior or lagged deviations from the mean) remain constant over time. The degree of time series autocorrelations is determined using a Ljung-Box statistical test where significant autocorrelation is established when $p<0.05$. Significant auto-correlation implies the time series analysis and future projections are rejected.

The population data for the LMB are deemed as non-seasonal, where the ARIMA models were denoted ARIMA (p,d,q) where parameters p, d, and q are non-negative integers; p is the order (the number of time lags) of the autoregressive models, d is the degree of differencing (the number of times the data have had past values subtracted), and q is the order of the moving average model. The validity of the models is dependent on the selected parameter values; parameter values for the each of the LMB countries are listed as Model Type in Table 57. Model statistics are reported in Table 58 and illustrated in Figure 94.

Table 56 ARIMA model descriptions used to forecast LMB population for 2030

			Model Type
Model ID	Population Viet Nam	Model 1	ARIMA (1,3,1)
	Population Cambodia	Model 2	ARIMA (2,2,5)
	Population Lao PDR	Model 3	ARIMA (0,2,0)
	Population Thailand	Model 4	ARIMA (0,3,4)

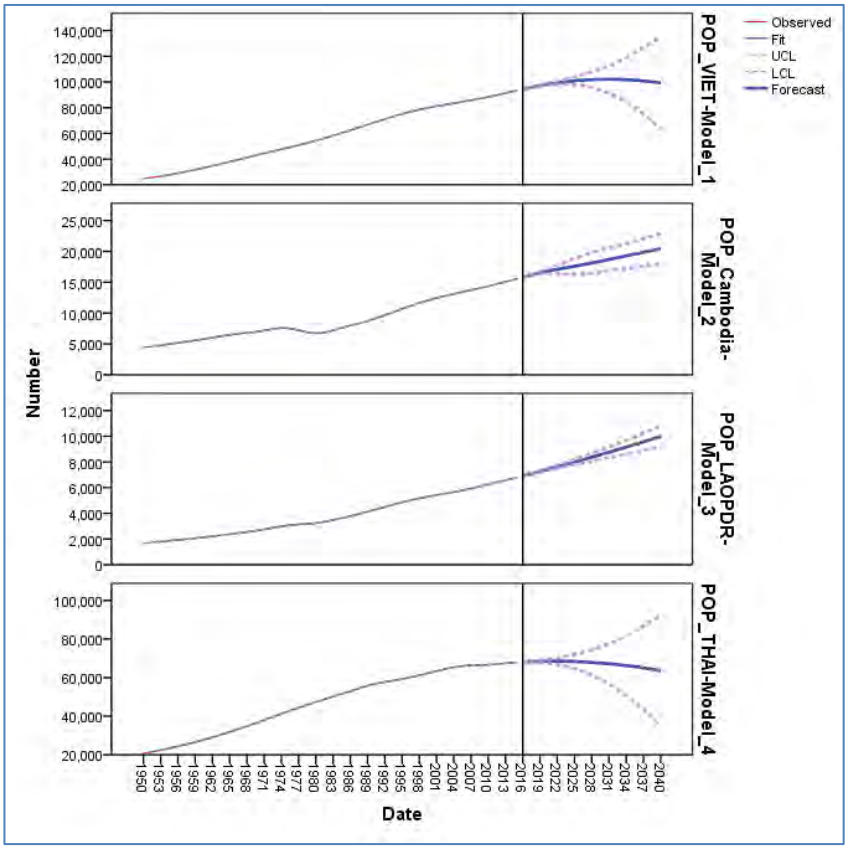
[24] World Bank (2017) http://data.worldbank.org/data-catalog/population-projection-tables accessed May 2017

Table 57 ARIMA model statistics for LMB population forecasts

Model	Model Fit statistics				Ljung-Box Q		
	Stationary R-squared	R-squared	RMSE	Normalized BIC	Statistics	DF	Sig.
Population Viet Nam-Model_1	.800	1.000	5.123	3.399	41.222	16	.001
Population Cambodia-Model_2	.973	1.000	6.471	3.930	65.839	15	.000
Population Lao PDR-Model_3	1.654E-14	1.000	5.351	3.419	142.671	18	.000
Population Thailand-Model_4	.552	1.000	16.968	5.794	109.241	16	.000

The values of the Ljung-Box statistic Q indicates that the assumption of constant autocorrelation is rejected (p<0.05) for all country estimates and the model forecasts for 2030 population levels are also rejected. Therefore, for the purposes of the Council Study, the population growth rates estimated in BDP 2 (MRC 2010) were not applied to the SIMVA zones, requiring investigation of alternative modelling approaches.

Figure 93 ARIMA population models (1950-2015) and forecasts for LMB countries 2016-2030.



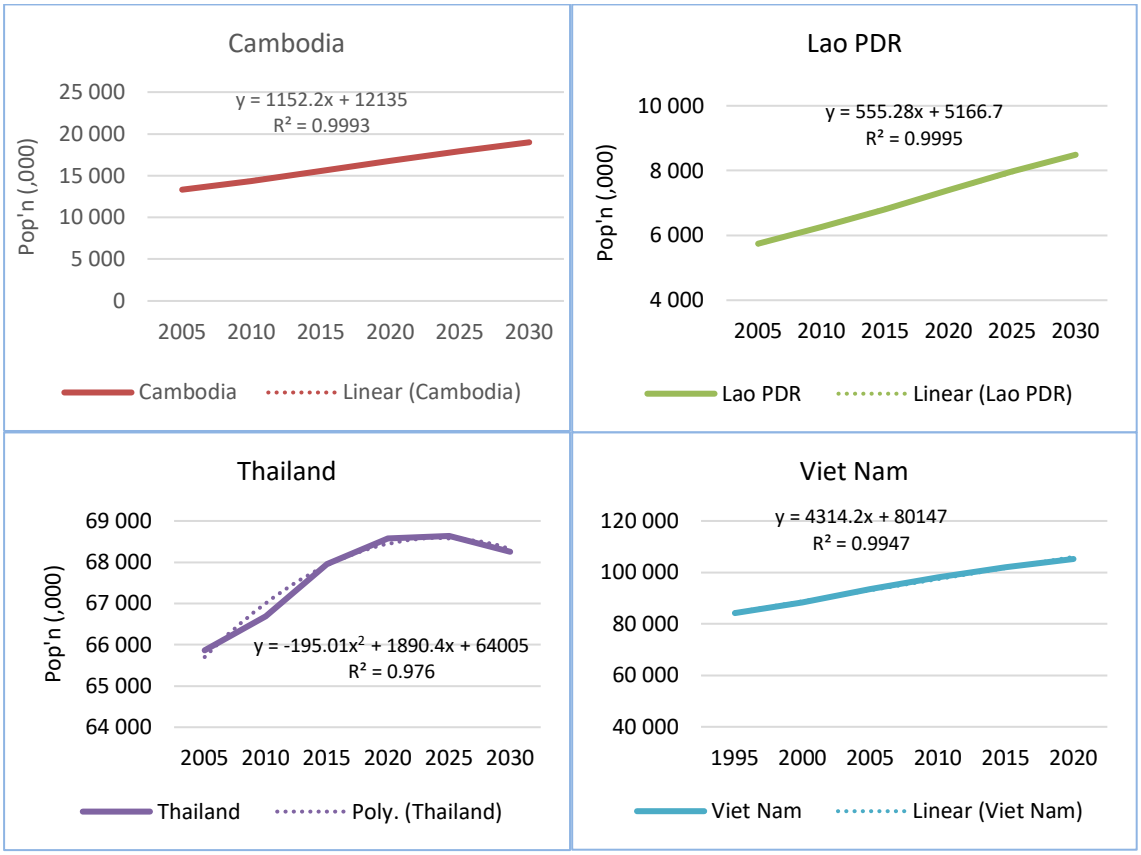
UCL: upper confidence level. LCL: lower confidence level

Probabilistic population projections

The United Nations Economic and Social Affairs[25] deploy a probabilistic population projections computed using Bayesian analysis based on country specific historical estimates of population by age and sex, and components of demographic change such as fertility and mortality and international net migrations between 1950 and 2015 (Gerland et al. 2014) and between country correlations (Fosdick and Raftery 2014) [26].

Population projections for the LMB countries at national level were estimated using OLS regression of the 2005-2030 UNESA population figures, illustrated in Figure 95. R^2 values were >0.976 and all coefficients significant (*t* values p<0.05).

Figure 94 Population projections 2005-2030 for Cambodia, Lao PDR, Thailand and Viet Nam



Source: derived from UNESA (2015)

The population growth rate function for the 24-year projection horizon (applied to M1, M2 and M3 scenarios) were estimated as:

Cambodia: P_t= 1152.2x + 12135

Lao PDR: P_t= = 555.28x + 5166.7

[25] : United Nations (2015). Probabilistic Population Projections based on the World Population Prospects: The 2015 Revision. Population Division, DESA. http://esa.un.org/unpd/ppp/

[26] Gerland, P. et al. 2014. "World population stabilization unlikely this century." Science 10 October 2014: 346 (6206), 234-237. doil:10.1126/science.1257469 - http://www.sciencemag.org/content/346/6206/234.full. Fosdick, B., & Raftery, A. (2014). Regional probabilistic fertility forecasting by modeling between-country correlations. Demographic Research, 30(35), 1011-1034. doi:10.4054/DemRes.2014.30.35. - http://www.demographic-research.org/volumes/vol30/35/

Thailand: $P_t = -195.01x^2 + 1890.4x + 64005$: (note that population estimates for Thailand were assumed to be stable after 2025).

Viet Nam: $P_t = 4314.2x + 80147$

Where:

P_t = population estimate for years t=1-24; x = years 2007 (year 1)-2030 (year 24).

The M1 (2007) population was checked against an estimate using the growth rate function:

$P_j = P_0*(1+r)^{-t}$;

Where:

P_0 = 2011, Pj = 2007, r = growth rate for each country (Cambodia = 1.0154; Lao PDR = 1.021; Thailand = 1.003 and Viet Nam = 1.012); and

t =4

11.1.1 Urban population located in the corridor zones

The proportion of urban population was estimated from the SIMVA 2015 data and referenced against WDI (2017). There are substantial differences in the WDI estimates of the % of the population living in urban centres compared to SIMVA 2015 estimates of the urban population in the corridor zones (Figure 96). The results are consistent with the SIMVA sampling regime which focussed on rural villages.

The urban populations for the Council Study corridor zones (aggregated to country level) for 2010-2011, growth rates over the 24-year projection horizon and urban poluation estimates for 2007 and 2030 are described in Table 59. The annual population estimates for the corridor zones from 2007 to 2030 can be located in the social economic spreadsheet tool (Ward and Munoz 2017[27]).

The annual population estimates for the corridor zones were held constant for the comparison and analysis of all development scenarios.

The SIMVA 2015 values were used to estimate the urban and rural populations for the Council Study. The calculation of rural population assumed that the area outside designated urban boundaries is considered as rural. Therefore, Rural Pop = Total Pop - Urban Pop (see MRC 2015: SIMVA 2015).

Note that the SIMVA 2015 survey derived population estimates for the corridor zones represent 2010-11 country statistics.

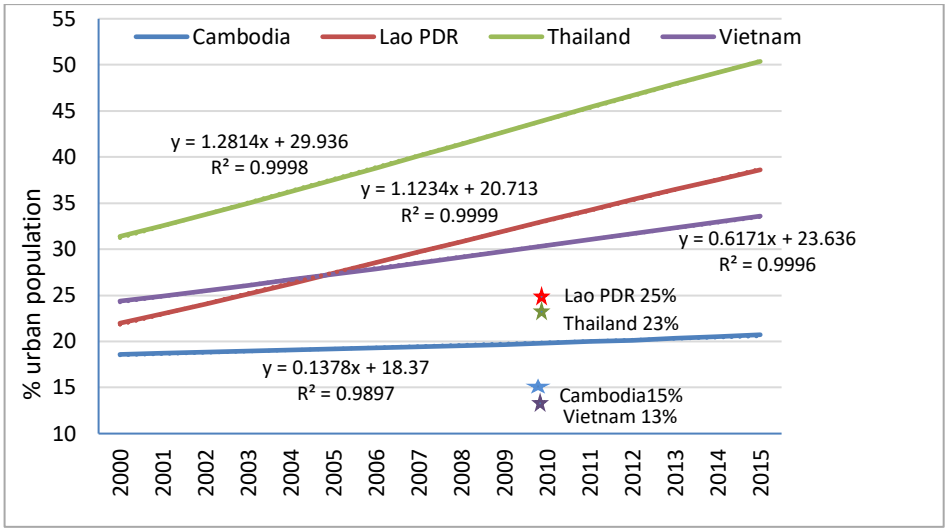
Projected annual urban growth rates were estimated based on WDI 2000-2015 time series data (WDI 2017) and a 3 year moving average analysis extrapolated to 2030. Annual urban growth rates (%) for the four Member countries are generally declining across the four LMB countries through time except Cambodia (Figure 97).

Without access to growth rate data specific to each sub-zone, we assume the national urban growth rates of urban populations are uniformly distributed across the respective corridor sub-zones and adjacent Provinces. The urban populations for the Council Study corridor zones (aggregated to country) for 2010-11, growth rates over the 24-year projection horizon and estimates for 2007 and 2030 are described in Table 59.

The annual population estimates for the CS corridor zones from 2007 through 2030 can be found in the Social economic assessment spreadsheet tool. The population estimates were held constant for all CS development scenarios.

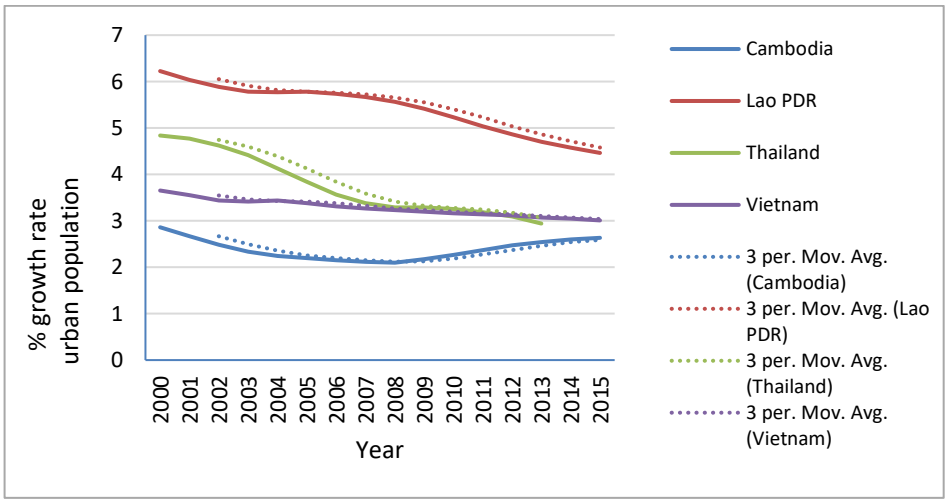
[27] Ward, J and Munoz, A. F.M. (2017) Food and nutritional security spreadsheet tool, developed for the MRC Council Study.

Figure 95 Percent (%) of urban population 2000-2015: Cambodia, Lao PDR, Thailand and Viet Nam.



Source: WDI (2017), SIMVA 2015:★ indicates the urban proportion of SIMVA (2015) population estimates

Figure 96 National urban growth rates from 2000-2015.



Source (WDI 2017)

Table 58 Proportion of urban population (2010) and estimated % for 2007

	WDI whole of country	SIMVA (2015)	CS 2007 M1
Lao PDR	33.10%	25%	23%
Thailand	44.10%	23%	21%
Cambodia	19.80%	15%	14%
Viet Nam	30.40%	13%	12%

The total, urban and rural zone populations reported in SIMVA (2015) and estimates for year 1 and Year 24 of the Council Study are reported in Table 60.

Table 59 Total, rural and urban population estimated for 2007 and 2030 by LMB corridor sub-zone

	SIMVA 2015	Council Study Year 1 (2007)			Council Study Year 24 (2030)		
	Population	Estimated population			Estimated population		
	Total	Total	rural	urban	Total	rural	urban
Zone 2 - Mainstream – Lao PDR	507,316	466,848	350,136	116,712	662,897	425,557	237,340
Zone 3 A - Lao PDR-Mainstream	1,016,355	935,282	701,461	233,820	1,317,295	841,809	475,486
Zone 2 B - Upper Thailand	83,108	82,118	63,231	18,887	97,729	61,745	35,984
Zone 2 C - Lower Thailand	84,025	83,024	63,929	19,096	98,177	61,796	36,381
Zone 3 B Thailand - Mainstream	743,228	734,376	565,469	168,906	754,420	432,619	321,801
Zone 3 C - Thailand - Songkhram	83,233	82,242	63,326	18,916	97,089	61,051	36,038
Zone 4 A - Cambodia - Khone Falls to Kratie	89,575	84,263	71,624	12,639	116,194	92,113	24,081
Zone 4 B - Cambodia - 3S	6,998	6,583	5,596	987	9,143	7,122	2,021
Zone 4 C - Cambodia - Kratie to Viet Nam border	4,113,428	3,869,504	3,289,078	580,426	5,455,404	4,267,617	1,187,787
Zone 5 A - Cambodia - Tonle Sap river	1,395,154	1,312,422	1,115,559	196,863	1,849,580	1,446,718	402,863
Zone 5 B - Cambodia - Tonle Sap lake	948,201	891,973	758,177	133,796	1,257,181	983,380	273,801
Zone 6 A - Viet Nam - Mekong Delta - freshwater	8,279,059	7,893,306	6,867,176	1,026,130	9,741,103	7,547,214	2,193,889
Zone 6 B - Viet Nam - Mekong Delta - saline	3,309,355	3,155,159	2,744,989	410,171	3,896,441	3,019,487	876,954

The assessment of projected development without water resources development was conducted using the population projections for all scenarios and sub-scenarios and applying the assessment criteria described earlier and Table 55.

The development impacts were driven by the predicted changes in the values of the discipline specific indicators under the M1 (where Year 1 =2007 and Year 24 = 2030) exogenous development conditions together with specific data relating to agriculture and fisheries production.

The values of each discipline specific indicator in each sub-zone were determined from the trend analysis (Section 4.3.5) and the value of assessment indicators based on the applied assessment criteria in terms of changes in the population affected from the M1 pre-development situation to the M2 and M3 development scenarios.

Thereafter, the outcomes of the assessment in each sub-zone were standardized and aggregated to provide an estimate of the outcomes by SIMVA sub-zone. The results were up-scaled to country level in consultation with the Macro-economic assessment team.

11.2 Food Balances and food-nutritional security

There are two essential requirements to conduct the CS social and economic assessment; first data specific to the corridor zones, or national and international data that can be reliably interpolated correspond with the corridor spatial boundaries; and two, variables capable of detecting changes in the assessment indicators that correspond with the attributes of the development scenarios. The primary outputs of the IWRM and BioRA Disciplines that detect changes in the development scenarios, were corridor specific and relevant to social and economic assessment were rice production and fish biomass. Developing tools capable of assessing food security was therefore selected as the foundation for the social and economic assessment.

An example of the estimation of food-nutritional security for the Socio-economic assessment is described in the following section, using the food balance tool developed for the CS corridor zones to model the estimated changes in response to the CS Development scenarios.

Food security is a multi-dimensional issue that includes the following four dimensions: food availability, food accessibility, food utilization, and food systems stability. "*Food security exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*"[28].

Food security, as defined by FAO, provides a useful goal towards which LMB countries strive as one key aspect of household wellbeing. Meeting minimum international food security recommendations and nutritional levels is additionally important for Lao PDR and Cambodia for graduation of Least Developed Country status to Lower Middle income status. Evaluating food security is also a useful metric for monitoring the design, implementation, and evaluation of agricultural policies and food related programs (Pinstrup –Anderson 2009). "*However, the interaction between household food access and household food acquisition and allocation behavior means that household food security is of only limited value as an indicator of individual food security*" (Pinstrup-Anderson p 7 2009). The prevalence of poor sanitation and unclean water in many developing countries, and the relationship with food security, limits the value of food security as an indicator of individual health nutrition. The Council Study assessment combines the water security indicators and food security indicators to provide a coherent and more comprehensive understanding of LMB household nutritional status.

Food Balance Sheets (FBS) are the appropriate metric to analyse past, current and future food demand and supply. The FAO short definition is:

> *"A food balance sheet presents a comprehensive picture of the pattern of a country's food supply during a specified reference period."*[29]

A Food Balance Sheet includes: (i) quantities, (ii) calories, (iii) proteins, and (iv) fats. Currently the FAO FBS approach can be considered as the default standard which provides the foundation of the CS socio-economic assessment analysis.

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[28] Pinstrup Anderson, P. (2009) Food Security: Definition and Measurement. Food Sec. (2009) 1:5–7 DOI 10.1007/s12571-008-0002-y

[29] (http://FAOSTAT.fao.org/site/354/default.aspx)

Per capita food supply results act as the basis of the food security sub-assessment indicator, particularly total KCal/day, the contribution of vegetal and animal products and the daily protein and fat levels compared to recommended daily intakes. Contributions of four main food crops were calculated, as it is important to understand the main food sources from livelihood activities and agricultural practices and management. The main food sources imputed to calculate food and nutritional security were rice, fish, other aquatic animals (OAA) and aggregated livestock (comprised of cattle/buffalo, pigs, poultry and goats).

As part of a MRC project, FutureWater (Hunink et al. 2014)[30] prepared Food Balances under climate change scenarios for the BDP zones. Four primary vegetal crops were identified: rice, maize, cassava and sugar cane, as well as fish and animal production.

Rice, livestock, fish and other aquatic animals (OAA) provide the foundation crops used in constructing the food balance sheets for the CS zones. The contribution to nutritional status of additional food sources were imputed as default values calculated from the FAO food balance estimates for each of the four Member Countries.

The FAO national level Food Balance Sheet approach were tailored in three ways to meet the CS socio-economic assessment requirements.

- First, Food balance sheets were developed to align with the CS zones for 2007 (the baseline) and 2011 (the SIMVA sampling year) using the National level FAOSTAT data calibrated against SIMVA 2011.
- Second Food Balances were calculated from estimates of zone specific land use, the area under production, numbers of slaughtered animals (by carcass weight) and crop yields modeled by the Thematic teams and FAO (where data were not available) for each of the CS zones.
- Third, Food Balances were calculated to reflect changes in Developments without water development (exogenous factors or the no dams-M1 scenario) and those associated with the changes in hydrology and land use corresponding with CS Development Scenarios (the M2 and M3 water development scenarios).
- The 2007 food balances (measured as kcal/day/capita, protein gms/day/capita and fat gms/day/capita) were used as the minimum reference level and kept constant for the M1, M2 and M3 main development scenarios and sub-scenario assessments over the 24-year projection horizon.

A spreadsheet tool has been developed to estimate the food-nutritional security and associated Development Scenario changes in agricultural surpluses. Details of the spreadsheet tool can be found in Section 11.2 and Appendix 10.2.

The relative proportions of production and surplus levels were adjusted to ensure household consumption was sufficient to sustain the 2007 food security levels for the entire population of each SIMVA zone. Absolute and relative changes in rice, livestock and fisheries production surpluses were estimated as a measure of food security potential and opportunities.

The economic value of crops and produce sold at market and the value of subsistence production were derived from FAOSTAT and the SIMVA data sets respectively. The economic value of subsistence production and contribution to household food security is a crucial input for the Economic and Cumulative Impact Assessment Disciplines from the Socio-economic assessment.

[30]Johannes Hunink, Peter Droogers, Kien Tran-Mai (2014) Past and Future Trends in Crop Production and Food Demand and Supply in the Lower Mekong Basin: Report prepared by FutureWater for the MRC, Vientiane.

The SIMVA 2011 data represents household level data collected using a proportional probability sampling (PPS) sampling regime specific to villages located within 15 km of Mekong River mainstream. The estimation of household level nutritional status, food security and food sources were primary foci of the survey and represent the most current and robust estimation of food balances and security for the Mekong River corridor.

The SIMVA analysis estimates kcal/day/capita for 2011 only and does not estimate protein and fat intake. The FAOSTAT provides time series food balance (kcal/day, protein and fat) and food security data from 1992 through 2014 at the National level only.

The SIMVA data represent food balance data for the spatial resolution of the Mekong used in the Council Study but only for 2011; the FAO data provides time series data but at the coarse spatial resolution of the National level. Time series are important for the Council Study to estimate values for the baseline year of the pre-development scenario (M1).

The FAOSTAT time series data was calibrated with the SIMVA reference data set to estimate variance and error values.

The FAOSTAT and SIMVA data were compared to estimate the differences in reported food balances. The objective of the analysis was to statistically account for the differences in spatial resolution (National and Mekong zones) and temporal extent of the two data sets. First the variance in the FAO national level food balance data was estimated when compared to the 8 Mekong zones investigated by the SIMVA 2011 survey. Second the analysis estimated the variance of projecting the SIMVA data back to 2000 and 2007, and forward to 2020.

The difference between the two data sets was estimated for 2011 using two food balance estimates;

1) FB1: the set of food sources specific to SIMVA 2011 (kcal/day/capita derived from rice, fish, OAA, eggs, meat and vegetables) and;

2) FB2: the SIMVA food sources plus the additional kcal/day/capita derived from sugar, fruit and oils.

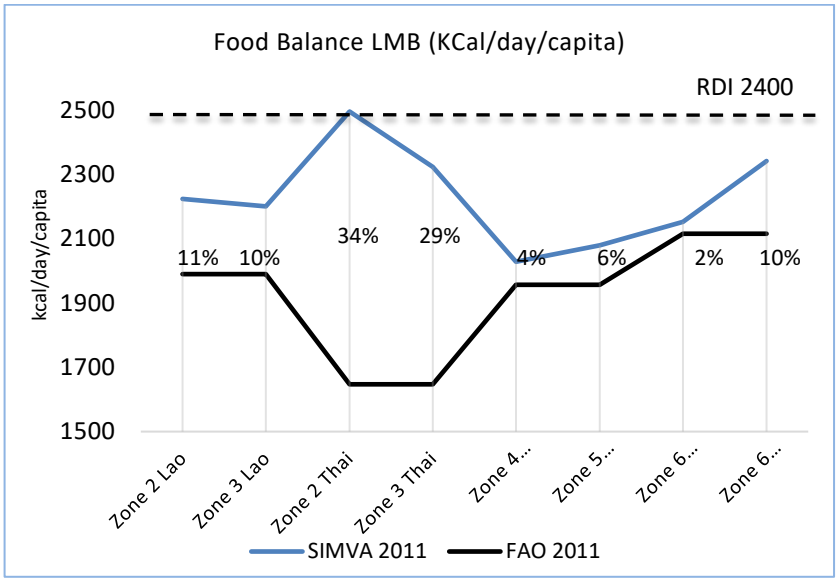
The result for FB1 is reported in Figure 98; the second estimate (FB2) is illustrated in Figure 99. Variance for food balance estimate 1) ranges from 2% (Zone 6 in Viet Nam) to 34% (Zone 2 in Thailand). Variance for food balance estimate 2) ranges from 0% (Zone 3 in Laos) to 10% (Zone 6 in Viet Nam). The estimated variance from food balance estimate 2) was used for further analysis and summarized in Table 61.

Table 60 Variance estimates and sensitivity bounds for the SIMVA zones

Kcal/day/capita	Zone 2 Lao PDR	Zone 3 Lao PDR	Zone 2 Thailand	Zone 3 Thailand	Zone 4 Cambodia	Zone 5 Tonle Sap	Zone 6 Viet Nam Fresh	Zone 6 Viet Nam Saline
SIMVA 2011	2224	2200	2495	2323	2028	2078	2152	2341
FAO 2011 (FB1)	1990	1990	1647	1647	1956	1956	2115	2115
FAO 2011 (FB2) (sugar/fruit/oil)	2200	2200	2368	2368	2210	2210	2369	2369
FAO/SIMVA (% ratio)	89%	90%	66%	71%	96%	94%	98%	90%
FAO/SIMVA + fruit and sugar (% ratio)	99%	100%	95%	102%	109%	106%	110%	101%

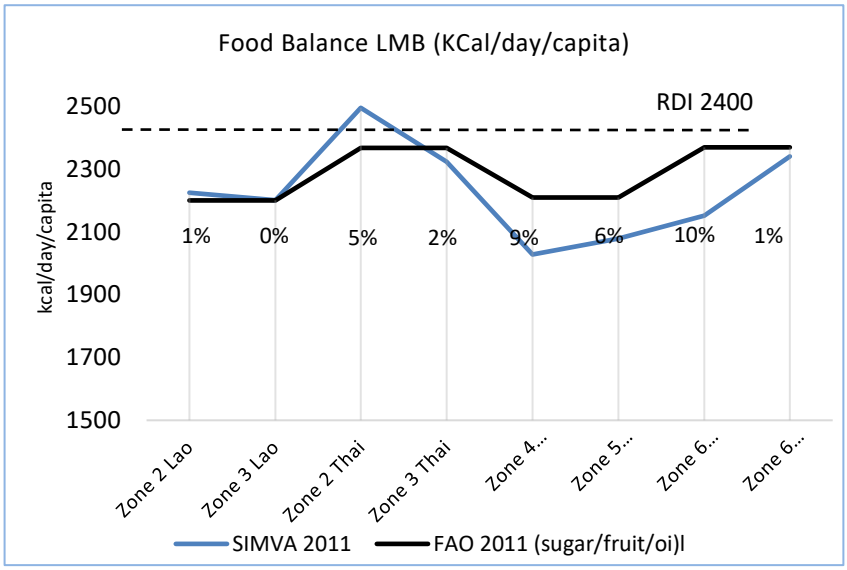
% variance	±1%	±1%	±5%	±2%	±9%	±6%	±10%	±1%

Figure 97 Comparison of FAO (2011) and SIMVA (2011) kcal/day/capita for the 8 Mekong zones (FB1).



(RDI 2400 represents FAO recommended daily Intake)

Figure 98 Comparison of FAO (2011) and SIMVA (2011) kcal/day/capita for the 8 Mekong zones (FB2).



(RDI represents recommended daily Intake)

11.2.1 Projections of FAO food-nutritional balances to Council Study baseline years

A final step calibrated the FAO food balance data to the SIMVA data. The FAO estimates rely on an expanded set of food sources compared to the set used in SIMVA, resulting in an increased estimate of total kcal/day/capita. In 2011 the differences in Kcal/day/capita between SIMVA and the FAO FB2

estimate were: Cambodia (-216); Lao PDR (-202); Thailand (-392) and Viet Nam (-347). For further analysis, the respective differences in Kcal/day/capita estimates for 2011 were assumed to be constant through time.

The differences in the Kcal/day/capita estimates for Thailand (SIMVA 2011 compared to FASSTAT) is illustrated in Figure 100.

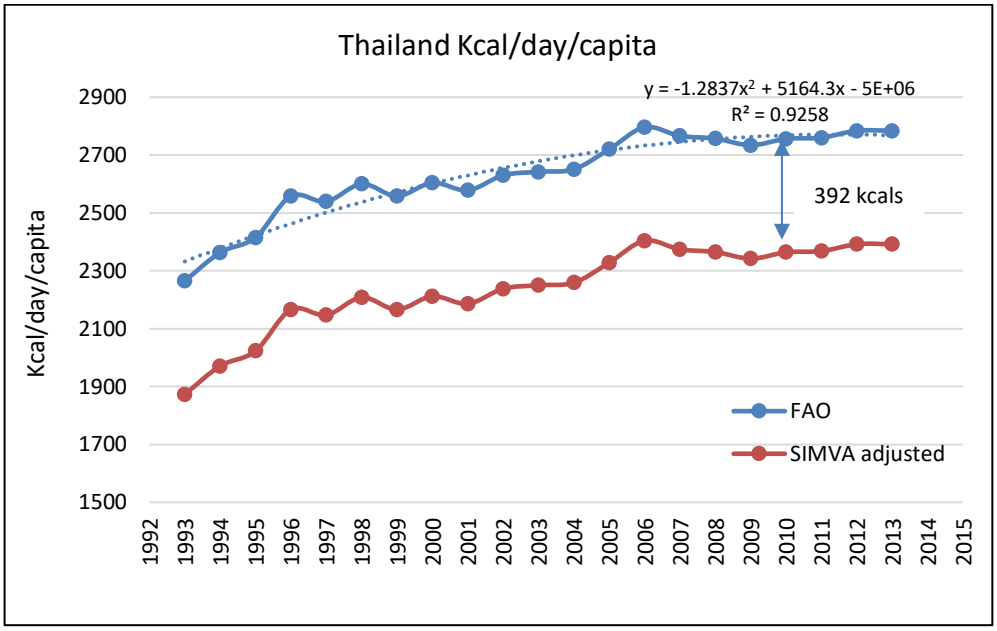
2007 is the year 1 baseline reference date for the Council Study. The FAO data was used to estimate the ranges of estimated Kcal/day/capita for each SIMVA zone for 2007 ± the respective estimated variance. The results for the FAO 2007 and the FAO values minus the difference in the SIMVA data are detailed in Table 62.

Table 61 Estimated ranges of food balance (kcal/day/capita) for the SIMVA (2011) zones

	Zone 2 Lao PDR	Zone 3 Lao PDR	Zone 2 Thailand	Zone 3 Thailand	Zone 4 Cambodia	Zone 5 Tonle Sap	Zone 6 Viet Nam Fresh	Zone 6 Viet Nam Saline
				Kcal/day/capita				
2007 FAO [a]	2255-2301	2255-2301	2628-2904	2711-2821	2173-2603	2245-2531	2293-2803	2523-2573
2007 SIMVA adjusted [b]	2053-2099	2053-2099	2236-2512	2319-2429	1957-2387	2029-2315	1946-2456	2176-2226

[a] Represents the full suite of FAO food sources. [b] represents the FAO data minus the difference in the constrained set of SIMVA food sources.

Figure 99 Estimates of Kcal/day/capita comparing SIMVA 2011 and FAO data (1992-2014) for Thailand.



Changes in irrigated area (primarily rice production) and fish biomass and subsequent catch in response to the altered hydrological sediment and nutrient regimes associated with the Development scenarios are a focus of the CS Discipline and Thematic teams. The modelled changes over the 24-year projection horizon of rainfed and irrigated rice area, changes in rice yields and fish production therefore represent the primary inputs of the food-nutritional calculations. Livestock

production and consumption of Other Aquatic Animals (OAAs) in the corridor zones have been included as additional inputs to the food security estimates.

The daily intake for nutrition by Corridor zone (**held constant for all development scenarios**) are listed in Table 63.

Table 62 Nutritional values for M1 scenario by corridor zone

Scenario M1	Absolute values		
Sub-Zone	Kcal/day/capita	Protein gms/day	Fat gms /day
Recommended daily intake	2400	65	50
Zone 2-Mainstream - Lao	2238	60	34
Zone 3 A-Lao-Mainstream	2253	62	35
Zone 2 B-Upper Thailand	2818	62	64
Zone 2 C-Lower Thailand	2817	62	64
Zone 3 B Thailand-Mainstream	2827	63	64
Zone 3 C Thailand-Songkhram	2839	65	65
Zone 4 A Cambodia-Khone Falls to	2311	63	35
Zone 4 B Cambodia-3S	2308	64	35
Zone 4 C Cambodia Kratie to Viet	2283	63	34
Zone 5 A Cambodia-Tonle Sap river	2291	63	35
Zone 5 B Cambodia Tonle Sap lake	2289	64	35
Zone 6 A Viet Nam Delta-	2593	73	53
Zone 6 B Viet Nam Delta-saline	2644	74	54

Source: adapted from SIMVA (2014) and FAOSTAT (2017)

The FAOSTAT data (2017) indicates that rice, fish, OAAS and livestock are the primary sources of kcals (energy), protein and fat in LMB national households in addition to a range of additional food sources. The aggregate nutritional contribution of food sources other than rice, meat, fish and OAA are listed in the 2007 FAO food balance estimates for the four LMB countries. SIMVA does not report these additional food sources and does not include estimates for protein and fat daily intakes in the corridor sub-zones. The contribution of the additional food sources has been included as a set of food-nutritional balance factors in the corridor food security estimates, listed in Table 64. The FAO values represent estimates only and the error or variance between national averages and those for the corridor have not been estimated due to data constraints.

Table 63 Additional food balance factors for the four Council Study countries

All food sources not including rice, fish, OAAs and meat			
Country	KCal/Day/ capita	Protein/ gms/day/ capita	Fat gms/day/ capita
Lao PDR	684	14	18
Cambodia	684	14	18
Thailand	1280	11	41
Viet Nam	791	12	24

Source (FAOSTAT 2017)

The following sections detail the trend analyses and projected changes in livestock production, rainfed and irrigated rice production and capture and farmed fish and OAAs used to estimate the food balances for each of the CS corridor zones.

11.3 Changes in LMB and corridor zone livestock populations

Livestock play an important role in many of the farming systems of LMB countries by providing a source of animal protein, cash income, draught power and manure, as well as financial security for subsistence farm households. The 2007 numbers of livestock for the four LMB countries are listed in Table 65 and the historic trends in livestock numbers between 1961 and 2014 illustrated in Figure 101 (Pigs), Figure 102 (cattle) and Figure 103 (poultry) (FAOSTAT 2017) [31].

Cattle/buffalo numbers have increased across all LMB countries except Thailand. The historical trajectory of cattle numbers in Thailand are unique amongst PLMB countries. First a substantial reduction in numbers from 1,879,450 in 1993 to 541,000 in 2000. In 2011 the number of slaughtered animals increased from 657,000 to 1,200,000 in 2014. Farm mechanisation and changes in dietary habits are cited as potential reasons for the rapid changes in cattle numbers (MRC 2015)[32]. The number of slaughtered animals is function of take-off/ retention rates and affects carcass weights, or the amount of meat available for consumption. The relationship between carcass weights and the number of slaughtered animals is central to food and security calculations. Thai carcass weights fell from 289kgs per animal to 170 kgs, which appears to be a continuing trend (FAO 2017). 2007 and 2023 carcass weight estimates for the LMB countries used in the CS assessments are detailed in Table 67.

Pig production (number of slaughtered animals) has continued an increasing trajectory in Cambodia, Lao PDR and Viet Nam, although the numbers have stabilised and slightly decreased in Thailand. Viet Nam is the major pig producer with 47 million in 2014 (compared to 38 million in 2007) followed by Thailand (2014: 12.8 m, 2007: 13.5 m), Lao PDR (2014: 2.3 million, 2007: 1.5 m) and Cambodia (2014: 2.2 million, 2007 2.4 m). With increasing per income capita incomes, the consumption of pig meat is likely to increase in the foreseeable future.

Poultry production has substantially increased in all LMB countries. Viet Nam and Thailand are the main poultry producers with 471 million and 133 million, respectively in 2014 (FAOSTAT 2017). Both Viet Nam and Thailand have also developed large industries for the export of poultry products. Poultry production is also becoming important in Lao PDR (34 million) and Cambodia (24 million) in 2014. The production of poultry meat and eggs is likely to continue to expand rapidly in response to domestic and export demand.

Table 64 2007 livestock estimates for the LMB countries

Country	Livestock	Animals Slaughtered	Total 2007
Cambodia	Pigs	Head	2,400,000
	Beef & Buffalo	Head	573,000
	Poultry	1000 Head	23,500
Lao PDR	Pig	Head	1,533,333
	Beef & Buffalo	Head	358,000
	Poultry	1000 Head	22,800
	Goat	Head	74,000
Thailand	Pig	Head	13,544,699
	Beef & Buffalo	Head	602,936

[31] http://www.fao.org/FAOSTAT/en/#data

[32] MRC (2015) Development trends and future outlook in the Lower Mekong Basin Countries: working document in support of the State of the Basin Report 2016-2020. Basin Development Plan Programme.

	Poultry	1000 Head	937,301
	Goat	Head	123,138
Viet Nam	Pig	Head	38,000,000
	Beef & Buffalo	Head	1,710,000
	Poultry	1000 Head	300,300
	Goat	Head	754,000

Source FAOSTAT (2017)

The MRC State of the Basin report (MRC 2015)[33] reports that smallholder farmers producing primarily meat and some milk represent the majority of production and ownership in the livestock sector (MRC social and Economic database 2015). Rice based farming systems common to Cambodia and Lao PDR retain some dependence on cattle and buffalo for draught power and manure, albeit these are being replaced by mechanised farm machinery. Most rural households rear poultry. Meat production has increased over the past two decades due to an increase in the number of animals but productivity remains variable (see Table 67). Commercial businesses are increasingly entering the livestock industry to supply a growing urban market[34]. Commercial pig and poultry production, located near urban centres, remain predominately small enterprises. There is significant scope to increase livestock productivity, particularly in Lao PDR and Cambodia (FAOSTAT 2017). The MRC (2015) contend that increasing productivity continues to be constrained by low quality fodder, inadequate animal health services and low potential of native livestock breeds. National pig, cattle and poultry production for Cambodia, Lao PDR, Thailand and Viet Nam from 1961 through 2013 are illustrated in Figure 101, Figure 102 and Figure 103 respectively.

Figure 100 LMB pig numbers: 1961-2014

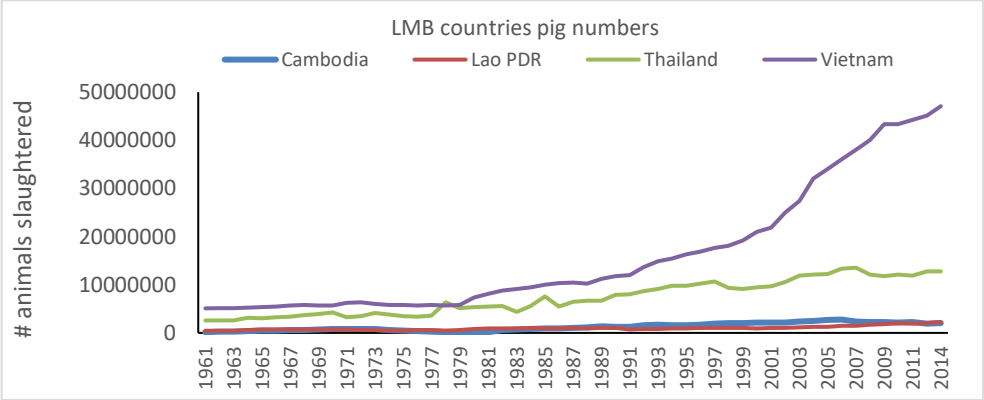
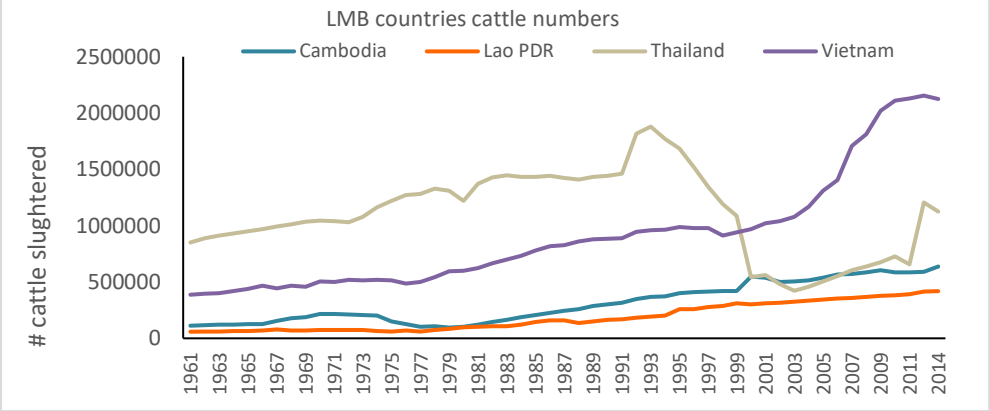


Figure 101 LMB cattle numbers: 1961-2014

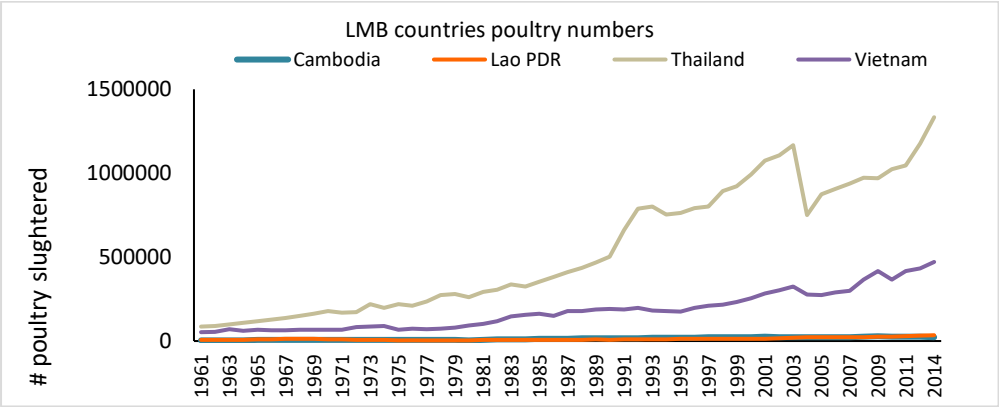
[33] MRC Basin Development Programme (2015) Development trends and future outlook in the Lower Mekong Basin Countries

[34] Luong Pham, Dominic Smith, Monticha putsakum, Warinthorn Maneerat and Witipon Intarathamwarin (2015), The Thai Beef Industry in "Regional Workshop on Beef markets and trade in Southeast Asian and China", Ben Tre, Vietnam, 30th Nov – 3rd Dec, 2015
Nampanya S, Khounsy S, Phonvisay A, Bush RD, Windsor PA. (2015) Improving smallholder food security through investigations of carcass composition and beef marketing of buffalo and cattle in northern Lao PDR. Trop Anim Health Prod. 2015 Apr;47(4):681-9
Luong Pham, Dominic Smith, Soun Sotheun and Sau Vitau (2015), The Cambodian Beef Industry in "Regional Workshop on Beef markets and trade in Southeast Asian and China", Ben Tre, Vietnam, 30th November – 3rd December, 2015
Dominic Smith, Luong Pham, Aloun Phonvisay (LRC) and Khamsone Sisaath (2015), The Lao Beef Industry in "Regional Workshop on Beef markets and trade in Southeast Asian and China", Ben Tre, Vietnam, 30th November – 3rd December, 2015



Source: FAOSTAT (2017)

Figure 102 LMB poultry numbers: 1961-2014



Source: FAOSTAT (2017)

11.3.1 Estimates of livestock in the CS corridor zones

There are no current livestock data available for the CS corridor zones. Estimates of the M1 Year 1 (2007) livestock numbers were derived from the FAO (2017) national values for 2007 divided by the proportion of the national population of the respective CS corridor zones assuming uniform zonal distributions (Table 66). The livestock numbers reflect the contribution of daily intakes of protein and fat for whole of country derived from the FAO data. Variations in the zonal numbers were compared to national averages, however data deficits preclude reliable estimates.

Table 65 Estimated Year 1 (2007) livestock numbers for the CS corridor zones

	Proportion of national livestock	cattle	goats	pigs	poultry
Zone 2-Mainstream - Lao	0.0810	29010	5997	124252	1847572
Zone 3 A-Lao-Mainstream	0.1623	58119	12013	248926	3701419
Zone 2 B-Upper Thailand	0.0012	751	153	16879	1168014
Zone 2 C-Lower Thailand	0.0013	751	153	16879	1168014
Zone 3 B Thailand-Mainstream	0.0111	6719	1372	150945	10445452
Zone 3 C Thailand-Songkhram	0.0012	751	153	16879	1168014
Zone 4 A Cambodia-Khone Falls to	0.0062	3577	462	14980	146683
Zone 4 B Cambodia-3S	0.0005	279	36	1169	11449
Zone 4 C Cambodia Kratie to Viet	0.0971	55656	7188	233115	2282586
Zone 5 A Cambodia-Tonle Sap	0.0660	37826	4885	158434	1551335
Zone 5 B Cambodia Tonle Sap lake	0.0353	20239	2614	84769	830027

Zone 6 A Viet Nam Delta-	0.0952	162853	71808	3618949	71807559
Zone 6 B Viet Nam Delta-saline	0.0381	65096	28703	1446588	28703347

Source: derived from FAO (2017) and (SIMVA 2015)

The changes in livestock numbers from 2007 to 2030 (the24-year CS projection horizon) were estimated as the change in the number of slaughtered animals from 2007 to 2014 for the respective livestock for the four LMB countries (FAOSTAT 2017). The changes were assumed to occur uniformly over the 24-year as equal annual increments and aggregated at national level. The estimated changes for livestock from 2007 to 2030 at the national level were assumed to also occur in the in the Cambodian, Lao PDR, Thai and Viet Namese corridor zones.

Relative changes in livestock and changes in carcass weights over the 24-year projection horizon are derived from the FAOSTAT time series data. The total % estimated changes for the four LMB countries and respective carcass weights estimates are listed in Table 67. Details for the annual changes in livestock for each of the 24-years of the CS projection horizon for each of the corridor zones can be found in the social economic assessment spreadsheet tool.

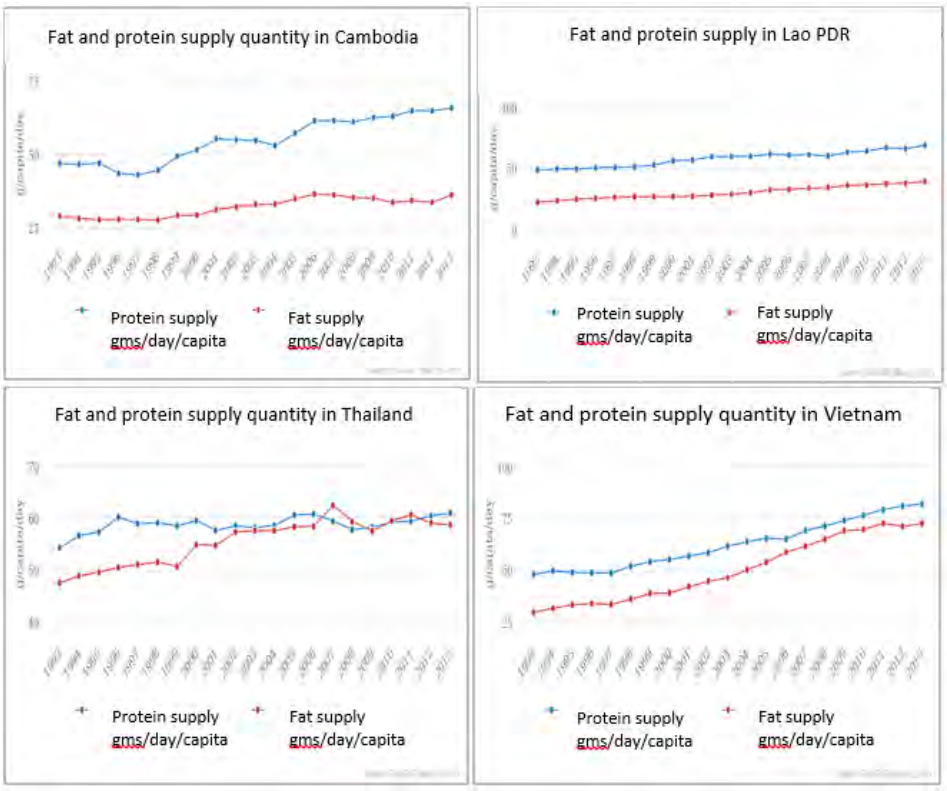
Table 66 Estimates for % changes in livestock production and carcass weight by LMB country 2007-2030

Livestock	Lao PDR		Thailand		Cambodia		Viet Nam	
% change from 2007 # slaughtered animals	2030		2030		2030		2030	
Cattle	26%		87%		11%		23%	
Buffalo	0%		0%		0%		0%	
Goats	0%		0%		0%		0%	
Pigs	49%		-5%		-13%		24%	
Poultry	52%		42%		0		57%	
Carcass weight (kgs)	2007	2030	2007	2030	2007	2030	2007	2030
Cattle	120	170	250	170	120	140	170	170
Buffalo	150	170	400	180	200	200	215	215
Goats	12	12	12	12	12	12	12	12
Pigs	30	30	70	70	50	50	70	70
Poultry	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

Source: FAOSTAT (2017) derived as % change of total national slaughtered animals 2007-2014

The protein and fat intake for the LMB countries for 1993-2013 are illustrated in Figure 104.

Figure 103 Fat and Protein supply Cambodia, Lao PDR, Thailand and Viet Nam: 1993-2013



Source: FAO (2017)

11.4 Rice production

Rice production is the dominant agricultural crop in the LMB countries, with an estimated total of over 13.1 million hectares cultivated in 2013 (Table 68; CS irrigation Thematic Team 2017). Thailand has the largest area of rice (approximately 5.9 million hectares) followed by Viet Nam (~3.9 million hectares), Cambodia ~(2.47 million hectares) and Lao PDR (~0.75 million hectares). The total rice harvest increased by 30% from 2007 (36,870,021 tonnes) to 2013 (47,960,404).

The total estimated M1, M2 and M3 corridor hectares used for dryland and irrigated rice production were derived from the CS Irrigation Thematic team combined with the rice yield estimates from the Modelling results (Table 69). Details for the annual changes in rainfed and irrigation hectares under rice production and projected yields for each of the 24-years of the CS projection horizon for each of the corridor zones can be found in the social economic assessment spreadsheet tool.

Table 67 Total LMB dryland and irrigated rice production hectares (2007-2013)

Country	**2007**		**2010**		**2013**	
Rice Area (ha)	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
Cambodia	1824961	291287	1958766	343914	2062004	410419
Lao PDR	581078	69777	604002	106440	657488	90962
Thailand	5202824	166713	6170188	543395	5640349	356514
Viet Nam		3305199		3536052		3887295
Total	7608864	3832977	8732956	4529801	8359841	4745190
	17943487	18926534	21639592	23384284	21945543	26014861

Total harvest	**36870021**	**45023876**	**47960404**

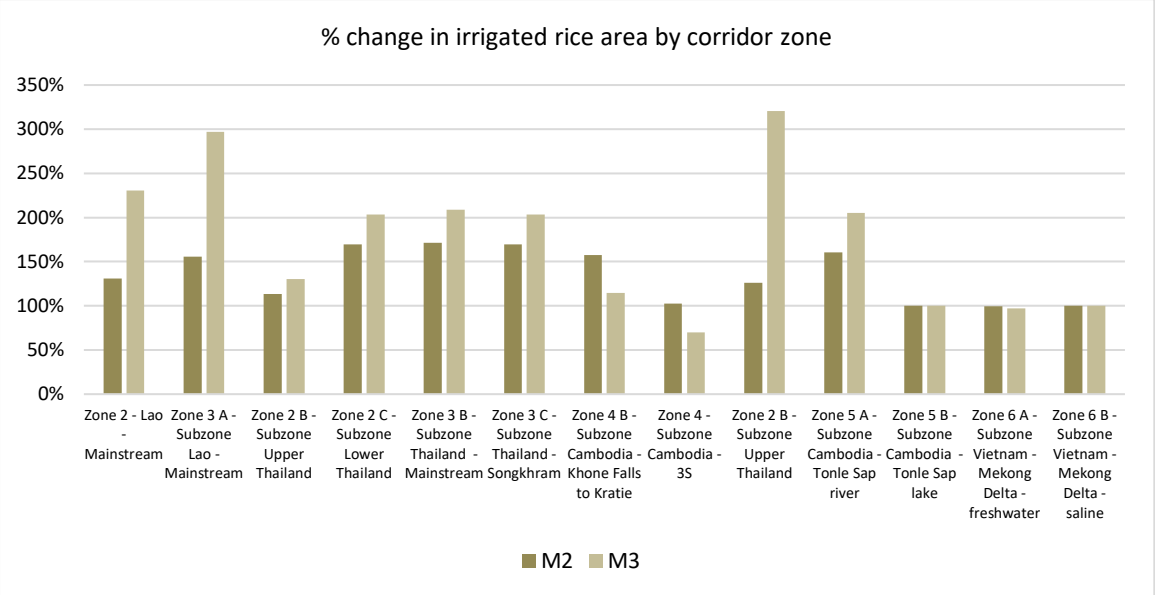
Source: CS Irrigation Thematic Team (2017)

Table 68 Estimated irrigated and rainfed rice production area (M1-M3) for CS corridor zones

	Irrigation area (ha)			Rainfed area (ha)		
Corridor zone	M1	M2	M3	M1	M2	M3
Zone2-Lao-Mainstream	13725	17687	31112	41850	42360	36968
Zone2B- Upper Thailand	16425	16425	18615	8100	8100	7926
Zone2C- Lower Thailand	11700	11700	19817	900	900	857
Zone3A- Lao-Mainstream	100575	156372	283511	99675	95850	91138
Zone3B- Thailand-Mainstream	60525	103850	126388	123300	125030	122419
Zone3C- Thailand-Songkhram				36900	35750	35192
Zone4- Cambodia-3S				450	450	480
Zone4B- Cambodia-Khone Falls to				2813	2813	2342
Zone4C- Cambodia-Kratie to Viet	426562	268560	683911	627656	575633	258880
Zone5A- Cambodia-Tonle Sap river	30938	49666	63566	246875	241551	239390
Zone5B- Cambodia-Tonle Sap lake	178438	178438	178438	536875	536562	538281
Zone6A- Viet Nam-Mekong Delta-	1233440	1230000	1199568	104844	104531	105312
Zone6B- Viet Nam-Mekong Delta-	182187	182500	182187	165156	165156	165156

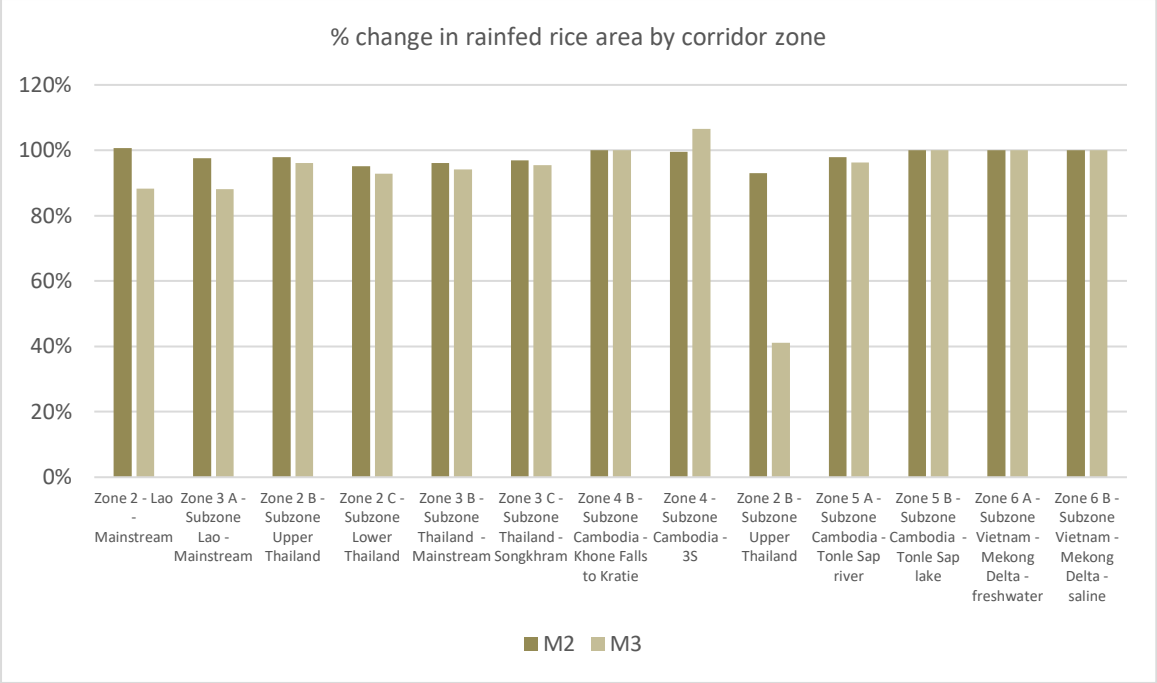
The estimated change (%) of the rain-fed and irrigated rice production areas for each of the 13 corridor zones are depicted in Figure 105 and Figure 106. The reduction in rainfed area suggests conversion of existing rainfed paddi to irrigated production except Cambodia where forest conversion to irrigated paddi is proposed (IRR Theme and IWRM Modelling Team based on consultations with Cambodian line Ministries).

Figure 104 estimated % change from M1 in irrigated rice area by corridor zones



Source: CS Modelling Team. The M1 scenario is represented by the baseline 100%

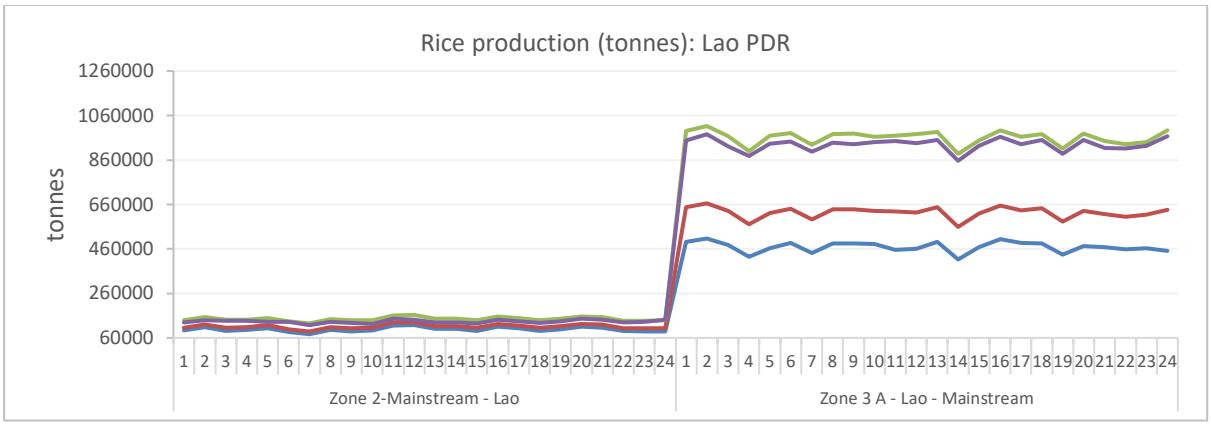
Figure 105 estimated % change from M1 in rainfed rice area by corridor zones

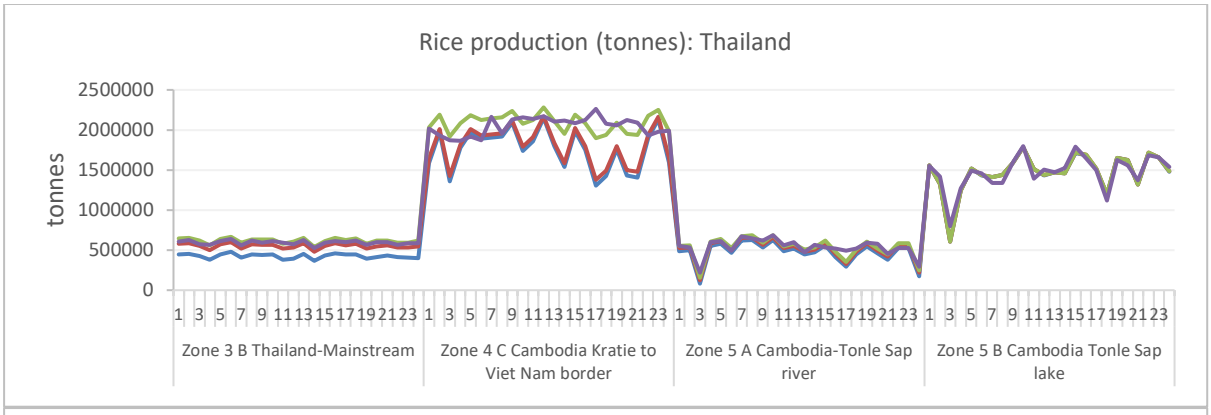


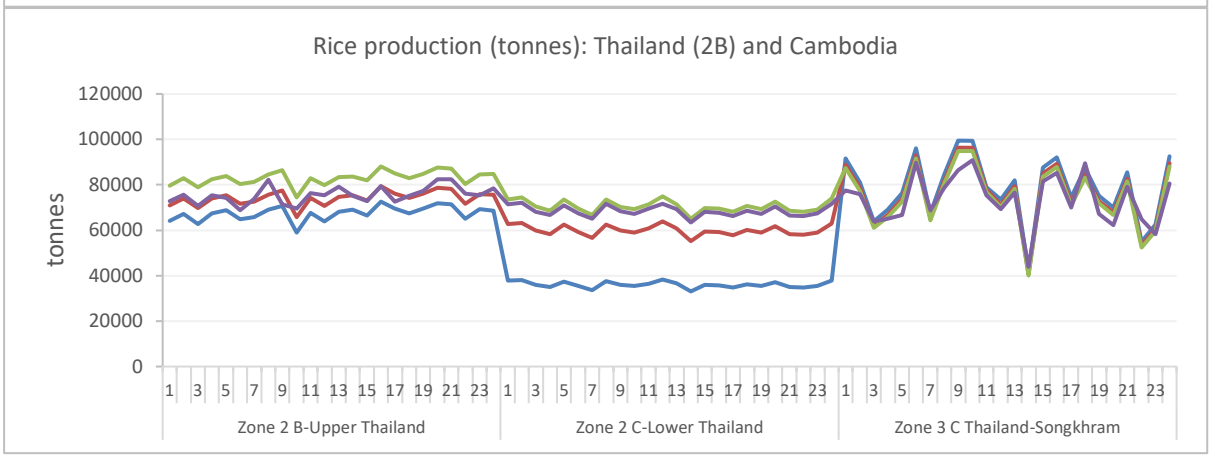
Source: CS Modelling Team. The M1 scenario is represented by the baseline =100%

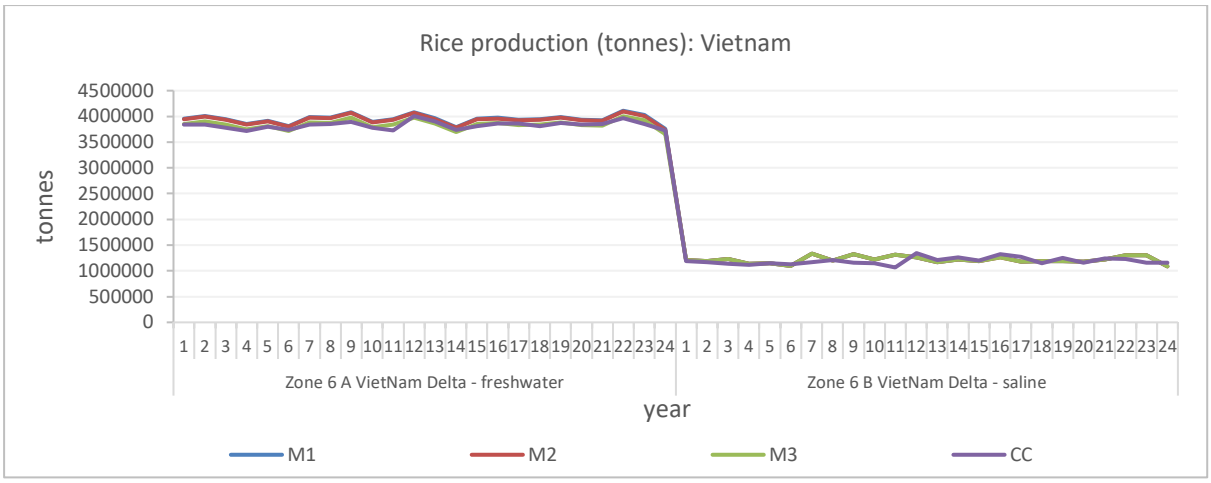
Rice production for the main development scenarios was modelled by the Modelling team as a function of estimated yields (subject to climatic conditions), land and soil suitability and hectares available for cultivation. Irrigated areas for the SIMVA zones were estimated the CS Irrigation Theme. The rice production estimates over the 24-year time horizon for the four main development scenarios for each zone are illustrated in Figure 107. Cambodian Zones 4a and 4b were excluded as they produce relatively minor rice tonnage.

Figure 106 Rice production (tonnes) over the 24-year time horizon by main development scenarios and corridor zones









11.5 Capture fisheries, aquaculture and other aquatic animals (OAAs)

Past trends in inland capture fisheries and aquaculture production are based on official annual data which are provided by national governments and compiled by the FAO (FAO Fisheries 2017). The MRC (2015) suggest that the capture fisheries data gathered by the national agencies were of variable reliability whereas official aquaculture estimates considered to be reasonably accurate. Inland capture fisheries in the LMB are "*primarily artisanal with a low proportion (<10%) of full-time fishers*". Most fish and OAAs are consumed by households that catch or grow them and so are not recorded in official data. The national and LMB statistics for capture and aquaculture fisheries 2005-2014 are summarized in Table 70 and Figure 108, representing data sets from FAO Fisheries (2017) and the CS Thematic teams respectively.

Note that the reported LMB estimates for the Viet Nam delta (Table 70) include the coastal fisheries estimated by Truong et al. (2008)[35] at 726,000 tonnes. Hortle and Bamrungrach (2015) estimate the freshwater capture fisheries at 349,000 tonnes (Table 71). Coastal fisheries are not included in the Council Study analysis.

The Hortle and Bamrungrach (2015) and So Nam et al (2015) estimates of the LMB freshwater catch (2.1-2.3 million tonnes; 2012) differ substantially from official figures (1.67 million tonnes; 2012). These differences were reconciled in the Social and Economic assessment analysis by cross referencing household fish consumption and catch data elicited in the SIMVA (2015) survey with the Hortle and Bamrungrach estimates and the BioRA analysis.

11.5.1 Aquaculture production in the LMB

Aquaculture in the LMB was estimated to produce between 2.1 million tonnes[36] and 2.6 million tonnes (MRC BDS 2016)[37]. Aquaculture production in the LMB has increased by approximately 42% in the period 2007-2013(an annual increase of approximately 6%). Lao PDR aquaculture production has increased by 64% in the same period (8-9% per annum), Cambodia by 242% (albeit from a low base of 33,390 tonnes; 34% per annum). The substantial increases achieved since 2007 in both Viet Nam and Thailand appear to have levelled out or declined at 2013 levels (Figure 109). The trends are consistent with the MRC projections that aquaculture will continue to increase to meet local export demands.

Hortle and Bamrungrach (2015 p 54) argue that despite the promotion of aquaculture as a replacement for capture fisheries losses, aquaculture also depends upon wild fisheries for the provision of broodstock, wild-caught fry or 'trash fish' used in feed. "*If fish prices rise, then greater investments in aquaculture could decrease the dependence on capture fisheries. However, it should be noted that capture fisheries are based on 'free' production, their benefits can be obtained by poor people with limited investment, and measures to conserve and manage capture fisheries are likely to provide relatively high returns*". *In contrast successful aquaculture requires access to land, water and capital as well as substantial technical training, and may shift the burden of work onto women. Consequently, social inequalities may be exacerbated by policies that seek to replace capture fisheries by aquaculture".* The potential for aquaculture based pollution, the spread of diseases, parasites and noxious species and competition with the capture fishery are aspects of aquaculture that demand recognition and careful management.

Table 69 Capture fisheries and aquaculture production at the national and LMB level

FAO freshwater capture fisheries (tonnes)	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Lao PDR	26560	26925	28410	29200	30800	30900	34105	38946	40165	42200
Cambodia	324000	422000	395000	365000	390000	405000	445000	449000	528000	505005
Thailand	198730	214000	225600	228600	206856	209300	224708	219428	210293	209800

[35] Truong, T.T, Do, Q.T.V. and Nguyen, V.H. (2008) Fisheries and aquaculture statistics for the Mekong River Delta in Viet Nam. *MRC Conference Series,* **7:** 65-81.

[36] So Nam, Souvanny Phommakone, Ly Vuthy, Theerawat Samphawamana, Nguyen Hai Son, Malasri Khumsri, Ngor Peng Bun, Kong Sovanara, Peter Degen And Peter Starr (2015) Catch and Culture vol 21: 3.

[37] MRC Basin Development Strategy (2016-2020). MRC Vientiane.

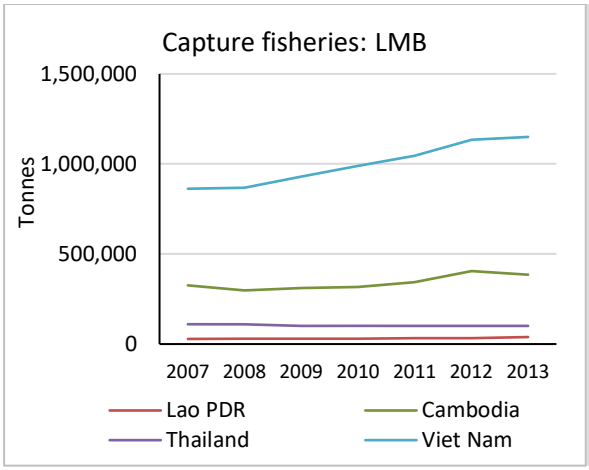
Viet Nam	196800	202900	198200	189700	188800	194400	206000	194500	196800	208100
Total	**748095**	**867831**	**849217**	**814508**	**818465**	**841610**	**911824**	**903886**	**977271**	**967119**
Aquaculture (tonnes)										
Lao PDR	60000	59980	63230	64280	74981	82080	95580	101870	107950	108310
Cambodia	25000	32800	33900	38270	47795	57600	69170	70820	86380	115315
Thailand	506331	498378	489218	485060	490092	403636	358822	431115	413536	401024
Viet Nam	961100	1157045	1530300	1898180	1956450	2146870	2211007	2471042	2479880	2609988
Total (tonnes)	**1,552,431**	**1,748,203**	**2,116,648**	**2,485,790**	**2,569,318**	**2,690,186**	**2,734,579**	**3,074,847**	**3,087,746**	**3,234,637**
Grand total (tonnes)	**2,300,526**	**2,616,034**	**2,965,865**	**3,300,298**	**3,387,783**	**3,531,796**	**3,646,403**	**3,978,733**	**4,065,017**	**4,201,756**

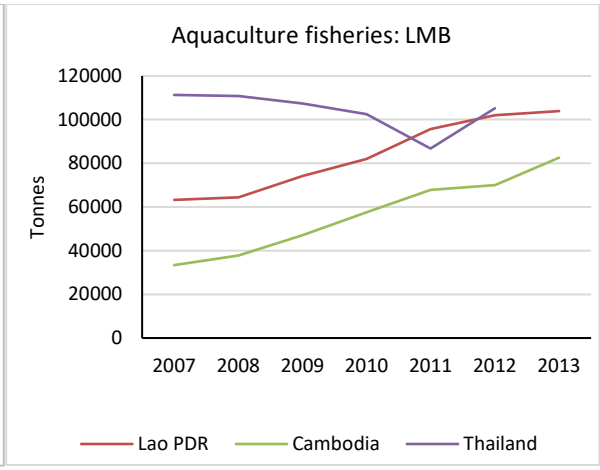
LMB capture fisheries (tonnes)	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	
Lao PDR	28410	29200	30800	30900	34000	34,105	38,947	
Cambodia	326710	297835	312380	316805	342940	405215	385440	
Thailand	110035	108765	101873	101137	102063	101478	101478	
Viet Nam	862402	866704	929449	989950	1044719	1133317	1149982	
Total	**1,327,557**	**1,302,504**	**1,374,502**	**1,438,792**	**1,523,722**	**1,674,116**	**1,675,847**	
Aquaculture (tonnes)								
Lao PDR	63250	64300	74200	82100	95600	101895	103896	
Cambodia	33390	37815	47120	57495	67810	70085	82560	
Thailand	111301	110683	107478	102533	86757	105151	na	
Viet Nam	1127688	1433711	1481445	1577889	1687436	1806451	1718536	
Total (tonnes)	**1,335,629**	**1,646,509**	**1,710,243**	**1,820,017**	**1,937,603**	**2,083,582**	**1,904,992**	
Grand Total (tonnes)	**2,663,186**	**2,949,014**	**3,084,745**	**3,258,809**	**3,461,326**	**3,757,698**	**3,580,839**	

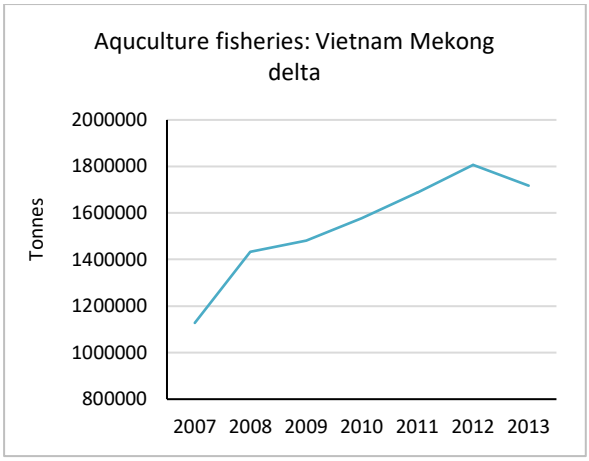
Source: FAO (fisheries 2017), CS ALU Thematic team.

Hortle and Bamrungrach (2015) reviewed and evaluated mainstream, rice field, aquaculture and reservoir fisheries data and multiple studies for the LMB. Total high, medium and low fisheries yields were estimated for four primary habitats: the major Mekong River flood zone; the rainfed zone; large waterbodies (including reservoirs outside the flood zone) and aquaculture. The yield estimates were compared and evaluated against total fish consumption in 2000 (estimated at 2,560 kt/year fresh whole animal equivalent).

Figure 107 Capture fisheries and aquaculture production in the LMB 2007-2013; Viet Nam aquaculture production







Source: CS ALU Thematic Team (2017)

Table 70 LMB most likely yield and consumption estimates

Habitat	Cambodia (high yield)	Lao PDR (high yield)	Thailand (medium – high yield)	Mekong Delta medium yield	Total LMB
River-floodplain within the major flood zone	565	92	117	260	1035
Rainfed outside the major flood zone	176	90	608	64	1044
Large waterbodies (mainly reservoirs) outside the flood zone	26	64	106	25	226
Total Yield Estimate	767	246	921	349	2301
Consumption Estimate Year 2000	558	166	861	659	2304
Surplus/Deficit	209	80	61	-310	0

Source Hortle and Bamrungrach (2015 p 51)

11.5.2 Estimates for (M1) fish catch and consumption in the corridor zones

As part of the SIMVA (2015) survey, household respondents in each zone reported the frequency of fish consumption (daily, 3 times a week, weekly and monthly), kgs consumed and whether fish

consumed was caught or purchased. Combined with the median number of household members, the results enabled an estimation of the annual fish consumption for each zone.

The reported fish consumption for each person (kgs/capita) was multiplied by the reported frequency of consumption and applied across the entire zone population (Table 72).

Therefore, total annual fish consumption for each SIMVA zone = kgs/capita/meal * frequency of consumption * zone population.

An example of the annual fish consumption estimate from Zone 5 B Cambodia Tonle Sap lake:

64% of respondents reported consuming fish daily; 32% twice weekly and 3% weekly. Median number of household members was five and 0.18 kgs/person per meal was reported consumption value. The estimated population in 2011 was 507,326. Using the formulae above the total annual fish consumption/capita was estimated as 52.70 kgs and total annual consumption for the zone estimated as 26,734,457 kgs (26,734 k/tonnes).

Hortle and Bamrungrach (2015) estimate an average value of the capture fisheries for the Tonle Sap at 224,000 tonnes per annum. The consumption estimate from SIMVA was subtracted from Hortle and Bamrungrach's estimate resulting in a surplus of 198,000 tonnes and a total capture fisheries of 224,000 tonnes.

The procedure for the Tonle Sap was repeated for each of the corridor zones. A proportion of the country capture fishery estimate was based on the proportion of the zone population compared to the national population where the total country catch was divided amongst more than one zone. This was the case for each of the corridor zones.

The same approach used to estimate the 2011 zone fisheries was applied to estimate the consumption and total catch and surplus of other aquatic animals (OAAs). The results are listed in Table 72.

11.5.3 Fish biomass composition and change

The BioRA Discipline team have estimated fish biomass composition and relative changes for eight fish habitat zones in response to the hydrological, sediment and nutrient levels associated with the CS development scenarios. The relative annual and mean changes of fish biomass and guild composition of the eight BioRA zones were adapted to the 13 SIMVA zones. Fish composition was classified as white, gray, black exotic and marine/estuarine fish guilds and estimated over the 24-year development scenario projection horizon.

The relative % changes of the M2, M3 and M3CC scenarios from the 2007 (M1) baseline for the eight BioRA zones are illustrated in Figure 109. The fish composition for the M1 baseline and the relative % changes from the baseline for the M2 and M3 scenarios across the respective SIMVA zones are listed in Table 73, Table 74and Table 75.

Household access and availability of fish for the M1 baseline was derived from the combined SIMVA and Hortle and Bamrungrach estimates. The % of zonal total fish biomass available for consumption and subsequent surplus (tonnes) for the M2 and M3 scenarios was calculated by applying the annual BioRA % estimates of fish biomass and relative guild composition.

Table 71 Capture fisheries, consumption per capita and total fish and OAA catch by corridor zones (2011)

M1 SIMVA Zone	Pop'n 2011	kgs/ capita/ meal	Total Fish consumed (kgs)	% purchased	Consumption /capita/yr (kgs)	Surplus (Kgs) [a]	Total Fish catch (kgs/yr)	OAA/kg/ person/yr	SIMVA OAA (kgs/yr)
Zone 2-Mainstream - Lao	463645	0.24	22,644,404	0.51	48.84	11,000,000	33,644,404	11.61	5,383,105
Zone 3 A-Lao-Mainstream	921345	0.24	38,077,351	0.35	41.33	55,000,000	93,077,351	6.57	6,053,237
Zone 2 B-Upper Thailand	82395	0.25	4,023,347	0.76	48.83	4,000,000	8,023,347	18.47	1,521,753
Zone 2 C-Lower Thailand	83035	0.25	4,378,437	0.68	52.73	5,000,000	9,378,437	11.50	954,695
Zone 3 B Thailand-Mainstream	739086	0.23	35,854,258	0.64	48.51	55,000,000	90,854,258	8.32	6,150,676
Zone 3 C Thailand-Songkhram	81755	0.25	4,310,937	0.46	52.73	15,000,000	19,310,937	8.76	716,173
Zone 4 A Cambodia-Khone Falls to Kratie	83863	0.2	4,910,363	0.49	58.55	14,000,000	18,910,363	51.10	4,285,414
Zone 4 B Cambodia-3S	6599	0.21	405,709	0.56	61.48	4,000,000	4,405,709	14.60	96,347
Zone 4 C Cambodia Kratie to Viet Nam border	3937450	0.22	175,673,274	0.68	44.62		112,300,000	8.76	34,492,063
Zone 5 A Cambodia-Tonle Sap river	1334939	0.22	68,752,006	0.88	51.50	96,500,000	165,252,006	9.49	12,668,567
Zone 5 B Cambodia Tonle Sap lake	885376	0.22	54,188,574	0.73	61.20	127,000,000	181,188,574	35.77	31,669,912
Zone 6 A Viet Nam Delta-freshwater	7809660	0.17	320,227,300	0.60	41.00	17,000,000	337,227,300	6.57	51,309,466
Zone 6 B Viet Nam Delta-saline	3123864	0.23	137,015,799	0.67	43.86	218,000,000	355,015,799	6.57	20,523,787

Source: adapted from SIMVA 2011, Hortle and Bamrungrach 2015 (MRC 2015a table 13)[38] [a] estimated as total catch (Hortle: MRC 2015a) – total fish consumed (SIMVA 2015)

[38] Hortle, K.G. and Bamrungrach, P. (2015) Fisheries Habitat and Yield in the Lower Mekong Basin. MRC Technical Paper No. 47. Mekong River Commission, Phnom Penh, Cambodia. 80 pp. ISSN: 1683-1489.

Figure 108 Fish biomass estimates for M1, M2, M3 and M3CC scenarios by BioRA zones FA1-FA8

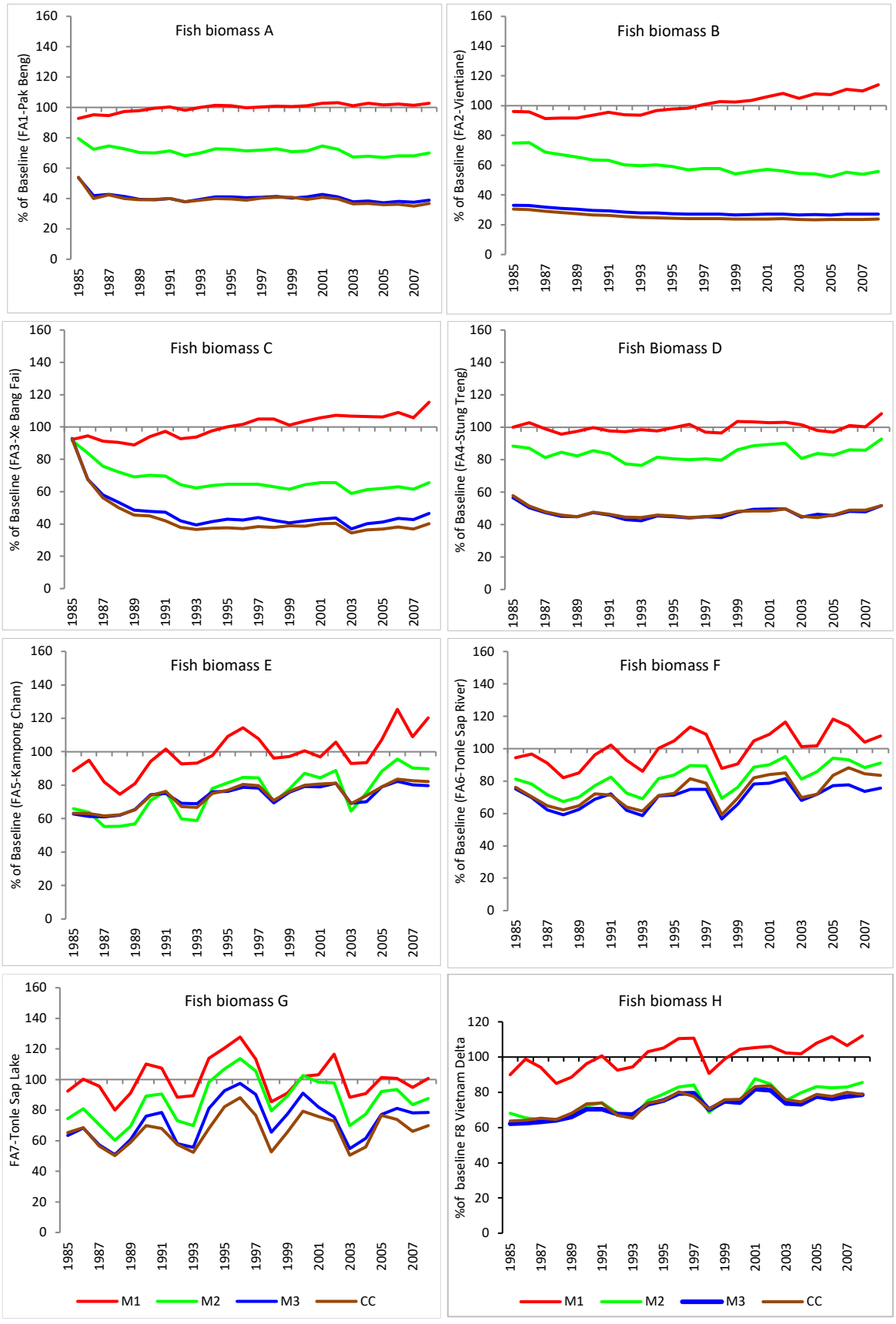


Figure 22 legend: BioRA zones and equivalent SIMVA zones

Fish biomass A: Zone 2 B-Upper Thailand; **Fish biomass B**: Zone 2-Mainstream – Lao, Zone 2 C-Lower Thailand; **Fish biomass C**: Zone 3 A-Lao-Mainstream, Zone 3 B Thailand-Mainstream, Zone 3 C Thailand-Songkhram; **Fish biomass D**: Zone 4 A Cambodia-Khone Falls to Kratie, Zone 4 B Cambodia-3S; **Fish biomass E**: Zone 4 C Cambodia Kratie to Viet Nam border; **Fish biomass F**: Zone 5 A Cambodia-Tonle Sap river; **Fish biomass G**; Zone 5 B Cambodia Tonle Sap lake; **Fish biomass H**; Zone 6 A Viet Nam Delta-freshwater, Zone 6 B Viet Nam Delta-saline.

Table 72 M1 Baseline fish Guild composition by CS corridor zones (2007 BioRA estimates)

M1 mean fish biomass composition						
BioRA Zone	CS Corridor Zone	White fish	Grey fish	Black fish	Exotic	marine estuarine
FA2	Zone 2-Mainstream - Lao	69.4%	21.8%	0.0%	8.3%	0.5%
FA3	Zone 3 A-Lao-Mainstream	81.1%	12.8%	0.1%	4.5%	1.7%
FA1	Zone 2 B-Upper Thailand	58.9%	18.6%	0.0%	22.7%	0.0%
FA2	Zone 2 C-Lower Thailand	69.4%	21.8%	0.0%	8.3%	0.5%
FA3	Zone 3 B Thailand-Mainstream	81.1%	12.8%	0.1%	4.5%	1.7%
FA3	Zone 3 C Thailand-Songkhram	81.1%	12.8%	0.1%	4.5%	1.7%
FA4	Zone 4 A Cambodia-Khone Falls to Kratie	44.4%	35.2%	5.8%	7.3%	7.4%
FA4	Zone 4 B Cambodia-3S	44.4%	35.2%	5.8%	7.3%	7.4%
FA5	Zone 4 C Cambodia Kratie to Viet Nam border	18.3%	79.4%	0.2%	0.9%	1.2%
FA6	Zone 5 A Cambodia-Tonle Sap river	36.6%	54.4%	7.0%	1.6%	0.8%
FA7	Zone 5 B Cambodia Tonle Sap lake	29.0%	44.1%	17.4%	3.4%	6.4%
FA8A	Zone 6 A Viet Nam Delta-freshwater	32.1%	32.6%	13.8%	21.0%	0.6%
FA8B	Zone 6 B Viet Nam Delta-saline	28.5%	36.4%	15.1%	12.8%	7.3%

Table 73 Fish Guild composition and % total change by corridor zone for M2 development scenario

M2 mean fish biomass composition							
CS Corridor Zone	White fish	Grey fish	Black fish	Exotic	marine estuarine	∑ biomass change	OAA change
Zone 2-Mainstream - Lao	40.9%	36.3%	0.0%	21.9%	1.0%	-39%	108.0%
Zone 3 A-Lao-Mainstream	61.6%	25.5%	0.1%	10.2%	2.7%	-38%	87.0%
Zone 2 B-Upper Thailand	14.8%	26.3%	0.0%	58.9%	0.0%	-33%	89.0%
Zone 2 C-Lower Thailand	40.9%	36.3%	0.0%	21.9%	1.0%	-39%	108.0%
Zone 3 B Thailand-Mainstream	61.6%	25.5%	0.1%	10.2%	2.7%	-38%	87.0%
Zone 3 C Thailand-Songkhram	61.6%	25.5%	0.1%	10.2%	2.7%	-38%	87.0%
Zone 4 A Cambodia-Khone Falls to Kratie	38.0%	38.6%	4.3%	10.5%	8.5%	-16%	88.0%

Zone 4 B Cambodia-3S	38.0%	38.6%	4.3%	10.5%	8.5%	-16%	88.0%
Zone 4 C Cambodia Kratie to Viet Nam border	16.6%	79.8%	0.1%	1.6%	1.7%	-24%	76.0%
Zone 5 A Cambodia-Tonle Sap river	32.1%	58.9%	5.6%	2.7%	0.8%	-19%	93.0%
Zone 5 B Cambodia Tonle Sap lake	26.7%	44.8%	16.3%	5.3%	6.8%	-12%	94.0%
Zone 6 A Viet Nam Delta-freshwater	3.6%	33.3%	11.7%	50.8%	0.6%	-25%	91.0%
Zone 6 B Viet Nam Delta-saline	3.6%	33.3%	11.7%	50.8%	0.6%	-25%	91.0%

Table 74 Fish Guild composition and % total change by corridor zone for M3 development scenario

M3 mean fish biomass composition							
CS Corridor Zone	White fish	Grey fish	Black fish	Exotic	marine estuarine	∑ change	OAA change
Zone 2-Mainstream - Lao	1.3%	19.4%		15.4%	0.5%	-70%	144%
Zone 3 A-Lao-Mainstream	12.7%	26.4%	0.0%	14.9%	1.2%	-59%	93%
Zone 2 B-Upper Thailand	2.9%	15.5%		33.6%		-51%	114%
Zone 2 C-Lower Thailand	1.3%	19.4%		15.4%	0.5%	-70%	144%
Zone 3 B Thailand-Mainstream	12.7%	26.4%	0.0%	14.9%	1.2%	-59%	93%
Zone 3 C Thailand-Songkhram	12.7%	26.4%	0.0%	14.9%	1.2%	-59%	93%
Zone 4 A Cambodia-Khone Falls to Kratie	0.3%	35.4%	5.3%	24.0%	5.8%	-39%	92%
Zone 4 B Cambodia-3S	0.3%	35.4%	5.3%	24.0%	5.8%	-39%	89%
Zone 4 C Cambodia Kratie to Viet Nam border	1.1%	101.0%	0.1%	18.8%	0.8%	+9%	90%
Zone 5 A Cambodia-Tonle Sap river	11.9%	42.8%	2.7%	16.1%	0.5%	-31%	92%
Zone 5 B Cambodia Tonle Sap lake	11.9%	35.0%	9.9%	16.0%	4.8%	-26%	93%
Zone 6 A Viet Nam Delta-freshwater	2.0%	25.8%	3.6%	38.0%	0.3%	-28%	86%
Zone 6 B Viet Nam Delta-saline	0.7%	7.7%	0.0%	19.4%	45.1%	-28%	86%

Table 75 Fish Guild composition and % total change by corridor zone for M3_CC development scenario

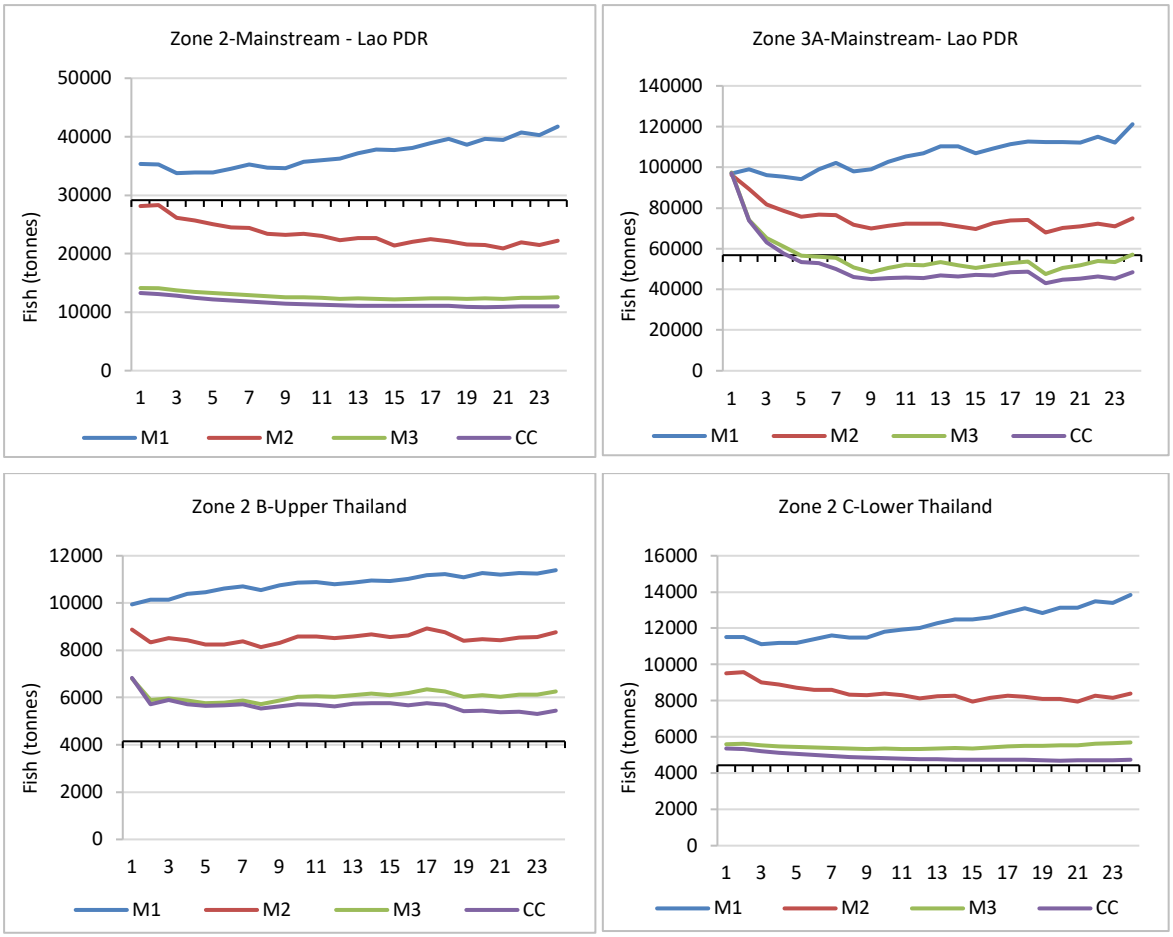
M3_CC mean fish biomass composition							
CS Corridor Zone	White fish	Grey fish	Black fish	Exotic	marine estuarine	∑ change	OAA change
Zone 2-Mainstream - Lao	0.0%	54.3%	0.0%	43.9%	1.8%	-73%	144%
Zone 3 A-Lao-Mainstream	0.0%	63.1%	0.2%	32.2%	4.5%	-63%	95%
Zone 2 B-Upper Thailand	0.0%	25.7%	0.0%	74.3%	0.0%	-52%	87%
Zone 2 C-Lower Thailand	0.0%	54.3%	0.0%	43.9%	1.8%	-73%	144%
Zone 3 B Thailand-Mainstream	0.0%	63.1%	0.2%	32.2%	4.5%	-63%	95%
Zone 3 C Thailand-Songkhram	0.0%	63.1%	0.2%	32.2%	4.5%	-63%	95%
Zone 4 A Cambodia-Khone Falls to Kratie	0.0%	55.6%	9.3%	23.8%	11.4%	-38%	98%
Zone 4 B Cambodia-3S	0.0%	55.6%	9.3%	23.8%	11.4%	-38%	98%
Zone 4 C Cambodia Kratie to Viet Nam border	0.9%	96.2%	0.1%	1.6%	1.2%	+10%	93%
Zone 5 A Cambodia-Tonle Sap river	20.6%	70.5%	4.5%	3.7%	0.7%	-27%	93%
Zone 5 B Cambodia Tonle Sap lake	19.7%	51.0%	13.8%	8.7%	6.8%	-34%	86%

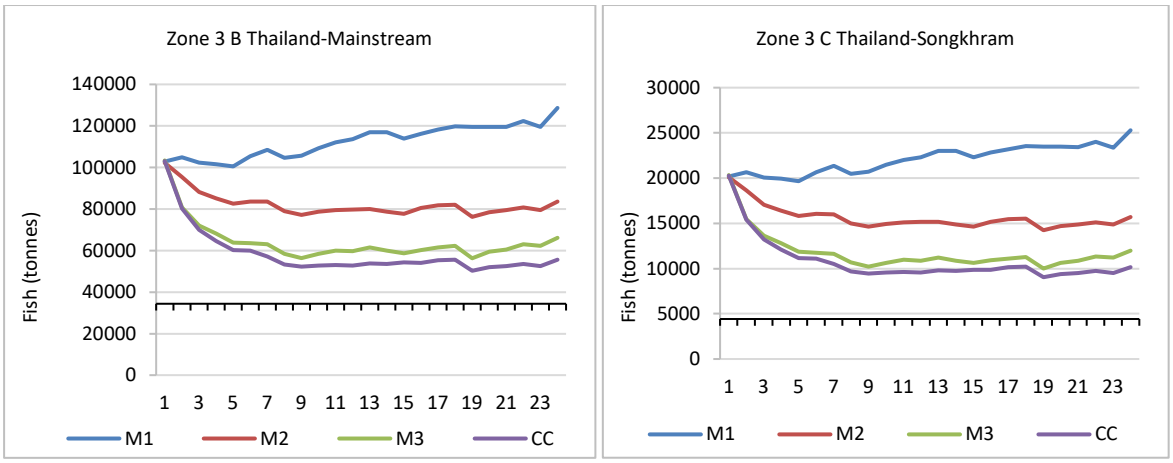
Zone 6 A Viet Nam Delta-freshwater	0.0%	29.5%	8.2%	62.0%	0.3%	-27%	89%
Zone 6 B Viet Nam Delta-saline	1.6%	10.9%	0.0%	30.3%	57.8%	-27%	89%

The capture fisheries biomass estimates for the SIMVA zones were combined with the fish catch estimates (Table 72) and illustrated in Figure 110, Figure 111 and Figure 112. The estimated annual fish consumption (tonnes) for the M1 scenario for each zone is represented by ┈┈┈┈┈┈┈┈┈┈┈┈┈┈┈┈.

Aquaculture is not included in the fish consumption estimates illustrated for each zone, although aquaculture estimates are included in the food balance calculations. Figure 112 depicts the native fish catch and the total estimated aquaculture production in the delta to provide a more comprehensive depiction of total fish production. The level of LMB aquaculture production is highest in the Viet Nam delta (FAO fisheries 2017 and CS estimates). Aquaculture production is depicted as - - - -.

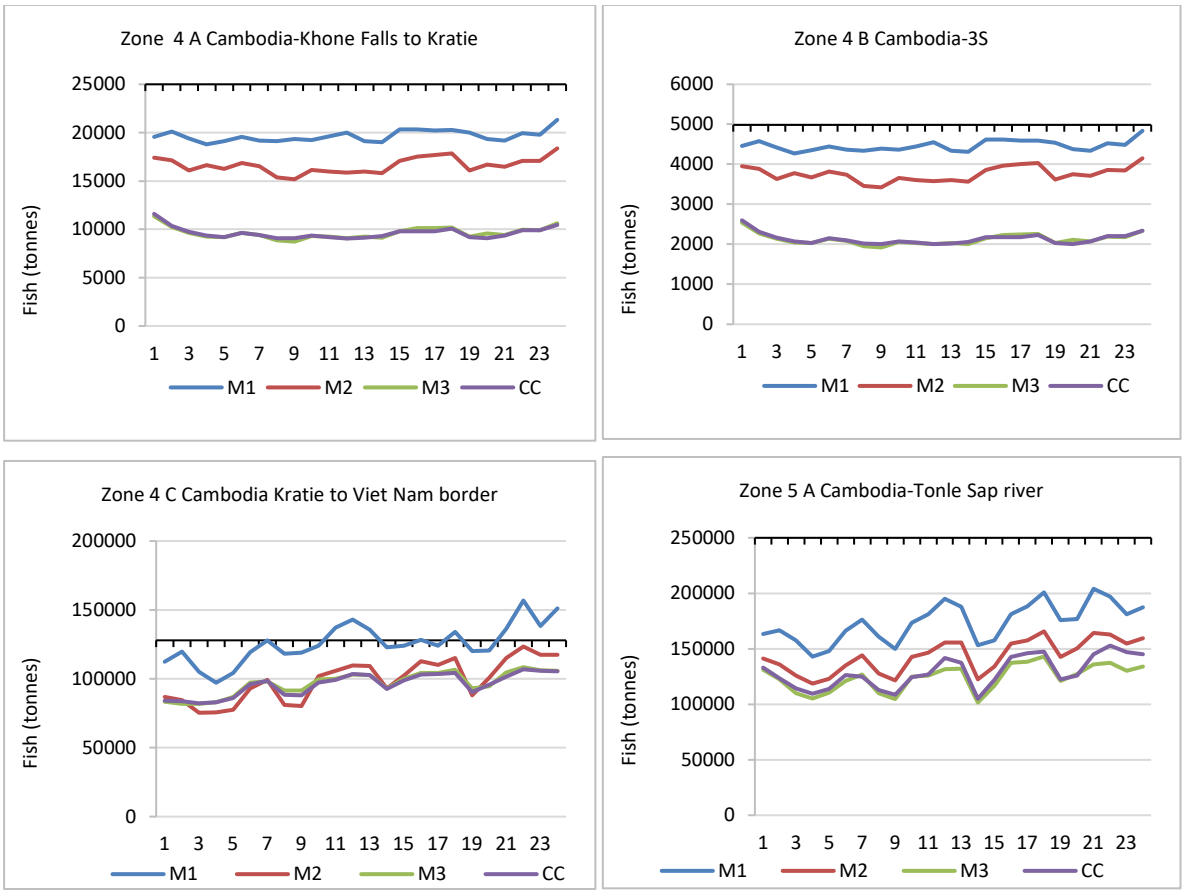
Figure 109 M1, M2, M3 and M3_CC estimated fish catch and M1 year 24 consumption level for Lao PDR and Thai corridor zones

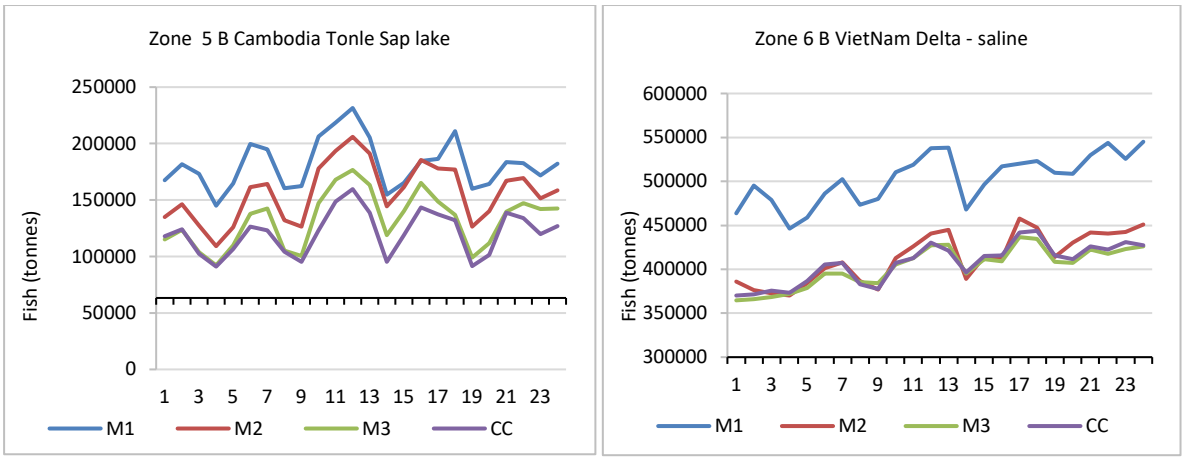




Source BioRA and SE estimates indicates M1 year 24 consumption (tonnes)

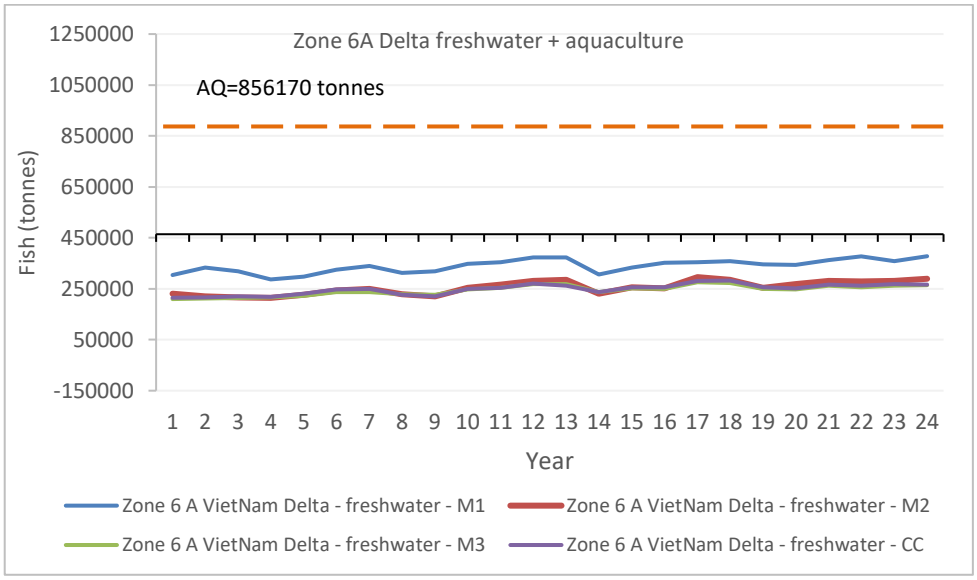
Figure 110 M1, M2 and M3 estimated fish biomass and M1 year 24 consumption level for Cambodian and Viet Nam corridor zones





Source BioRA and SE estimates indicates M1 year 24 consumption (tonnes)

Figure 111 M1, M2 and M3 estimated native fish catch, aquaculture production and M1 year 24 consumption level Viet Nam freshwater corridor zone



AQ indicates aquaculture production indicates M1 year 24 consumption (tonnes)

Source BioRA and Council Study SE Asessment estimates

The BioRA team estimated the catch of other aquatic animals for the M1 baseline. The estimates for reptiles, amphibians and invertebrates for the 13 corridor zones are detailed in Table 77.

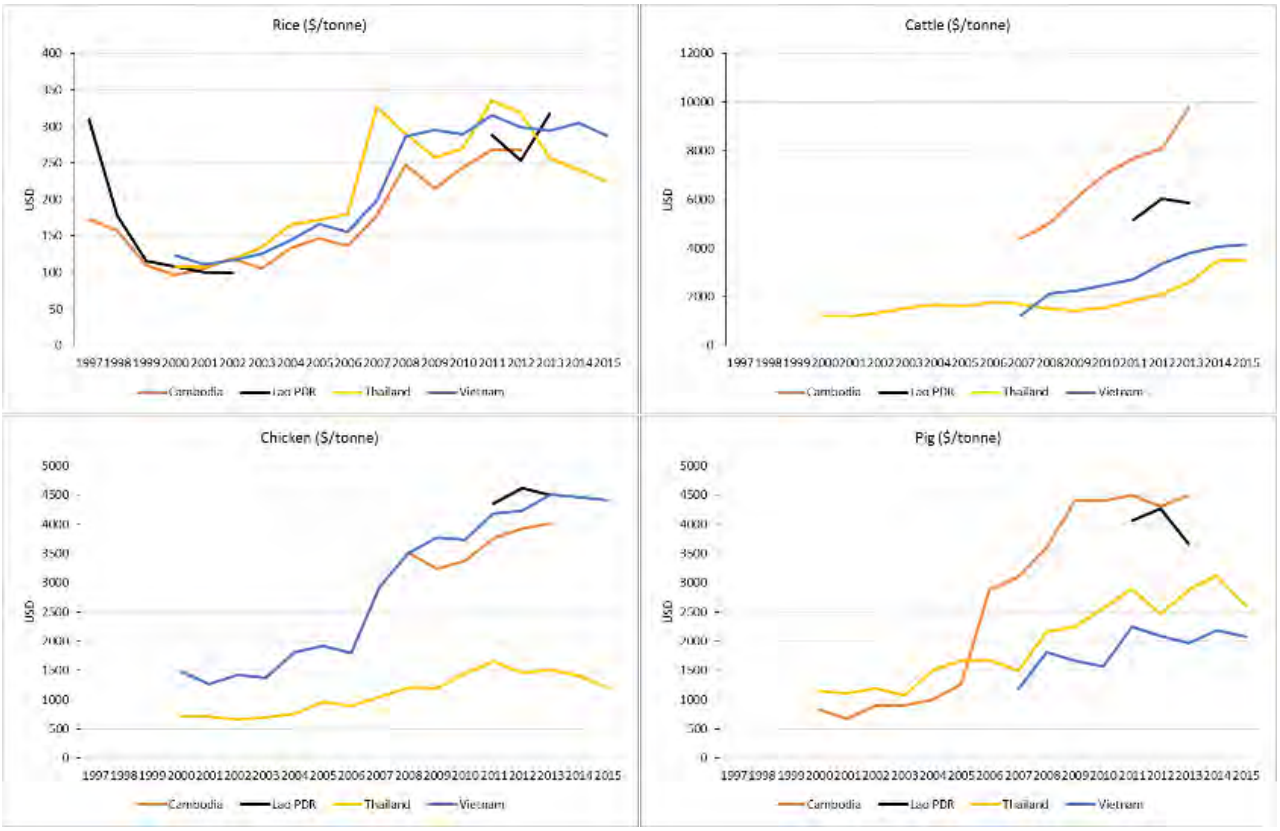
Table 76 Estimated catch of other aquatic animals by SIMVA zones

CS Corridor Zone	Reptiles (M1 tonnes)	Amphibians (M1 tonnes	Invertebrates (M1 tonnes)
Zone 2-Mainstream - Lao	104	520	4759
Zone 3 A-Lao-Mainstream	160	240	5653
Zone 2 B-Upper Thailand	16	84	1422
Zone 2 C-Lower Thailand	10	13	932
Zone 3 B Thailand-Mainstream	20	72	6059
Zone 3 C Thailand-Songkhram	10	36	670
Zone 4 A Cambodia-Khone Falls to Kratie	35	140	4110
Zone 4 B Cambodia-3S	35	140	21
Zone 4 C Cambodia Kratie to Viet Nam border	140	560	33792
Zone 5 A Cambodia-Tonle Sap river	140	565	11964
Zone 5 B Cambodia Tonle Sap lake	1130	1692	28847
Zone 6 A Viet Nam Delta-freshwater	250	350	50709
Zone 6 B Viet Nam Delta-saline	162	50	20312

11.5.4 Agricultural commodity prices

The historical prices (USD/tonne) recorded from 1997-2015 for LMB countries for rice, cattle, chickens and pigs are illustrated in Figure 113. Note prices for Lao agricultural commodities are available for 2011-2013 only within the CS projection horizon, where year 1=2007.

Figure 112 Historical price trends for rice and livestock by LMB country



Source: compiled and adapted from FAO (2017); Lao PDR Department of Agriculture and Livestock; Cambodian Ministry of Agriculture Forests and Fisheries[39]

Food security price assumptions applied to the Development Scenarios.

- Prices and price variations were uniformly applied across all scenarios
- Where price increases were relevant to the analyses, national Inflation factors were applied throughout the projection horizon, based on the mean inflation rate from2003-2016 (WDI 2017)[40]. National estimates of inflation factors:
    - Cambodia: 5.7%
    - Lao PDR: 7.6%
    - Thailand: 3.7%
    - Viet Nam: 11.1%

[39] MAFF 2013, Annual Report for Agriculture Forestry and Fisheries 2012-2013, Phnom Penh, Cambodia; Lao PDR Department of Agriculture and Livestock: Annual livestock report 2014

[40] http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#

Rice: rice prices for 2015 historical paddi prices (FAO Stat 2017) were applied over the 24-year projection horizon. Rice prices in Lao PDR follow Cambodian rice prices due to data deficits. Farm gate paddi prices for Cambodia and Lao PDR were estimated at US$ 272/tonne; US$ 225/tonne for the Thailand zones and US$287 /tonne for the Viet Nam Delta zones. Food balance calculations rely on rice available for consumption by utilizing rice milled equivalent values, a measure that represents net losses incurred during the milling process. Farm gate paddi prices (2015-US$/tonne), milled equivalent factors and the calculated milled equivalent prices for each SIMVA zone are detailed in Table 78.

Table 77 Rice paddi prices, milled equivalent factors and milled equivalent prices for SIMVA zones

SIMVA Zone	Paddi price (US$/tonne	Milled equivalent factor	Milled equivalent (US$/tonne)
Zone 2-Mainstream - Lao	272	0.54	504
Zone 3 A - Lao -	272	0.54	504
Zone 2 B-Upper Thailand	225	0.57	395
Zone 2 C-Lower Thailand	225	0.57	395
Zone 3 B Thailand-Mainstream	225	0.57	395
Zone 3 C Thailand-Songkhram	225	0.57	395
Zone 4 A Cambodia-Khone Falls to Kratie	272	0.52	523
Zone 4 B Cambodia-3S	272	0.52	523
Zone 4 C Cambodia Kratie to Viet Nam	272	0.52	523
Zone 5 A Cambodia-Tonle Sap river	272	0.52	523
Zone 5 B Cambodia Tonle Sap lake	272	0.52	523
Zone 6 A Viet Nam Delta - freshwater	287	0.52	552
Zone 6 B Viet Nam Delta - saline	287	0.63	456

Source: FAOSTAT (2017)

Fish: The BioRA team estimated fish prices (landing site) for each fish guild by corridor zone (Table 79). Capture Fish prices for the remainder of the 24-year projection horizon were calculated as the 2014 price + the national inflation factor + 3% to reflect declining production where necessary. Aquaculture prices were estimated at 2014 prices.

Table 78 Fish Guild prices by Zone (US$/tonne)

SIMVA Zone	white fish	black fish	gray fish	exotic	marine	aquaculture
Zone 2-Mainstream - Lao	4000	3000	3500	2700	4500	2700
Zone 3 A - Lao -	4000	3000	3500	2700	4500	2700
Zone 2 B-Upper Thailand	7500	3000	3000	3000	4500	3000
Zone 2 C-Lower Thailand	7000	3000	6000	3000	4000	3000
Zone 3 B Thailand-Mainstream	7000	3000	6000	3000	4000	3000
Zone 3 C Thailand-Songkhram	7000	3000	6000	3000	4000	3000
Zone 4 A Cambodia-Khone Falls to Kratie	2800	3200	3000	3000	4000	2900
Zone 4 B Cambodia-3S	2800	3200	3000	3000	4000	2900
Zone 4 C Cambodia Kratie to Viet Nam border	2800	3200	3000	3000	4000	2900
Zone 5 A Cambodia-Tonle Sap river	2800	3200	3000	3000	4000	2900
Zone 5 B Cambodia Tonle Sap lake	2800	3200	3000	3000	4000	2900
Zone 6 A Viet Nam Delta - freshwater	1600	1600	1600	1600	1600	2900
Zone 6 B Viet Nam Delta - saline	1600	1600	1600	1600	1600	2900

Source: BioRA

Other aquatic animals (OAA): The BioRA team estimated OAA prices (landing site) for amphibians, reptiles and invertebrates for each corridor zone (Table 79). Capture Fish prices for the remainder of the 24-year projection horizon were calculated as the price at 2014 + the national inflation factor + 3% to reflect declining production where necessary. Aquaculture prices were estimated at 2014 prices.

Table 79 OAA prices by corridor zones (US$/tonne)

CS Corridor Zone	Reptiles (US$/tonne)	Amphibians (US$/tonne)	Invertebrates (US$/tonne)
Zone 2-Mainstream - Lao	4375	2813	3120
Zone 3 A-Lao-Mainstream	4688	3125	5250
Zone 2 B-Upper Thailand	4375	2813	2000
Zone 2 C-Lower Thailand	4000	1500	3120
Zone 3 B Thailand-Mainstream	4375	1500	5250
Zone 3 C Thailand-Songkhram	4375	1500	5250
Zone 4 A Cambodia-Khone Falls to Kratie	19920	1125	1500
Zone 4 B Cambodia-3S	19920	1125	1500
Zone 4 C Cambodia Kratie to Viet Nam border	19920	1125	1500
Zone 5 A Cambodia-Tonle Sap river	2518	1500	2400
Zone 5 B Cambodia Tonle Sap lake	2500	1750	1560
Zone 6 A Viet Nam Delta-freshwater	2500	1750	3610
Zone 6 B Viet Nam Delta-saline	5000	12000	3610

Source: BioRA

Livestock (cattle, buffalo, poultry and pigs): historical prices for 2007-2015 were applied where available for the projection horizon. Livestock prices for 2007-2015 are extremely volatile. The final year livestock prices, where data are available + the national inflation factor were applied for the remaining 14 years of the projection horizon for each of the Development Scenarios (Table 81).

Table 80 Livestock prices by Corridor Zone (US$/tonne)

CS Corridor Zone	Cattle (US$/tonne)	Goats (US$/tonne	Pigs (US$/tonne)	Poultry (US$/tonne)
Zone 2-Mainstream - Lao	5860	3900	3900	4400
Zone 3 A-Lao-Mainstream	5860	3900	3900	4400
Zone 2 B-Upper Thailand	3477	2607	2607	1203
Zone 2 C-Lower Thailand	3477	2607	2607	1203
Zone 3 B Thailand-Mainstream	3477	2607	2607	1203
Zone 3 C Thailand-Songkhram	3477	2607	2607	1203
Zone 4 A Cambodia-Khone Falls to Kratie	9000	4500	4500	4040
Zone 4 B Cambodia-3S	9000	4500	4500	4040
Zone 4 C Cambodia Kratie to Viet Nam border	9000	4500	4500	4040
Zone 5 A Cambodia-Tonle Sap river	9000	4500	4500	4040
Zone 5 B Cambodia Tonle Sap lake	9000	4500	4500	4040
Zone 6 A Viet Nam Delta-freshwater	4161	2083	2083	4413
Zone 6 B Viet Nam Delta-saline	4161	2083	2083	4413

Source: FAOSTAT (2017)

11.6 Income security

There are three dimensions to the Income Security assessment indicator: 1) the diversity of household income sources; 2) households have an income sufficient to reliably cover all their expenses; and the majority of households are above the National Poverty line. Income Security was first evaluated as the M1 Baseline and analysed to detect changes in any of the three dimensions in response to the water Development M2, M3 and M3-CC Main Scenarios and sub-scenarios.

Livelihood diversity

Primary and secondary occupations were differentiated from the perceived importance of 'livelihood activity'. For example, many respondents from the SIMVA 2015 and EMRF 2012 surveys who were self-declared farmers by their primary occupation also reported fishing as one of the most important livelihood activities although many did not nominate fishing as an occupation. The SIMVA (2015) report argues that the discrepancy between occupation data and livelihood activity data needs careful consideration, especially regarding fishing.

Adaptation

Livelihood adaptation is influenced by a suite of multiple and often inter-dependent factors. [41] These include (*inter alia*):

- Perceptions of risk;
- Willingness and capacity to migrate;
- Inter-generational investment and path dependencies;
- Factors related to human resources
    - Attitude and identity, values and beliefs;
    - Education;
    - Technical skills;
    - Entrepreneurial skills
    - Health
    - Organizations, networks and kinship
    - Factors related to natural resources - agriculture and land
    - Non-agriculture based activities, incl. fisheries
- Factors related to financial resources
    - Diversity of financial resources
    - Credit
    - Wages
    - Remittances

[41] Marshall, N.A., Smajgl, A., 2013. Understanding variability in adaptive capacity on rangelands. Rangel. Ecol. Manag. 66:88–94. http://dx.doi.org/10.2111/REM-D-11-00176.1.
Rogers, E.M., 2010. Diffusion of Innovations. 4th edition. Free Press.
Ward, J., Poutsma, H., 2013. The Compilation and Summary Analysis of Tonle Sap Household Livelihoods. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia.
Hammond, J., Mark T. van Wijk, Alex Smajgl, John Ward, Tim Pagella, Jianchu Xu, Yufang Su, Zhuangfang Yi, Rhett D. Harrison (2017) Farm types and farmer motivations to adapt: Implications for design of sustainable agricultural interventions in the rubber plantations of South West China. Agricultural Systems; 154, p1-12.
Ward, J., Varua, M.E., Maheshwari, B., Oza, S., Purohit, R., Hakimuddin and Dave, S. (2016) Exploring the Relationship Between Subjective Wellbeing and Groundwater Attitudes and Practices of Farmers in Rural India. Journal of Hydrology 540: 1-16.

    - Productivity and profitability
    - Investment in growth
- Access to and availability of physical resources
- Property rights and institutional arrangements
- Household physical resources
- Infrastructural development

Age Dependency ratio

As part of the Council study the Social and Economic Assessment also evaluates the baseline Age Dependency ratio. Age dependency ratio is a measure of those typically not in the labour force (the *dependent* part ages 0 to 14 years and 65+ years) and those typically in the labour force (the *productive* ages 15 to 64 years). The dependency ratio is used to measure the pressure on the *productive* population. The mean dependency ratios of the SIMVA (2015) corridor zones were calculated as Cambodia (80%, range 70-90%); Lao PDR (80%, range 70-90%); Thailand (60%, range 60-70%) and Viet Nam (60%).

The World Development Indicators report substantially lower national level age dependency ratios. The WDI 2014-15 reports ratios of: Cambodia (56%); Lao PDR (64%); Thailand (39%) and Viet Nam (42%).

A higher dependency ratio indicates increased pressure on the working population to support those not able to work through for example health care, education and social services. The difference in the SIMVA and WDI ratios suggests that households located in the corridor are more vulnerable to changed employment circumstances compared to households located outside the corridor.

Subject to data constraints, changes to the age dependency ratio in response to the development scenarios were included in the income security analysis.

11.6.1 Reported livelihoods in the LMB corridor

Crop farming, including gardening, was the main occupation for 59% of the working age population (i.e., not including dependents: children, elderly, disabled and students) in the LMB Corridor. Crop farming is the secondary occupation for 7% of the working population and livestock work the secondary occupation for 29.2% of respondents.

Fishing, as the only occupation for a household member, is the main occupation for only 1.7% of the working population. Fish processing, aquaculture, navigation and sand mining from the river, each of these is the main occupation for less than 1% of the working population. Collection of OAA is the main occupation for only 0.2%, but the secondary occupation for as many as 15.5% of the working population. Thus, collection of OAA/Ps is the third largest secondary occupation in the LMB corridor.

The percentage-wise distribution of primary and secondary occupations by sub-zone reported by the SIMVA (2015) respondents is detailed in Figure 114. Crop farming is the main occupation in all zones and livestock worker the main secondary occupation in the majority of zones. The collection of OAA is prominent as a secondary occupation of respondents in Lao PDR and Cambodian sub-zones.

Similar distributions, diversities and livelihood priorities were reported by the EMRF (2012) respondents (Figure 115, Figure 116). Note that rice has been excluded from both graphs to facilitate ease of interpretation. Consistent with the SIMVA findings rice was the dominant primary livelihood activity reported by respondents for all sites (Tonle Sap, 60%; Nam Ngum, 67%; Hua Sai Bart, 84%; and Viet Nam Delta, 72%).

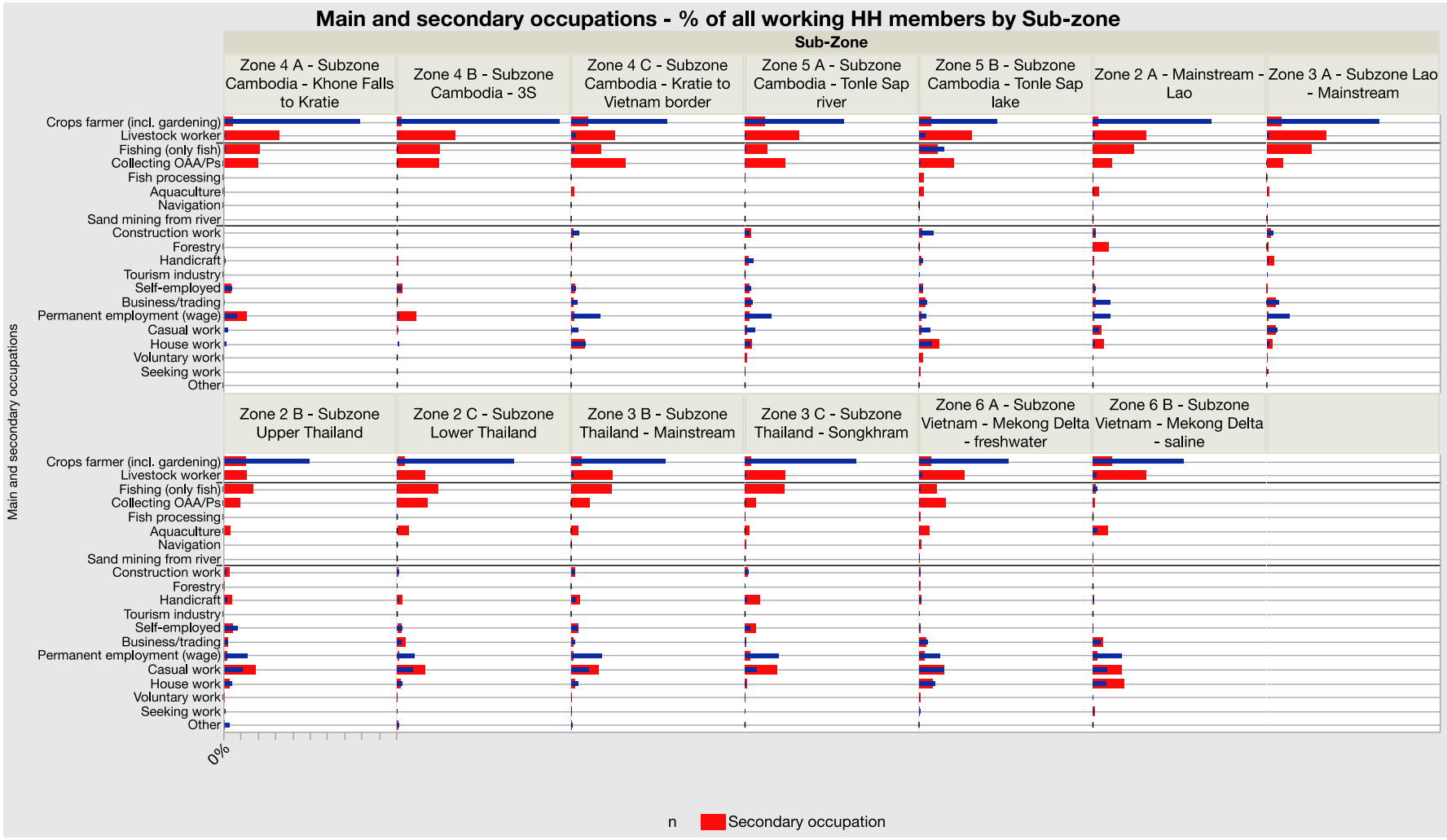
Excluding rice production, family businesses and fishing were the next ranked primary and secondary livelihoods in the Tonle Sap. Government employment and family businesses were the second ranked

primary activity in the Nam Ngum (respondents were not asked about secondary but did report up to 3 wet season, dry season and off farm cash activities respectively). Sugar cane is the main secondary and primary activity in Hua Sau Bart and additional agricultural and aquaculture based activities (vegetables, fruit trees livestock and cassava) were the highest ranked secondary activities in the Viet Nam delta. The relative rates of participation and region specific distribution of primary and secondary livelihoods is reflected in (Figure 116) which illustrates the aggregated primary and secondary livelihoods.

Both the SIMVA and EMRF livelihood data indicate that households have a diverse set of seasonally adjusted livelihoods. Livelihood activities tend to be region specific, dependent on opportunities, the institutional framework and available resources, in contrast to a set of activities uniformly distributed across the LMB. In all sites and zones rice production remains the dominant activity.

As an additional measure of livelihood/employment diversity the EMRF responses to wet season, dry season and off farm livelihoods were reclassified into three diversity classes (Table 82). Respondents who had different farming activities in the wet season and dry season were assigned to the wet season + dry season class (at least two farming activities); those with different farming and off farm activities were assigned to the agriculture + off farm class (at least two different livelihood activities); and respondents engaged in different wet season, dry season and off farm livelihood activities (at least three livelihood activities) were assigned to the final wet+ dry + off farm class.

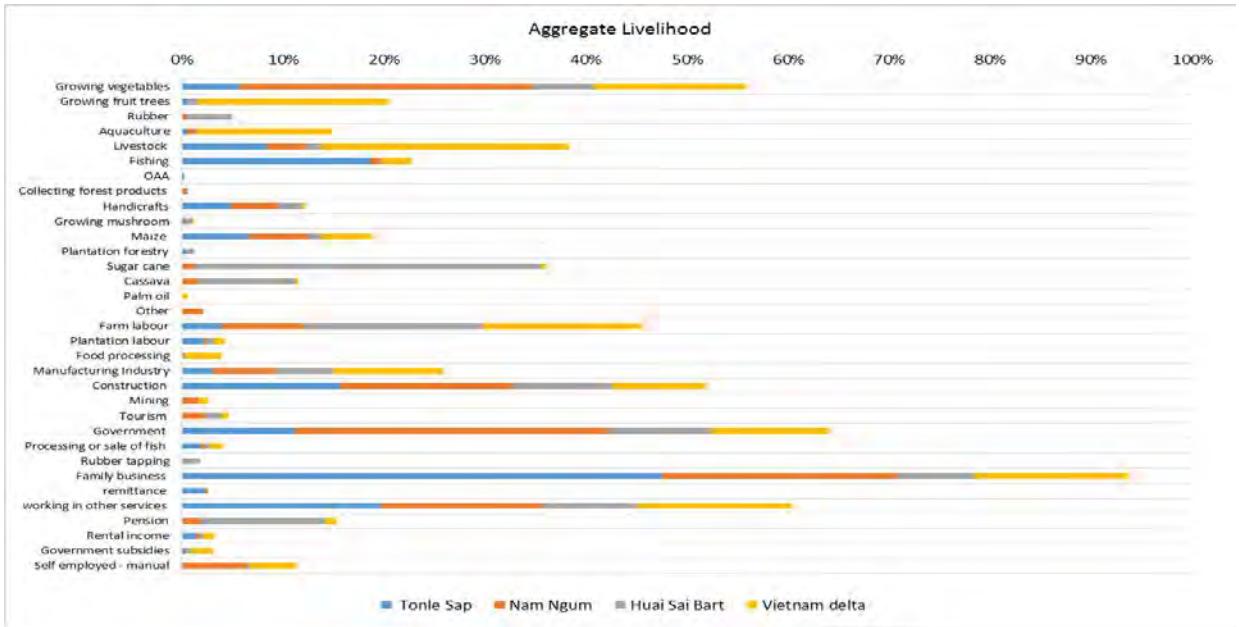
Figure 113 Household members' occupations - % of working members by Sub-zone



Source SIMVA (2015)

Figure 114 Primary and secondary livelihood activities in selected LMB sites

Figure 115 Aggregated primary and secondary livelihoods for selected LMB sites



Source: EMRF (2012) Figures 30 and 31

The results suggest that at least 50% of household members were assigned to one of the livelihood diversity classes and are engaged in at least two livelihood activities. Lao PDR had the highest proportion of diversified livelihoods in all classes. Household members in the Viet Nam delta (70%) focus on off farm activities to diversify incomes; Hua Sai Bart household tend to diversify in wet and dry season farming activities as do those located in the Tonle Sap. Off farm livelihood activities are an important source of household income for the four LMB sites.

The emphasis on farm activities in contrast to off farm in Hua Sai Bart and the Tonle Sap is partially an artefact of the household members available for interview. The high migration rates to work in major cities of the two sample regions (discussed the migration Section 7.10.2) implies that the remaining population have a bias to farm and agricultural activities in contrast to off farm livelihoods.

Table 81 Levels of livelihood diversification

Income sources by-livelihood activity	Nam Ngum (Lao PDR)	Hua Sai Bart (Thailand)	Tonle Sap (Cambodia)	Mekong Delta (Viet Nam)
Wet season + dry season	70%	56%	59%	31%
Agriculture + off farm	70%%	49%	54%	70%
Wet season + Dry season + off farm	57%	41%	42%	23%

Source: EMRF (2012)

11.6.2 Willingness and capacity to adapt existing livelihoods

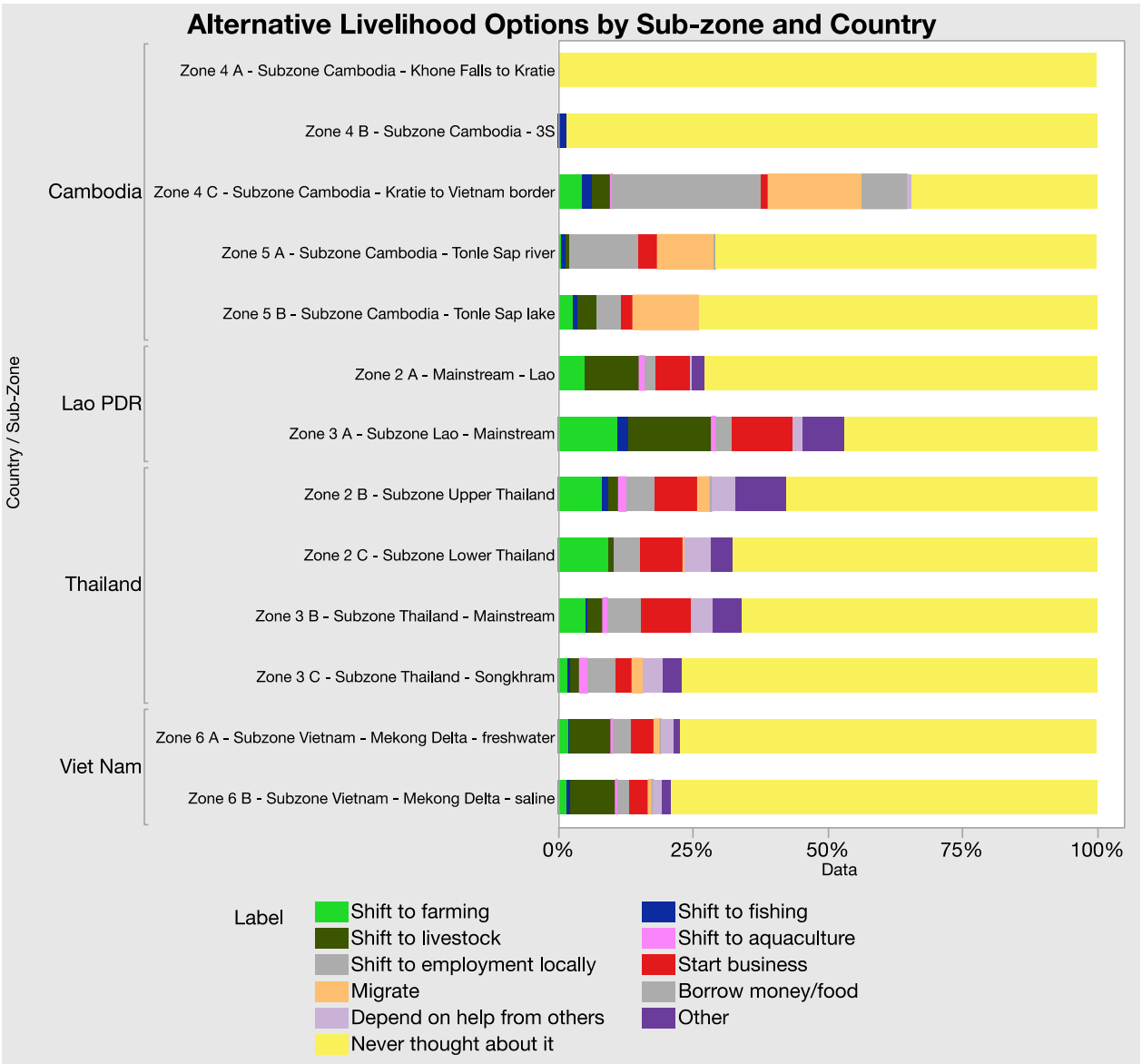
The SIMVA (2015) survey asked the sample households what they would do if they could not continue their present livelihood (Figure 117). 70% of all households answered that they had not considered the possibility nor had developed alternative livelihood strategies. 40% of the total Lao PDR respondents indicated they would adapt if changed livelihood circumstances arose. 13% indicated they would shift to livestock husbandry, 9% would start a business, and 8% would shift to farming. In Sub-zone 3A - mainstream Lao PDR, 55% had considered alternatives: 15% would shift to livestock, 11% start a business, 11% start farming and 8% had described variable options.

In Cambodia, overall 10% of the households would shift to employment locally, while 9% would migrate. 28% of respondents in Sub-zone 4C Kratie to Viet Nam would seek local employment 17% would migrate, while 8% would borrow money or food. In Thailand, 7% would start a business, 5% seek local employment, 6% shift to farming and another 6% would seek alternative options. In Thailand 1% of households answered they would migrate. In Viet Nam 6% would shift to livestock, 5% would start a business, another 5% seek local employment, 4% would start farming and 3% had other options.

Respondents participating in the EMRF (2012) survey were asked to respond to a series of questions to elicit their future adaptation intentions and strategies including ”what would you do if your income was reduced by 50 % for 5 years”? The responses to why would you not try something else and why would you not move to another location are depicted in Figure 118 and Figure 119 respectively. Reasons for not adaptation options with less than 3% of the responses have not aggregated as “other” to assist interpretation. The main impediments to adapting were: financial constraints; perceived lack of skills and education; continue current lifestyle and livelihoods; support and infrastructure is not available; continue ancestral obligations and traditions; and respondents indicated they need food for living.

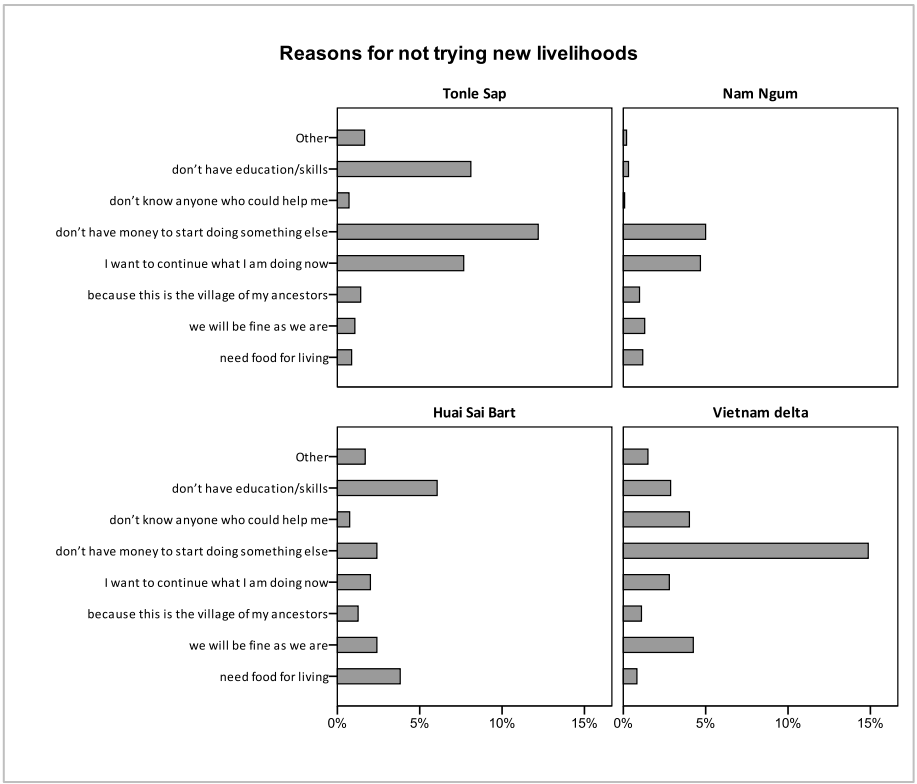
Money constraints, a lack of skills and education, a desire to continue current lifestyle and a lack of social support are the main reported impediments to amending livelihoods to new adaptation strategies Continuing current lifestyle, money constraints, respect for previous generations and a lack of social support and education/skills are the reported impediments to adaptation reliant on migration strategies

Figure 116 Alternative livelihood options by SIMVA sub-zone and country



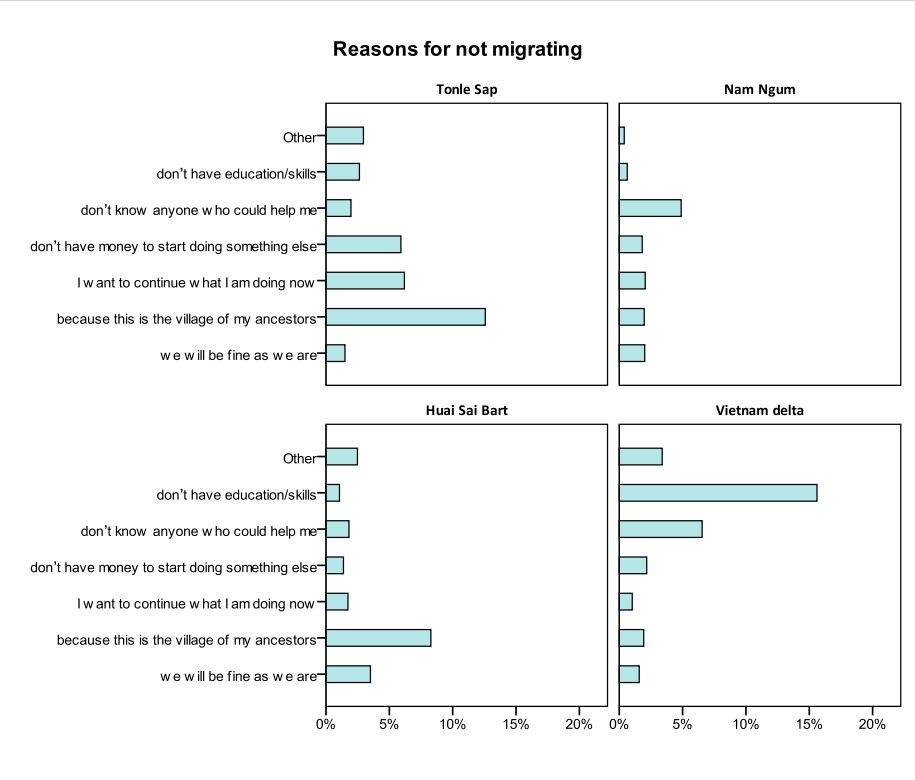
Source SIMVA (2015)

Figure 117 Main reasons for not trying alternative livelihoods



Source: EMRF (2012)

Figure 118 Main reasons for not migrating or moving to try alternative livelihoods



Source: EMRF (2012)

11.7 Household incomes

The MRC SIMVA 2011 report notes that household income is an important measure of vulnerability[42]. When comparing household income between countries it should be recognized that price and expenditure levels differ significantly, due to the difference in proportions between the subsistence and the monetary economy. Households in the Lower Mekong undertake a diversity of concurrent livelihood activities and as a corollary, a diversity of income sources (Figure 115, Figure 116 and Figure 117). Undertaking a diversity of livelihoods and relying on multiple incomes sources represents a widely implemented risk management strategy for poorer and more vulnerable communities and households where endowments, entitlements and capacities allow, and is included one of the Social and Economic sub assessment indicators.

The SIMVA (2015) report notes that a diversity of income sources is one of the factors constituting household resilience. Resilience represents "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change" (IPCC WG2, 2007, p880)[43]. The SIMVA (2015) study documented household levels of consumption, expenditure, and livelihood assets, with the assumption that households with (i) more consumption and spending, (ii) more food stored, (iii) *more diverse livelihood assets and sources of income* and (iv) better health and more social capital, will be more resilient to change (italics inserted).

SIMVA (2011) reports the Lao PDR reports the mean monthly income per capita of surveyed households ranged from $98 in zone 3 in Lao PDR, to $826 in zone 6 fresh-water in Viet Nam. In Cambodia, the figures were $303 and $246 in zone 4 along the mainstream and zone 5 around Tonle Sap, respectively. In zone 2 in Thailand average annual income per capita was $665 and zone 3 in Thailand $362. High-income outliers were censored at US$ 10,000. Income sources assessed included agricultural and fish sales, income from riverbank gardens and livestock, business activities permanent, seasonal and casual employment and remittances.

The EMRF survey implemented a set of similar but more extensive set of livelihood activities including a monetized estimate of the subsistence economy.[44] The subsistence economy is comprised of production for household consumption, bartering and sharing. For comparative analysis subsistence production can be expressed as a proxy income by calculating a monetary value of farm production used by the household for home consumption, estimated from the reported value of produce sold at market, or if no produce was, from the mean of produce sold by adjacent households. The median household incomes of survey respondents are illustrated in Figure 120.

Reported incomes for the Tonle Sap, Nam Ngum River Basin, Huai Sai Bart and the Viet Nam Delta were disaggregated into farm incomes, off-farm income and subsistence income (Figure 119). The main livelihood activity reported by respondents was assigned to the main economic sectors of the Council Study: Agriculture, Secondary, Tertiary and mining. Outlier incomes were censored at USD 10,000 and students and those not working excluded from the analysis. The majority of households across all sectors had farm, off-farm and subsistence income sources, including those working in the secondary and tertiary sectors. The median total household income in Lao PDR ranged from USD 2074 -4731 across sectors; USD 2185-2838 in Cambodia; USD 2068-2035 in Huai Sai Bart and USD 2476-3920 in the Viet Nam Delta. The estimated monetized value of subsistence production was

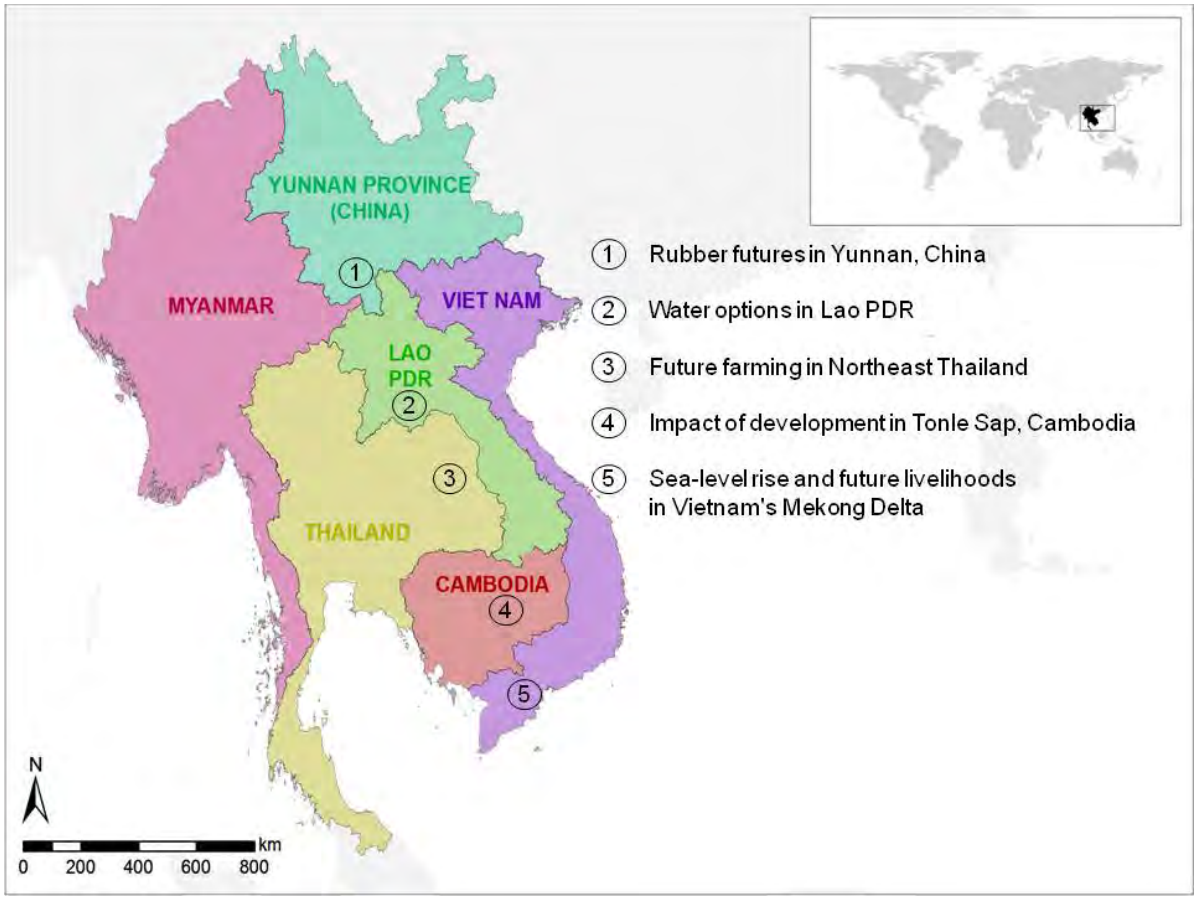
[42] MRC (2011) SIMVA report on social Baseline Survey of the Lower Mekong Mainstream and Flood plan areas. MRC Vientiane.

[43] IPCC (2007) WG2 Global Climate Change report 880

[44] Ward, J. and Smajgl, A., Nolintha, V., Bannalath, K. and Phetvixay, C. (2016). A compilation and summary analysis of Nam Xong Household livelihoods: Exploring cross sectoral futures for the Nam Xong, Lao PDR. Mekong Region Futures Institute, Bangkok, Thailand.

approximately 50% or greater of farm income, except in Viet Nam representing a substantial proportion and central component of aggregate household incomes across all sectors.

Figure 119 EMRF survey sites



Source EMRF (2012) 1: Xishuangbanna; 2; Nam Ngum sub basin; 3:Hua Sai Bart; 4: Tonle Sap; 5: Mekong delta, Vietnam.

Recognising the importance of the subsistence economy, including notions of self-reliance, autonomy and the role as a household risk strategy, combined with potential diminished role as Mekong economies move to expanded and commercial agriculture and the expansion of the manufacturing and service sectors is one foci of the CS social and economic assessment.

To further understand the composition of household incomes and the relative monetary value of the Council Study sectors, incomes from farming activities, off farm employment and subsistence value were aggregated according to the four sector classes. That is agricultural and subsistence incomes were aggregated into the agriculture sector, off farm incomes segregated into the secondary and tertiary sectors and mining incomes into the mining sector.

Median incomes for the agricultural sector in 2012-2013 ranged from USD 2930 in the Tonle Sap - 5965 in Huai Sai Bart and Viet Nam; Manufacturing incomes from USD 499 -3354 in Huai Sai Bart and Viet Nam and the Nam Ngum respectively; Service sector incomes from USD 2789 in the Tonle Sap to 1110 in Huai Sai Bart and mining income of USD 3570 in the Nam Ngum. Note that Manufacturing and Service sector livelihoods were generally reported as secondary occupations and mean incomes were significantly higher.

Figure 120 median household incomes (USD) by source across survey sites

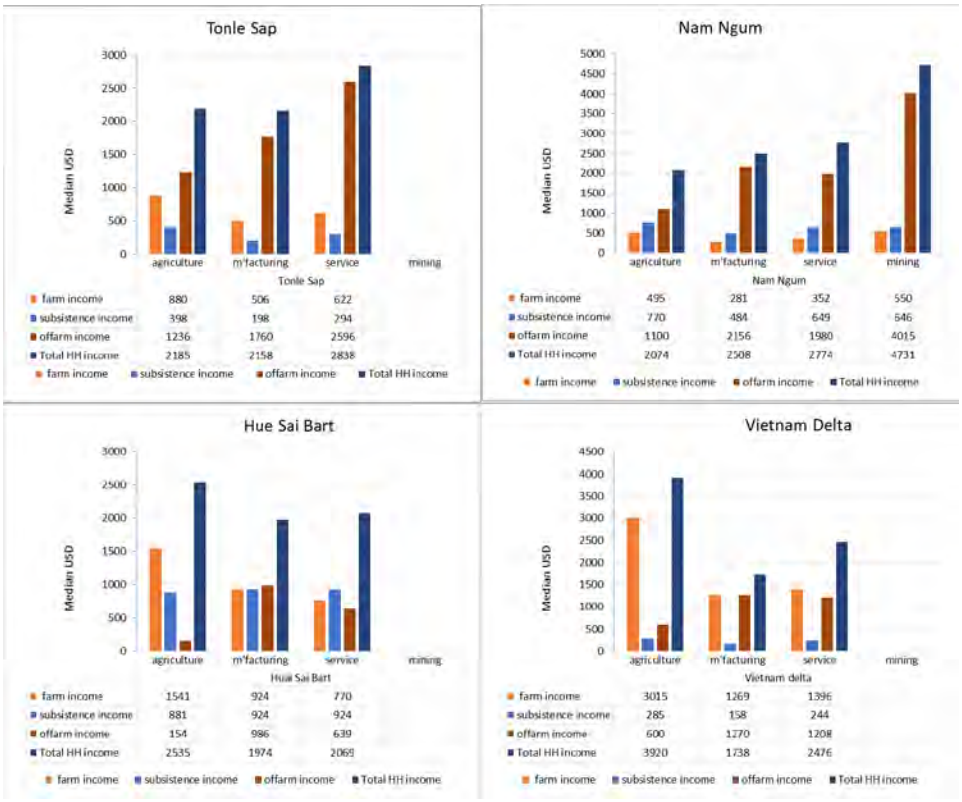
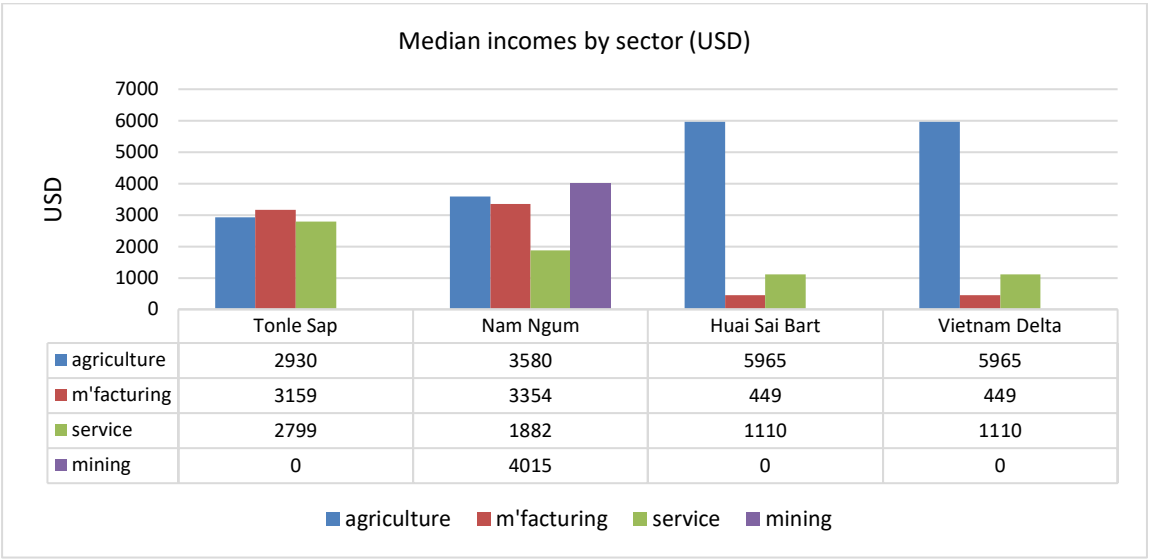


Figure 121 Median incomes across four sites by Council Study sectors



	Tonle Sap	Nam Ngum	Huai Sai Bart	Vietnam Delta
agriculture	2930	3580	5965	5965
m'facturing	3159	3354	449	449
service	2799	1882	1110	1110
mining	0	4015	0	0

Source: EMRF (2012)

11.7.1 Household expenditure

Household income expenditure represents a surrogate indicator of wealth and resilience, where income information might be understated by respondents, particularly in countries where a large

proportion of the population are engaged in farming and/or the informal sector (International Labour Organization, 2003)[45].

SIMVA (2014) analyzed Corridor household expenditure per capita over a period of 3 months. Mean expenditure per capita for the whole Corridor was US$298: Lao PDR expenditure was US$59; Cambodia (US$122); Viet Nam (US$523) and Thailand (US$487). The SIMVA (2014 p 63) suggests "*country-by-country comparisons solely on economic parameters should be taken with caution due to different economic conditions such as price levels and buying power, taxes, and inflation*".

Low expenditure proportions on non-food items suggests high expenditure on food. Poorer households spend most of their income on food and spend little on things such as investment in education, medical care, boat, nets, fishing gear, farming inputs, labour hire and business. A higher expenditure on non-food items tends to imply a greater resilience to shocks or declining water resources. Alwang et al., (2001)[46] argue that two distinct types of poverty prevail: consumption and investment poverty. People who are not consumption-poor may still be investment-poor due to the decline of their asset bases over time and because of their inability to generate sufficient surpluses to protect, maintain, or enhance their assets. The lowest average percentage of expenditure on non-food items was in Lao PDR at 58% and the highest was in Viet Nam at 83%. In Cambodia and Thailand about 66% of household expenditure was spent on nonfood items.

11.8 Employment in the LMB corridor zones

Changes in the structure and composition of employment in the LMB corridor associated with the Development scenarios is one of the social and economic sub-assessment indicators. The primary variables assessed are the estimated number of fulltime employment (FTE) and the relative employment contribution of the CS sectors to communities residing in the LMB corridor. The Employment indicator has clear linkages to the Income Security indicator, particularly the diversity of household income sources and the proportion of income derived from the Agricultural sector. An historical perspective and future predictions are presented in the Section, followed by a discussion of data variance and the diversity of livelihood activities and occupations observed in the LMB corridor.

The selected assessment indicators under the strategic indicator of employment are defined as the levels of employment in sectors related to water resource development and the related gender equity consideration, as shown in Table 83.

Table 82 Formulation of assessment indicators related to Employment

Assessment indicator	Assessment criteria	Discipline specific indicators	Data source
Employment	No. of people employed in MRC sectors	Full time equivalent (FTE) paid or unpaid employment	Economic assessment data
	Proportion of total labour force employed in MRC sectors	Total people of employable age (male and female) from dependency ratio	MRC SEDB, WDI, ADB

[45] International Labour Organization. (2003). Household Income and Expenditure Statistics. Paper presented at the Seventeenth International Conference of Labour Statisticians http://www.ilo.org/public/english/bureau/stat/download/17thicls/r2hies.pdf. Accessed on July 2017. Cited SIMVA (2014)

[46] Alwang, J., Paul, S. B., & Steen, J. L. (2001). Vulnerability: A view from different disciplines *Social Protection Discussion Paper Series*: Social Protection Unit, Human Development Network, The World Bank. Cited in SIMVA (2014)

Assessment indicator	Assessment criteria	Discipline specific indicators	Data source
Gender equity	% of female in water, food, income and health secure communities; % of male in water, food, income and health secure communities.	Village population by gender	MRC SEDB and where available SIMVA 2015 (Village data)

Employment (expressed as full-time equivalent (FTE) jobs in MRC sectors) is only partially covered by both the SIMVA data and data available in the socio-economic database. To overcome this, estimates were made by reference to the levels of production in each sector as determined in the economic assessment, and from the CS Economic Assessment from which labour requirements can be determined. A Spreadsheet Tool was developed to connect the food security and the agricultural-fisheries analysis with sectoral employment estimates and the macro-economic assessment of the Council Study (Appendix 10.3).

Between 1990 and 2010, the economies of Viet Nam, Cambodia and Lao PDR have experienced rapid structural changes with a significant reduction in the proportion contributed to national GDP by the agricultural sector to national GDP. Associated with the reduction of agricultural GDP contributions, has been a notable increase in the GDP contributions by the industrial and service sectors. In Viet Nam, the contribution of the agricultural sector as a percentage of GDP fell from 39% in 1990 to 19% in 2010.

Table 83 Contribution of the Agricultural Sector as % of GDP: Actual and Projected

Country	1990	2000	2010	2020	2030	2060
LMB countries						
Thailand	10.0%	9.2%	10.5%	8.0%	6.0%	3.0%
Viet Nam	38.7%	24.5%	18.9%	15.0%	10.0%	5.0%
Cambodia	56.5%	37.6%	36.0%	25.0%	15.0%	10.0%
Lao PDR	61.2%	48.5%	32.6%	20.0%	12.0%	6.0%
Other ASEAN countries						
Malaysia	15.0%	8.3%	10.5%	8.0%	6.0%	3.0%
Indonesia	19.4%	15.6%	15.3%	12.0%	10.0%	6.0%
Philippines	21.9%	14.0%	12.3%	10.0%	8.0%	4.0%
East Asia						
South Korea	8.7%	4.6%	2.6%	2.0%	1.5%	1.2%
Taiwan	4.2%	2.1%	1.6%	1.4%	1.2%	1.2%
China	27.1%	15.1%	10.1%	8.0%	6.0%	3.0%

Sources: World Development Indicators (2017); MRC (2015) estimates for 2020 to 2060 projections.

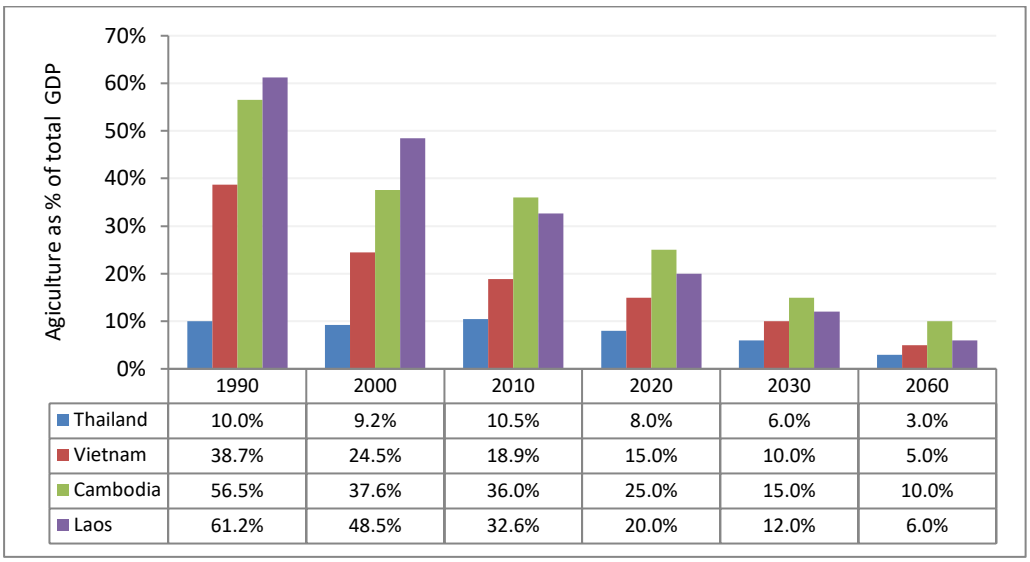
The economies of Cambodia and Lao PDR remain primarily based on agriculture and fisheries, a similar scale of transformation was experienced over this period, i.e. 57% to 36% (Cambodia) and 61% to 33% (Lao PDR). In Thailand, structural transformation occurred in the 1970s and 1980s so, by 1990, the contribution of the agricultural sector had reduced to 10% of GDP and remained at this level until 2010. In other selected ASEAN and East Asian countries, there have also been reductions in the contributions of the agricultural sector between 1990 and 2010. Chinese agricultural value added as a proportion of GDP fell from 27% to 10%.

The MRC (2015a) estimated future projections of the contributions of the agricultural sector to GDP for 2020, 2030 and 2060. The projections forecast that the relative contributions of the agricultural

sector will continue to decline in LMB countries as the industrial and service sectors expand. By 2060, it is expected that agriculture will account for between 3% (Thailand) and 10% (Cambodia) which will reflect the high to middle income status of the LMB countries. The contributions of the agricultural sector to GDP in LMB countries are illustrated in Figure 122.

The information reported in Table 85 indicates that in 1990 a substantial proportion of the LMB countries' population were dependent on the agricultural sector for their livelihoods and employment; ranging from 63% in Thailand to 85% in Lao PDR. Agricultural sector employment declined between 1990 and 2010. In 2014, the proportion of the population depending on agriculture and fisheries ranged from 32% in Thailand, 44% in Viet Nam and 65% in Cambodia and Lao PDR (Figure 123).

Figure 122 Contribution of Agricultural Sector as % of GDP in LMB Countries



Source: MRC (2015a)

Table 84 Contribution of the Agricultural Sector as % of Employment: Actual and Projected

Country	1990	2000	2010	2020	2030	2060
LMB countries						
Thailand	63.3%	44.2%	38.2%	32.0%	25.0%	15.0%
Viet Nam	72.1%	64.4%	49.5%	40.0%	35.0%	20.0%
Cambodia	81.4%	73.7%	72.3%	60.0%	50.0%	30.0%
Lao PDR	85.4%	76.3%	72.2%	55.0%	45.0%	25.0%
Other ASEAN						
Malaysia	26.0%	16.7%	13.6%	10.0%	8.0%	5.0%
Indonesia	55.9%	45.3%	38.3%	30.0%	25.0%	18.0%
Philippines	44.9%	37.1%	33.2%	25.0%	20.0%	15.0%

Sources: World Development Indicators (2015), World Bank (2014), (MRC 2015a) estimates for 2020 to 2060 projections.

The agricultural sector's contribution to employment in LMB countries has not fully reflected the structural transformation in LMB economies which have seen a very substantial fall in the agricultural sector's contribution to GDP. That is agricultural employment levels have remained high in the LMB countries relative to the decline in GDP contributions. Continuing low levels of productivity is a

common explanation, requiring modernization, land consolidation and improved crop varieties. However, the absence or partial inclusion of the monetized value of subsistence production in GDP calculations coupled with the informal reporting of small holder production and artisanal fishing offers an additional and often neglected explanation.

The dependence on agriculture and fisheries as the main source of livelihood and employment for a large proportion of the population is also likely to continue. The MRC (2015a) future projections forecast that the relative contributions of the agricultural sector to livelihoods and employment will continue to gradually decline in the long term. By 2060, the MRC (2015a) estimate the agricultural sector will account for between 15% (Thailand) and 30% (Cambodia) of national employment.

Figure 123 Time series trends of LMB country level sectoral employment

Source: ADB (2016); LAO PDR: ADB (2016), World Bank (2017) and Lao PDR 8th NSEDP (2016)[47]

The relative changes in the Agriculture, Secondary and Tertiary sectors in the LMB countries are illustrated in Figure 123. The Agricultural sector here includes agriculture, fisheries and forestry; the secondary sector includes mining, manufacturing, energy generation and construction; the tertiary sector includes all services.

The service sector in Cambodia has increased from 19.8% in 2000 to 27% in 2015 despite a substantial downward adjustment in 2005-2006. There are substantial data deficits describing sectoral employment in Lao PDR, however there is trend of increasing employment in the services sector, a national strategy emphasised in the Lao PDR 8th 5 year NSEDP (MPI 2016). The secondary and service sectors in both Thailand and Viet Nam have increased since 2000: Service sector employment increased by 8% in Thailand and 9% in Viet Nam; secondary sector employment increased by 4% and 7% respectively. The service sector in Thailand now employs more people than those engaged in agriculture.

International sources of employment data and assessments of the LMB country economies rely generally on National Statistics (ADB 2016; WDI 2017, International Labour Organisation 2017). Sectoral employment data are commonly compiled at the National Level particularly time series data. Two questions arise: how consistent are the data sets and are the National level data representative of the employment in the LMB corridor?

Five sets of sectoral employment data are listed in Table 86; data from the World Development Indicators (WDI 2017), the ADB (2017) and the ILO (2017) (National level data); and the SIMVA (2015) and Exploring Mekong Region Futures data (2012). The latter are specific to the LMB corridor or to regions adjacent to the corridor and employed the same randomised sampling regime (n=4,920 and 5,632 respectively).

To enable temporal comparison, the ADB, WDI and ILO data for Thailand and Viet Nam represent 2012-13 except Lao PDR which represents 2011: the SIMVA data are for 2014 and the EMRF data represents 2012-2013. The noted employment trends for 2014-15 are illustrated in Figure 123. The ILO (2016) data are included to emphasise the historical decline in agricultural employment and as reference to the most recent data available. Note that the estimate of Lao PDR Agricultural employment increased from 71% in 2011 to 78% in 2016.

Table 85 Estimates of sector employment in the LMB countries (% of total employed)

	Sector	Cambodia	Lao PDR	Thailand	Viet Nam
WDI (2011) [b]	Agriculture	51.0%	85.4%	41.0%	48.3%
	Secondary	18.6%	3.5%	19.4%	21.3%
	Tertiary	30.4%	11.1%	40.0%	30.4%
ADB (2014) [c]	Agriculture	63%	80%	33%	47%
	Secondary	8%	20%	39%	34%
	Tertiary	27%		27%	20%
ILO (2011-13)[e]	Primary	54%	71%	41%	48%
	Secondary	16%	8%	19%	21%
	Tertiary	30%	20%	40%	30%
	Agriculture	66.0%	60.0%	68.0%	61.0%

[47] ADB (2016) Key Indicators for Asia and the Pacific 2016, ADB, Manila. World Bank database (2017) http://data.worldbank.org/ ; Lao PDR Ministry of Planning and Investment (2016); Lao PDR 8th 5 year National Socio-economic Development Plan (2016-2020) Ministry of Planning and Investment

SIMVA (2015) [d]	Secondary	20.0%	6.0%	21.0%	18.0%
	Tertiary	13.0%	30.0%	11.0%	20.0%
EMRF (2011-12)[a]	Agriculture	65.1%	70.4%	84.3%	73.9%
	Secondary	5.3%	4.7%	3.3%	7.3%
	Tertiary	21.7%	18.9%	6.3%	7.6%
ILO (2016)	Primary	42%	78%	34%	42%
	Secondary	20%	4%	23%	23%
	Tertiary	38%	18%	43%	35%

Sources [a]: Exploring Mekong Region Futures (2012); [b] World Development Index (2017); [c] Asian Development Bank (2017); [d] SIMVA (2015); International Labour Organisation (2017)[48] Note The ADB and ILO estimates for Lao PDR represent 2011 data (2014 data N/A)

The data in Table 86 (and illustrated in Figure 124) indicate substantial variability and discrepancies in the estimated proportions of sectoral employment in the LMB countries. The ADB, ILOP and WDI estimates of Agricultural employment are relatively consistent for Thailand and Viet Nam and vary by more than 10% for Cambodia and Lao PDR. Similar variance occurs for the Secondary (10.6% and 16.5% respectively) and Tertiary (3% and 9% respectively) sectoral employment estimates for Lao PDR and Cambodia. Similar variance occurs for the Secondary and Tertiary employment for Thailand and Viet Nam. The discrepancies highlight probable divergence in the methods deployed to compile National data. The discrepancies also highlight the compelling requirement for the Member Countries to complete and update their contributions to MRC social and economic database, particularly at Provincial level, to enable robust analysis for the CS.

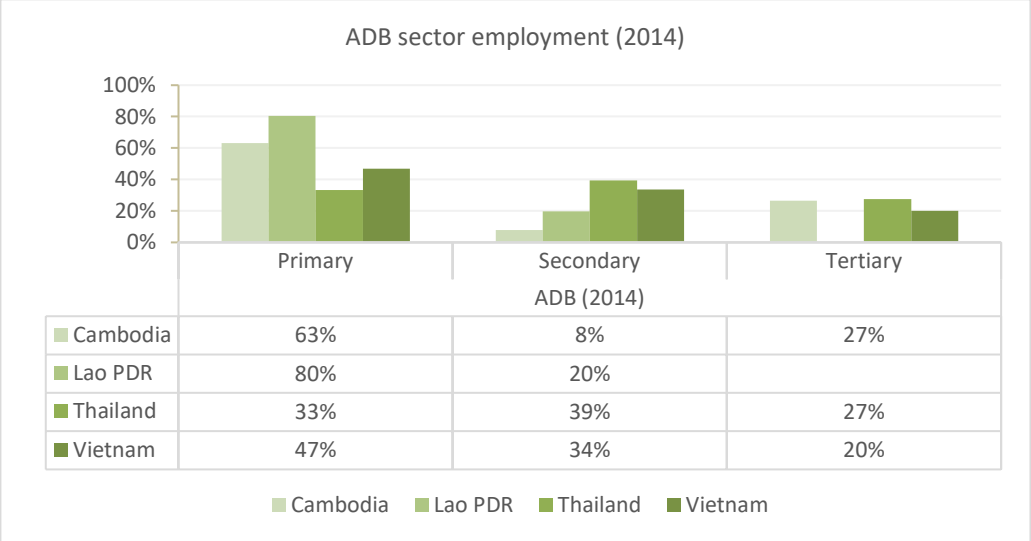
Sectoral employment form three sources are presented in Figure 124: The ADB represents whole of country; SIMVA represents corridor employment and the EMRF results represent both the corridor (Tonle Sap and the Delta) and two adjacent sites (the Nam Ngum River basin in Lao PDR) and Hua Sai Bart (north eastern Thailand). The ADB data substantially underestimates Primary sector employment in Thailand and Viet Nam compared to the two corridor based data sets (33% compared to 67% and 84%) while the proportion of Secondary sector employment is higher compared to SIMVA and EMRF for all four countries. The ADB provides no data for Lao PDR Tertiary employment. The variations are a probable result of the inclusion of major urban centres in the ADB data whereas the corridor surveys centred on rural populations.

The differences highlight the high probability of introduced bias in either extrapolating or interpolating corridor employment estimates to the whole of the LMB or vice-versa.

The EMRF and SIMVA results also vary substantially: Agricultural employment estimates are higher for Lao PDR, Thailand and Viet Nam compared to SIMVA and consistent with the ADB comparison, Secondary employment is generally lower in the EMRF estimates. SIMVA Tertiary estimates are higher for Lao PDR, Thailand and Viet Nam. The range of possible occupations presented to SIMVA respondents was constrained compared to the EMRF possible occupations. This combined with the sampling of remote communities where agriculture was the dominant livelihood activity is a possible explanation.

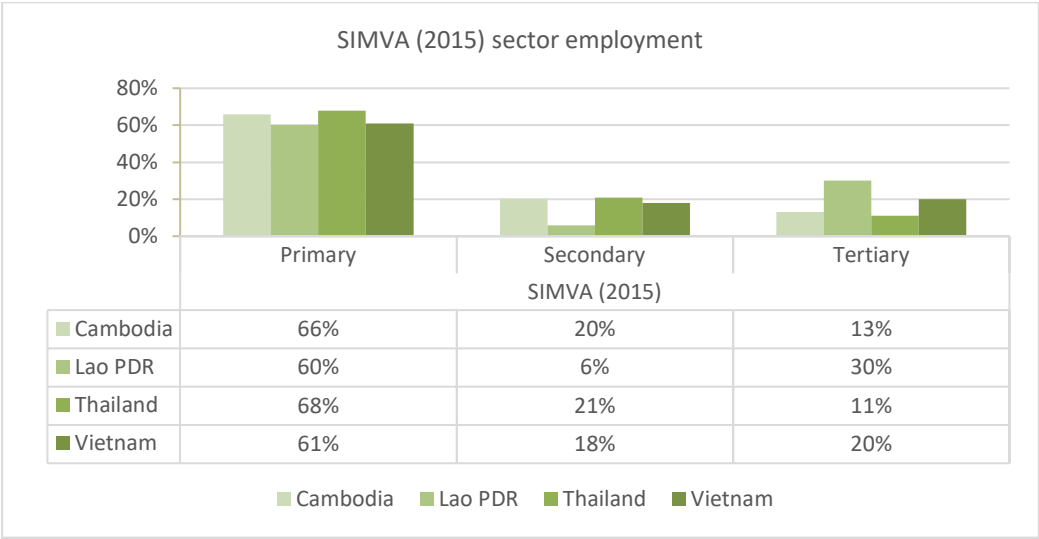
[48] Exploring Mekong Region Futures (2012) see for example Ward, J and Poutsma H. (2013) The compilation and summary analysis of Tonle Sap Household livelihoods: Exploring Tonle Sap Futures Project. CSIRO Climate Adaptation Flagship; Canberra Australia; World Development Indicators (2017) http://data.worldbank.org/data-catalog/world-development-indicators ; Asian Development Bank (2017) https://sdbs.adb.org/sdbs/ ; SIMVA (2015) Social Impact Monitoring and vulnerability assessment, MRC Vientiane; International Labour Organisation (2017) http://www.ilo.org/global/statistics-and-databases/lang--en/index.htm

Figure 124 National level, corridor level and region specific employment by sector (2012-2014)



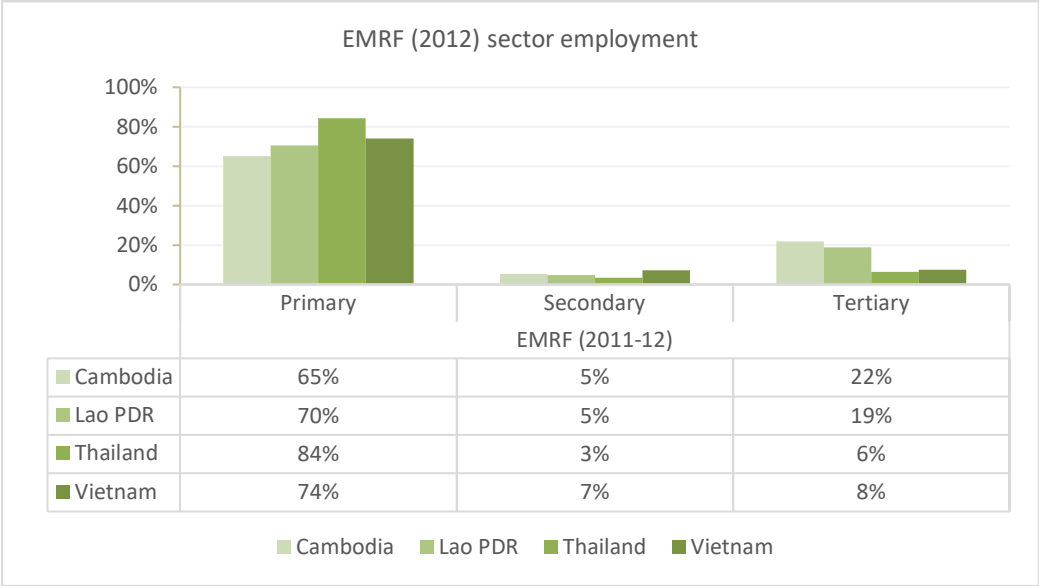
ADB (2014)

	Primary	Secondary	Tertiary
Cambodia	63%	8%	27%
Lao PDR	80%	20%	
Thailand	33%	39%	27%
Vietnam	47%	34%	20%



SIMVA (2015)

	Primary	Secondary	Tertiary
Cambodia	66%	20%	13%
Lao PDR	60%	6%	30%
Thailand	68%	21%	11%
Vietnam	61%	18%	20%



EMRF (2011-12)

	Primary	Secondary	Tertiary
Cambodia	65%	5%	22%
Lao PDR	70%	5%	19%
Thailand	84%	3%	6%
Vietnam	74%	7%	8%

Source: Source: ADB (2017); SIMVA (2015); EMRF (2012)

11.9 Macroeconomic indicators

To expand and refine the set of socio-economic indicators, the socio-economic Assessment team is coordinating with the Economic Assessment Team to develop a standardised set of social and economic indicators, set out in Table 87. The teams have exchanged data and results to reinforce both the CS Economic and Socio-Economic assessments and contribute to the Cumulative Impact Assessment.

Table 86 Economic dimension: strategic and assessment indicators

Strategic Indicators	Assessment Indicators
Economic performance of MRC sectors	▫ Economic value of irrigated agriculture: ▫ Economic value of recession agriculture ▫ Economic value of lowland rain fed agriculture ▫ Economic value of hydropower production ▫ Economic value of mainstream navigation ▫ Economic value of flood damage ▫ Economic value of drought damage ▫ Economic value of capture fisheries ▫ Economic value of reservoir fisheries ▫ Economic value of aquaculture ▫ Economic value of river bank gardens ▫ Economic value of upland forestry ▫ Economic value of flooded forests ▫ Economic value of wetlands, key habitats and conservation areas ▫ Economic value of sand mining ▫ Economic value of productive activities in areas affected by salinity ▫ Economic value of assets in locations affected by river bank erosion ▫ Economic expenditure on tourism and recreation ▫ Aggregate economic value (from above)
Contribution to basin economy	▫ Proportion of MRC sectors contribution to overall basin GDP ▫ Food security: % of national food grain demand met from basin resources ▫ Food security: % of national protein demand met from basin resources ▫ Energy security: % national demand met from hydropower generation ▫ Economic value of investments in MRC sectors

(source Table 2.1 of the CS Economic Assessment Report, November 2016)

11.10 Urban flood risk in the LMB

The Aqueduct Global Flood Analyzer is a web-based interactive platform which measures river flood impacts by urban damage, affected GDP, and affected population at the country, state, and river basin scale across the globe, as well as 120 cities (WRI 2017)[49]. It aims to raise the awareness about flood risks and climate change impacts by providing open access to global flood risk data free of charge. The Analyzer enables users to estimate current flood risk for a specific geographic unit, taking into account existing local flood protection levels. It also allows users to project future flood risk with three climate and socio-economic change scenarios. These estimates can help decision makers quantify and monetize flood damage in cost-benefit analyses when evaluating and financing risk mitigation and climate adaptation projects.

The Flood analyzer identifies the future change in flood risk driven specifically by climate change and socio-economic development, which helps decision makers identify the drivers of future change and prioritize development focuses accordingly for strategic planning.

Socio-economic change and development relies on the data from the Shared Socio-economic Pathways (SSP; see for example Fujimori et al. 2017[50]). These data are produced assuming certain story lines of socio-economic development across the world. In total 5 storylines are available and future data on economic and urban development as well as population growth is available per country. We downscaled the country GDP and population estimates using a sophisticated downscaling procedure that differentiates growth estimates over urban and rural areas.

SSP 2 - Middle of the Road (or Dynamics as Usual, or Current Trends Continue, or Continuation, or Muddling Through): In this scenario, trends typical of recent decades continue, with some progress towards achieving development goals, reductions in resource and energy intensity at historic rates, and slowly decreasing fossil fuel dependency. Development of low-income countries proceeds unevenly, with some countries making relatively good progress while others are left behind. Most economies are politically stable with partially functioning and globally connected markets. A limited number of comparatively weak global institutions exist. Per-capita income levels grow at a medium pace on the global average, with slowly converging income levels between developing and industrialized countries. Intra-regional income distributions improve slightly with increasing national income, but disparities remain high in some regions. Educational investments are not high enough to rapidly slow population growth, particularly in low-income countries. Achievement of the Millennium Development Goals is delayed by several decades, leaving populations without access to safe water, improved sanitation, medical care. Similarly, there is only intermediate success in addressing air pollution or improving energy access for the poor as well as other factors that reduce vulnerability to climate and other global changes.

SSP 3 - Fragmentation (or Fragmented World): The world is separated into regions characterized by extreme poverty, pockets of moderate wealth and a bulk of countries that struggle to maintain living standards for a strongly growing population. Regional blocks of countries have re-emerged with little coordination between them. This is a world failing to achieve global development goals, and with little progress in reducing resource intensity, fossil fuel dependency, or addressing local environmental concerns such as air pollution. Countries focus on achieving energy and food security

[49] World Resources Institute (2017) http://floods.wri.org/#/

[50] Fujimori. S, Tomoko Hasegawa, Toshihiko Masui, Kiyoshi Takahashi, Diego Silva Herran, Hancheng Dai, Yasuaki Hijioka, Mikiko Kainuma (2017) SSP3: AIM implementation of Shared Socioeconomic Pathways. Global Environmental Change 42 p 268-283

goals within their own region. The world has de-globalized, and international trade, including energy resource and agricultural markets, is severely restricted. Little international cooperation and low investments in technology development and education slow down economic growth in high-, middle-, and low-income regions. Population growth in this scenario is high as a result of the education and economic trends. Growth in urban areas in low-income countries is often in unplanned settlements. Unmitigated emissions are relatively high, driven by high population growth, use of local energy resources and slow technological change in the energy sector. Governance and institutions show weakness and a lack of cooperation and consensus; effective leadership and capacities for problem solving are lacking. Investments in human capital are low and inequality is high. A regionalized world leads to reduced trade flows, and institutional development is unfavourable leaving large numbers of people vulnerable to climate change and many parts of the world with low adaptive capacity. Policies are oriented towards security, including barriers to trade.

Scenario A: RCP 4.5 (moderate climate change) and SSP 2 (continued social and economic development trends);

Scenario B: RCP 8.5 (severe climate change related effects) and SSP 2;

Scenario C: RCP 8.5 and SSP 3 (uncontrolled urban growth and fragmented economies);

100 year flood protection and 2 year flood protection (assumed to reflect zero flood protection);

Urban damage refers to estimates the annualized damage to urban assets and infrastructure due to flooding. Urban centers were differentiated as high, low density and non-urban areas. Damage was estimated according to depth damage function.

Affected population refers to estimates of the annualized number of people affected by inland flooding in a specific area.

Affected GDP (USD$) estimates the annualized GDP affected by inland flooding in a specific area.

100 year protection	**2030**	**Urban damage ($)**	**Affected population (,000)**	**Affected GDP ($)**
Scenario A	Current Annual Expected Urban Damage	$159.9M	142.8	$495.0M
	Increased Impact Due To Socio-economic	$567.0M	28.4	$1.1B
	Increased Impact Due To Climate Change	$154.6M	34.1	$507.9M
	2030 Annual Expected Urban Damage	*$881.5M*	*205.3*	*$2.1B*
Scenario C	Current Annual Expected Urban Damage	$159.9M	142.8	$495.0M
	Increased Impact Due To Socio-economic	$672.9M	83.5	$1.7B
	Increased Impact Due To Climate Change	$462.3M	162.5	$1.5B
	2030 Annual Expected Urban Damage	*$1.3B*	*388.9*	*$3.6B*
Zero flood				
Scenario A	Current Annual Expected Urban Damage	$2.0B	3.1M	$10.7B
	Increased Impact Due To Socio-economic	$6.1B	285.2K	$17.3B
	Increased Impact Due To Climate Change	$1.4B	289.8K	$6.7B
	2030 Annual Expected Urban Damage	*$9.5B*	*3.6M*	*$34.7B*
Scenario C	Current Annual Expected Urban Damage	$2.0B	3.1M	$10.7B
	Increased Impact Due To Socio-economic	$4.8B	596.6K	$18.0B
	Increased Impact Due To Climate Change	$1.8B	595.4K	$7.6B
	2030 Annual Expected Urban Damage	*$8.6B*	*4.3M*	*$36.4B*

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