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1 Acknowledgments

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Finally, we are grateful to members of local communities and local government officers across the Nam Ngum River Basin for hosting numerous research visits, and participating in household surveys. The Muang Feuang District authorities and authorities in several villages in that district have been particularly helpful in working with us over a sustained period. We hope that the information and knowledge generated through our research activities contribute in addressing some of the day-to-day challenges faced by these communities, and future policy development that seeks to attain sustainable development goals in Laos.

2 Executive summary

Laos has achieved an impressive rate of economic growth since its transition from socialist planned economy to market-based economy in the mid-1980s. In spite of the steady aggregate economic growth led by export of natural resources, attainment of food security and other dimensions of wellbeing and public health for its population remains a critical development challenge. Close examination of landscape and livelihood changes in the Nam Ngum River Basin highlight mounting pressures on land, forest and water induced by rapid population growth and expansion of resource-based development including hydropower, mining and plantations. Results of spatial analysis carried out by the project shows a trend of forest fragmentation and loss since 1995. Between 1995 and 2014, over 200,000 ha of forest area has been lost. Large tracts of forest loss occurred in Mountainous, Highland and Lowland Zones within the River Basin.

The case of Nam Ngum River Basin exemplifies not only rapidly changing environmental conditions but also changes in social conditions of people's lives. As infrastructure development such as roads has improved the connectivity of rural communities with urban centres, householders' lives are no-longer based primarily on subsistence-based swidden farming in the uplands or rain-fed paddy rice cultivation in the lowlands complemented by collection of food from wild sources. Close examination of over 3,300 households in the River Basin shows that despite high level of livelihood diversification, agriculture remains as both primary and supplementary livelihood activity for households across the River Basin. Our survey highlights a high level of livelihood diversification, and livelihood activities concurring in multiple locations as improved mobility and economic opportunities outside of villages enable household members to engage in on and off-farm activities beyond their localities. While some households are able to capitalise on the increasing market opportunities to commercially expand their agricultural activities moving away from subsistence rice production in the uplands and the lowlands to cash crop and livestock production, and incorporate new economic opportunities to improve their living conditions, others continue to suffer from poverty and poor health.

Our data, which combines household livelihood, food security and nutrition status of household members further suggest that even in communities that are centrally located and relatively accessible to the country's capital, there are pockets of poverty and food insecurity. In these communities, we observe population groups that continue to suffer moderate to severe level of under-nutrition. Our study shows higher concentration of poverty and poor nutritional status of children under five among socially marginalised minority groups (e.g. Mon-Khmer ethnolinguistic group such as Khmu) situated in areas experiencing rapid degradation of the resource base. This suggests that weak food security and under-nutrition is not merely an issue prevalent in remote and inaccessible parts of the country (e.g. northern or southern Laos), but a persisting reality for socially disadvantaged population groups scattered across the country. Our study thus highlights the importance of identifying pockets of disadvantaged, and at-risk communities to address the next decade of development challenges in Laos, which includes securing food and improving nutritional status. Furthermore, our study results suggests that any efforts to promote farmer participation in agriculture or strengthening food security and improving nutrition status of households will need to consider the differential effects of environmental changes on households and its members.

Our case study in the Nam Ngum River Basin also highlights political challenges of managing natural resources. Despite the injection of over 40 million USD in public funding since 1995, planning and management of the Nam Ngum River Basin remains highly fragmented due to increasing pressures on its natural resources. Our research project facilitated a series of small-scale stakeholder discussions at district and village levels, as well as at the ministry level to discuss some of the persisting challenges. Exchange of information, and the need for meaningful participation in the development decision making process remain critical challenge in the River Basin. Our study highlighted the importance

of small and targeted series of discussions with key stakeholders at different levels to facilitate effective discussions on critical issues.

Finally, our research also demonstrated the importance of building trust and mutual understanding among not only stakeholders but also research partners for successful delivery of an interdisciplinary research project. A series of research trainings and workshops involving research partners in Australia and in Laos during the life of the project not only helped to strengthen the research capacity of researchers but also fostered cross-institutional relationships that became fundamental to smooth the delivery of the current project. The project highlights the importance of multi-disciplinarity and demonstrates that multi-disciplinary research approach is an iterative and on-going process of learning, where research partners continue to learn from one another building on their relationships based on trust. Such learning process is essential for developing a deeper understanding on complex development problems and fostering an environment for multi-sector collaborations.

3 Background

Natural resource wealth and development in Laos

Laos has undergone steady economic growth since the mid-1980s. World Bank (2010) estimates that about one third of this growth has been achieved through investments in large-scale resource development projects, particularly in the hydropower and mining sectors. Developing the country's natural wealth continues to be a key strategy for achieving economic growth and meeting core development objectives in the foreseeable future (GoL 2010, 7th NSEDP 2011-2015). While the rapid development of hydropower, mining and plantations are projected to bring financial revenues to the national economy, there are a number of risks and uncertainties that come with such investments (GoL 2010; World Bank 2010; AusAID 2010). A key concern is that poverty, malnutrition and inequality may increase for poor and vulnerable households who are disproportionately dependent on natural resources for their livelihoods (World Bank 2010, p.2).

To date, many environmental and social impact assessments have been undertaken for specific resource development projects in Lao PDR (i.e. hydropower, mining), however, the effectiveness of various measures prescribed for restoring or improving livelihoods remains unclear. Monitoring of livelihood programs is either inadequate or not based on independent assessments (McDowell et al. 2010; IR 2010). Often, the results of the studies are not made public. For those that are made public, assessment of household livelihood is focused on the conditions facing households in the resettled locations that often do not take into account of complex and dynamic livelihood strategies taken by individual households within those locations or in surrounding communities facing more indirect encroachments on their resource base.

Our research reflected on the core economic and social development goals of the Government of Lao PDR (GoL) including achieving sustainable economic growth, reducing poverty and inequality, and shedding the status of Least Developed Country by 2020 (GoL 2010b). As Laos aims to graduate from the least developed country status by 2020, improving the production and access to food, and quality of food consumed by members of household are particularly important in reducing the high-level of stunting among children less than five years of age. This has prompted the GoL to establish the National Nutritional Policy in 2008, and Agricultural Development Strategy 2011-2020 to expand food security and address the persisting problem of poor nutrition status of children (GoL 2008; GoL 2010). GoL increasingly recognises that poverty reduction goals and targets are constrained by growing inequality and that some groups in society are not reaping the benefits from the country's rapid economic growth (GoL 2010b; MAF and WREA 2010; Messerli et al. 2008). In particular, some of the more vulnerable groups appear to be facing difficulties adapting their lives and livelihoods to the rapid changes in natural resources availability, and accompanying processes of socio-economic and cultural transformation (WFP 2007; GoL 2008; World Bank 2010; Lagerqvist et al. 2014). The key aim of our research was to explore links between natural resource development, resource availability for livelihood purposes, changing livelihood patterns and associated nutritional outcomes.

Nam Ngum River Basin: A microcosm of resource and livelihood change in Laos

Nam Ngum River Basin (See Figure 1) has historically been the site of numerous research, development and conservation projects (Hirsch et al. 1996 and 1999; Lagerqvist et al. forthcoming). Since 1995, investments in Nam Ngum River Basin have increased dramatically in line with the heavy emphasis on natural resource development (especially hydropower, mining, and plantations) as a centrepiece of Lao PDR's economic growth strategy. The Nam Ngum case thus provides a microcosm and baseline for assessing local implications of intensified resource use as well as a geographical and institutional

testing ground for initiatives aimed at optimising livelihood opportunities through collaborative learning, planning and management at multiple levels.

Our research responded to an urgent need for more informed discussion and better coordination among stakeholders in Nam Ngum River Basin to optimise potentials in agriculture, fisheries and other livelihood adaptation opportunities, including non-agricultural pursuits (Boulapha and Lyle 2011). Our project also complemented existing efforts by international donors and others to confront the deep fragmentation in the way resources and socio-economic priorities are managed (e.g. food security and energy production are considered in isolation from one another) by generating knowledge of livelihood adaptation experiences, potentials and constraints.

Nam Ngum River Basin covers approximately 16,000 square kilometres in north-central Laos and cuts across five administrative boundaries: Vientiane province, Vientiane Municipality, Xieng Khouang province and small parts of Luang Prabang and Bolikhamxay (Figure 1). Nam Ngum is a particularly significant River Basin because: it is home to almost 10% of Lao PDR's population (500,000 people) including some of its poorest communities; it contributes about 10% of the water flow to the Mekong River; it accounts for 34% of the country's total dry season rice production; it supports the country's largest and longest established reservoir (Nam Ngum1) and it is close to the capital Vientiane (Vattenfall et al. 2008, Appendix B:1).

To date seven hydropower dams have been completed in the River Basin (Figure 2, Table 1). These include Nam Ngum 1, completed in 1971, which was for long the lynchpin project of Lao PDR's natural resource-based export economy; both Nam Leuk and Nam Song projects constructed during the 1990s divert water into Nam Ngum reservoir; and the three most recently completed dams, Nam Lik 1-2, which began operating in 2010, and Nam Mang 3 and Nam Ngum 2 which began operating in 2012. Table 1 synthesises information from the Ministry of Energy and Mines, International Finance Corporation and Asian Development Bank and lists cascade of existing and planned hydropower projects in the Nam Ngum River Basin.

Mineral production has also increased dramatically in recent years. By 2006, over 6,000 square kilometres of mining exploration and operation concessions were approved. Nam Ngum River Basin hosts one of the largest mining projects in Laos, the Phu Bia Gold Mine and associated Phu Kham Copper-Gold Project, owned by Pan Australian Resources (Vattenfall et al. 2008, A:93; Pan Australia 2015). According to the company website, Phu Bia Mining (Pan Australian Resources registered company name in Laos) has a mineral exploration and production agreement with the Government of Laos in an area over 260,000 ha (See also <http://www.panaust.com.au/phu-kham-copper-gold-operation>) that lies within the Nam Ngum River Basin. Further to this, the Basin also hosts estimated area of at least 8,200 ha of tree plantations areas mostly rubber (Vattenfall et al. 2008, A: 74).

Based on statistics from different government ministries in Laos, approximately 23% of land area within the watershed has been allocated for resource-based investment activities including;

- Mining concessions (332,100 ha) including the country's largest gold and copper mine (Ministry of Energy and Mines, MEM)
- Hydropower (15,781 ha) including 7 completed dams and water diversion schemes and 3 more dams in the pipeline (MEM)
- Agricultural plantations (24,969 ha), including new projects that have agreement from the government (Provincial Department of Planning and Investment)

Numbers of reports and studies raise concerns that cumulative as well as project-specific impacts from mining, hydropower, tree plantations could be significant if activities are not coordinated or properly regulated (World Bank 2010; Vattenfall et al. 2008; Bartlett et al. 2012; Jeuland et al. 2014). In spite of the numerous policies and strategies that are geared

to encourage sustainable resource development in the Nam Ngum River Basin, management of resources in the River Basin has been largely fragmented. Furthermore, increasing population pressure in the River Basin induced by improved accessibility and economic opportunities not only contribute to rapid degradation of resource base but further loss of agricultural land to urbanisation (Figure 3). It is anticipated that if resource development projects in the Basin continue to proliferate without coordination, they will threaten water quality, fisheries, agriculture and tourism potential, making it not only difficult for the local population to maintain and adapt their livelihoods to the changing environment, but further impacting the country's ability to produce sufficient food and ensuring healthy lives for its entire population, and ultimately discourage optimal use of natural resources to sustain economic growth.

Table 1 List of hydropower development projects in the Nam Ngum River Basin

Projects	Investors	Installed capacity	Commercial operation
Nam Ngum 1	EDL (100%)	155 MW	1970
Nam Leuk	EDL (100%)	60 MW	2012
Nam Mang 3	EDL (100%)	40 MW	2012
Nam Song (or Nam Xong)	EDL (100%)	6 MW	2013
Nam Lik 1-2	EDL (20%), China International Water and Electric Corporation, China (80%)	100 MW	2010
Nam Ngum 2	EDL (25%), Shlapak Group, USA (4%), Ch. Karnchang, Thailand (28.5%), PT Construction and Irrigation (4%), Ratchburi Electricity Generating Holding PLC., Thailand (25%), Bangkok Expressway PLC, Thailand (12.5%), TEAM Consulting Engineering (1%)	615MW	2012
Nam Ngum 5	EDL (25%), Sinohydro, China (75%)	120 MW	2012
Nam Ngum 3*	GMS Power, Thailand (27%), Axia Power Holdings B.V. (25%), Rachaburi Electricity Generating Holding PLC, Thailand (25%), Lao Holding State Enterprise (23%)	440 MW	2017
Nam Lik 1	EDL (20%), Hydro Engineering Co., Thailand (80%)	61 MW	2017
Nam Bak 1 and 2**	Nam Ngum 2 Hydropower Company	160 MW	Feasibility Study

* Based on Final Environmental Impact Assessment document for Nam Ngum 2 Hydropower Project prepared for Asian Development Bank in 2011

** According to the Ministry of Energy and Mines' website (updated on 11 November 2015), Nam Bak 1 (Nam Chia) has signed a project development agreement in August 2013 (<http://www.poweringprogress.org/new/power-projects/plan>). See also an article on Nation on-line (<http://www.nationmultimedia.com/business/Ch-Karnchang-secures-deal-for-hydropower-plant-in-30212617.html>), which suggests that CH Karnchang, which constructed Nam Ngum 2 and Xayabouri hydropower projects, signed the agreement with the Government of Laos in August 2013, with estimated project value of 20 billion Thai Baht.

Figure 1 Map of Laos and research site

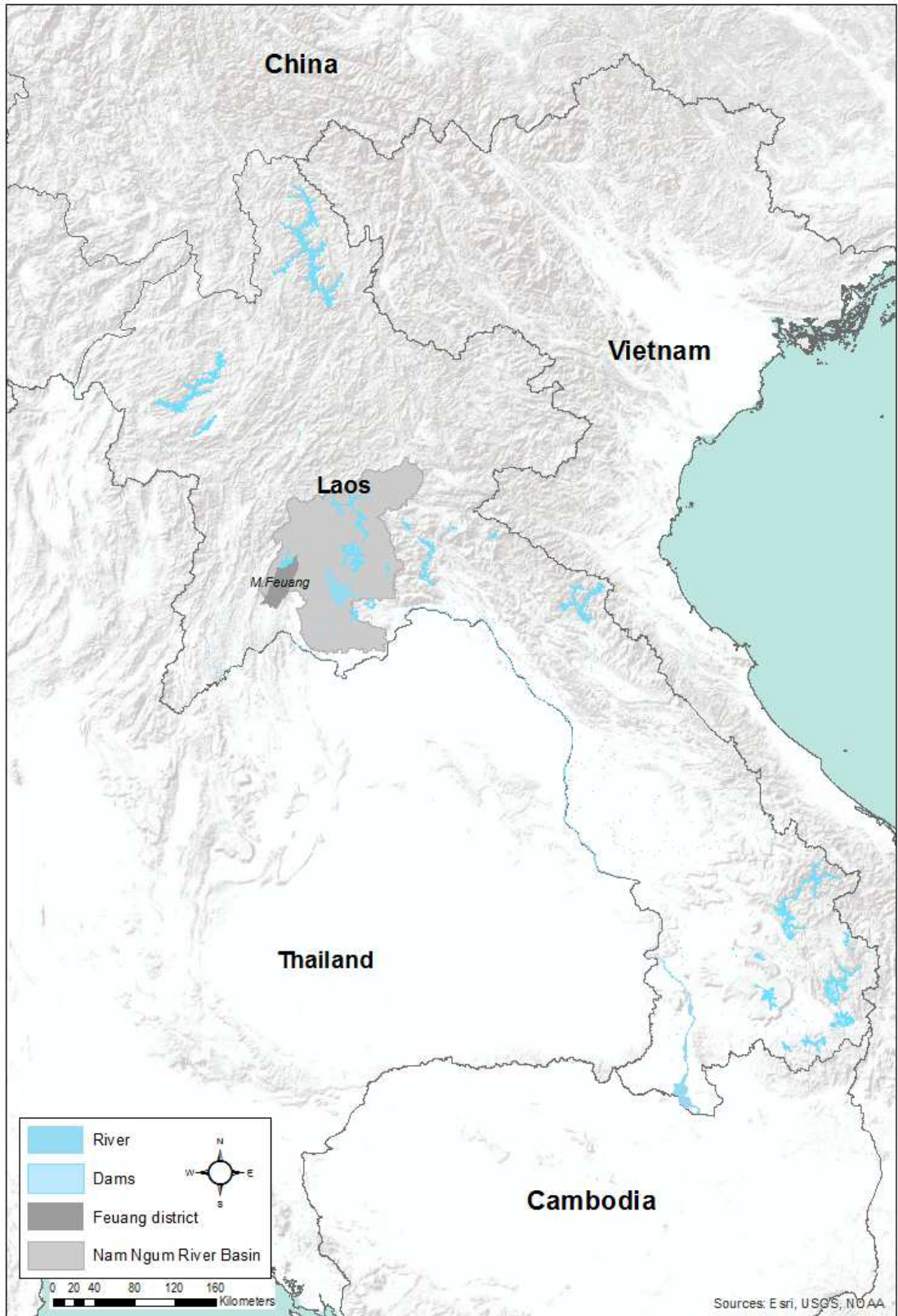
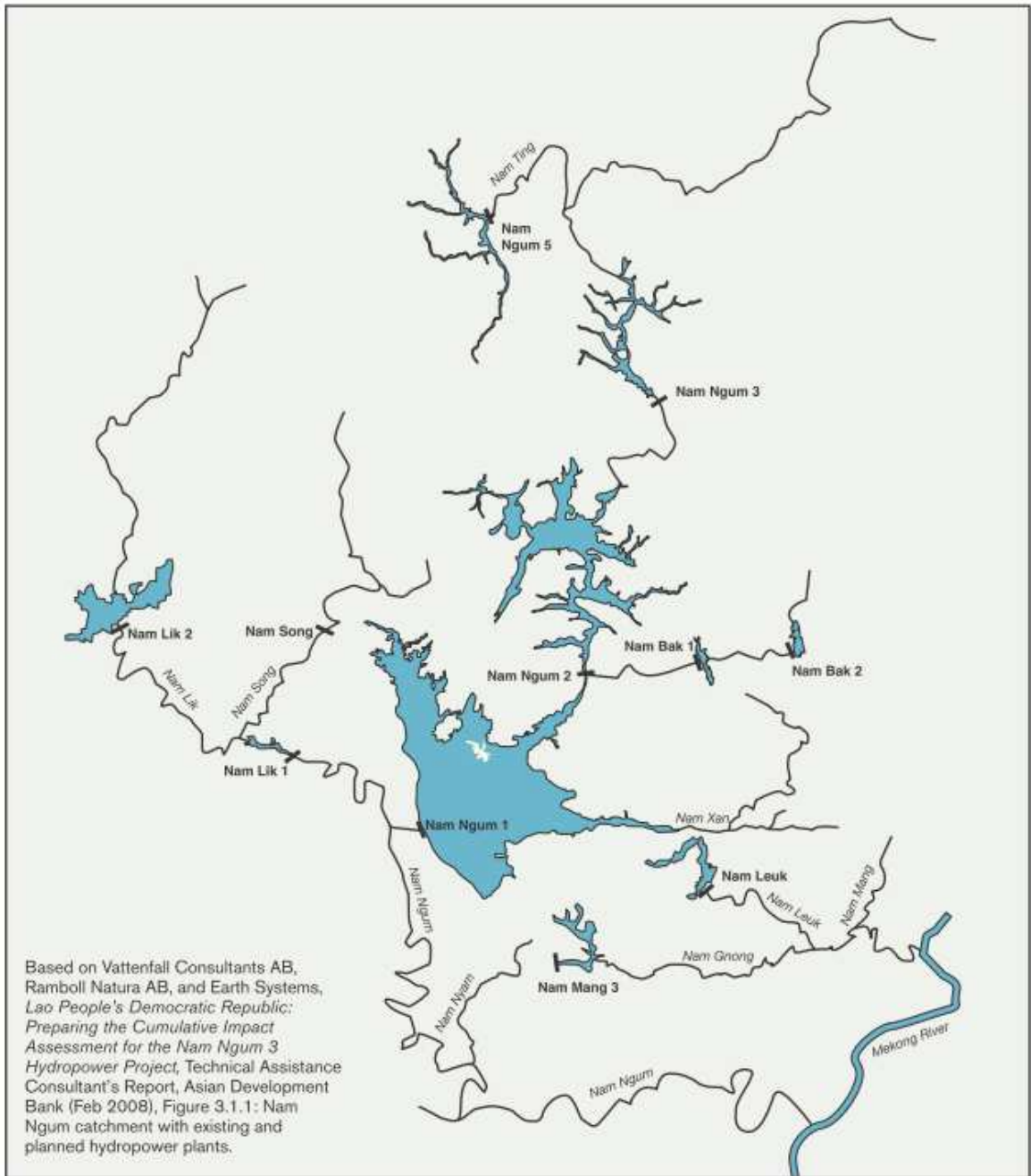
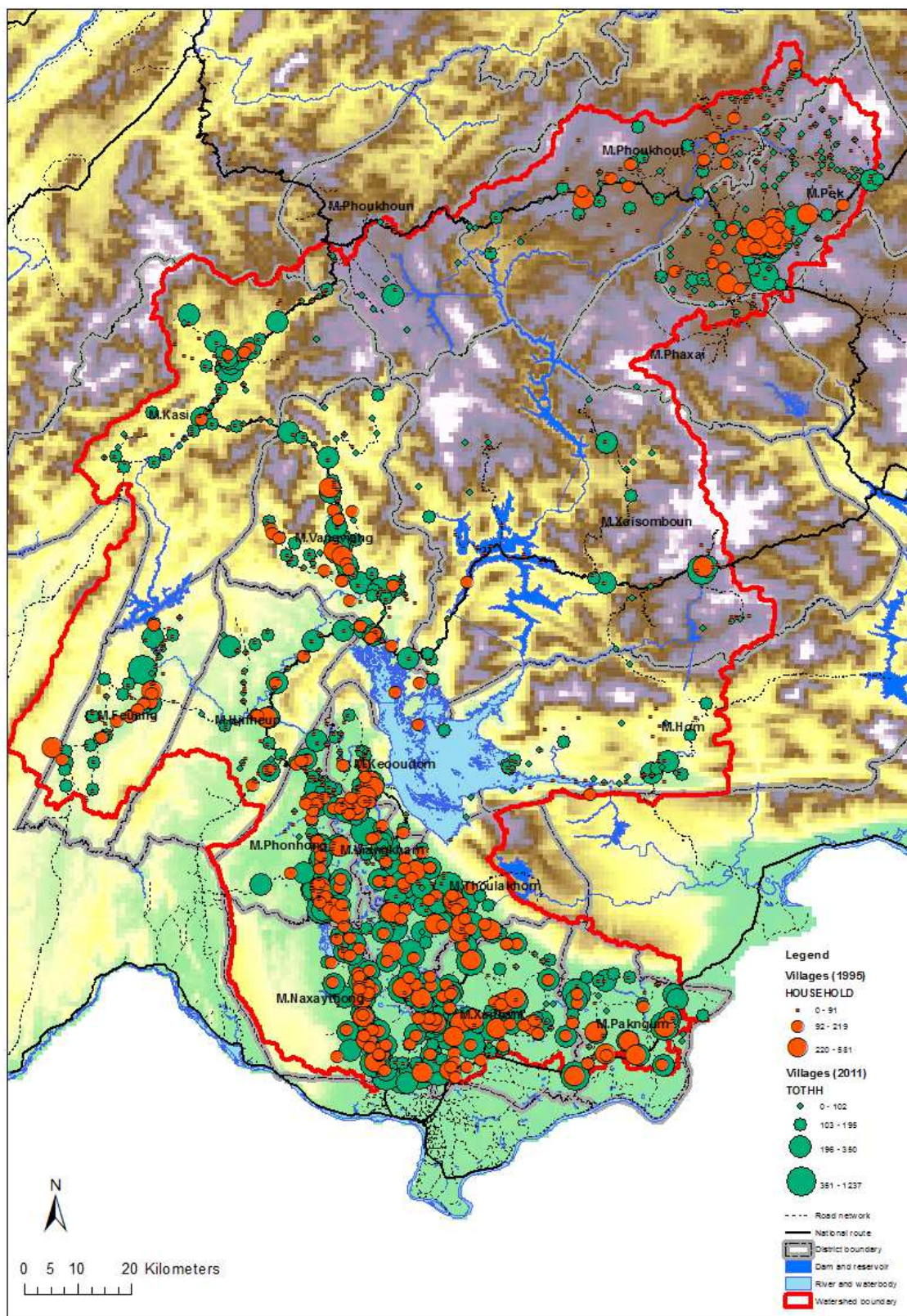


Figure 2 Hydropower development in the Nam Ngum River Basin



Source: International Rivers (2008)

Figure 3 Demographic changes in the Nam Ngum River Basin 1995 and 2011



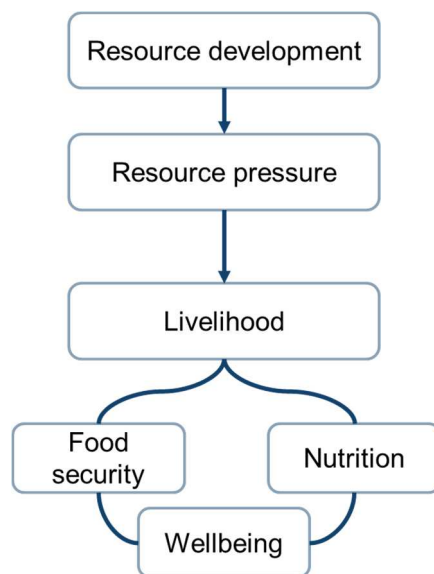
Source: ACIAR Lao Livelihood Project, based on Population Census (1995), Agricultural Census (2011)

4 Objectives

The project aimed to explore the nexus of resource development, livelihood and food security in Laos. Our key goal is to ultimately contribute towards shared understanding on the ways in which sustainable natural resource use and management, (i.e. water, forest and land) is linked to improvement of health and nutritional wellbeing of the population. Our current research is aligned with the current policy focus in Laos, which aims to ensure sustainable resource development and at the same time achieve food security and reduction of poverty.

Using the case study of Nam Ngum River Basin, the current project aimed to review historical patterns of land use change and understand how some drivers such as resource development and demographic changes contribute towards adding pressure on resources and trigger land use change. Furthermore, our research examined how such transformation of the landscape affects rural livelihood, food and nutrition security (Figure 4). Our study also aimed to understand the gaps in the current resource management institutions that seek to improve food access and wellbeing in Laos.

Figure 4 Conceptual framework of the research



Our research aimed to address two main questions:

- 1) *How can the livelihoods of people facing natural resources pressures be improved through a stakeholder-inclusive assessment of livelihood change and adaptation?*
- 2) *How can governance structures and institutions be strengthened through a process of social learning to adopt and upscale livelihood innovations that reduce people's vulnerability?*

In order to answer the research questions, we applied multi-scalar and interdisciplinary approach (See Section 5 below), and designed our research project to address the following three main objectives:

Objective 1 *To identify and understand historical patterns of resource and demographic change and associated instances of critical resource pressure.*

Objective 2 *To assess ways in which households/individuals experience and adapt their livelihoods in response to changing resource pressures.*

Objective 3 *To employ a social learning process to build institutional capacity in facilitating livelihood adaptation at village, local government and watershed levels.*

5 Methodology

As highlighted in Section 4, the current project applied an interdisciplinary approach combining several fields of study including Human Geography, Agriculture, Forestry, Environmental Science and Public Health. The project also incorporated a multi-scalar approach to understand the nested factors that influence the land use change, livelihood and food security nexus.

Our research project adopted mixed methods and incorporated three main analytical approaches as follows:

- Spatial data collection and analysis to assess the overall patterns and trend of land use change in the Nam Ngum River Basin, and drivers contributing to resource degradation (e.g. resource development, population change).
- Quantitative data collection and analysis to assess overall livelihood conditions of households in the Nam Ngum River Basin, and their access to livelihood asset, food, and nutrition status of individual household members.
- Stakeholder discussions and qualitative data analysis to better understand livelihood adaptation process in areas affected by rapid resource development and to assess the development challenges faced by local communities.

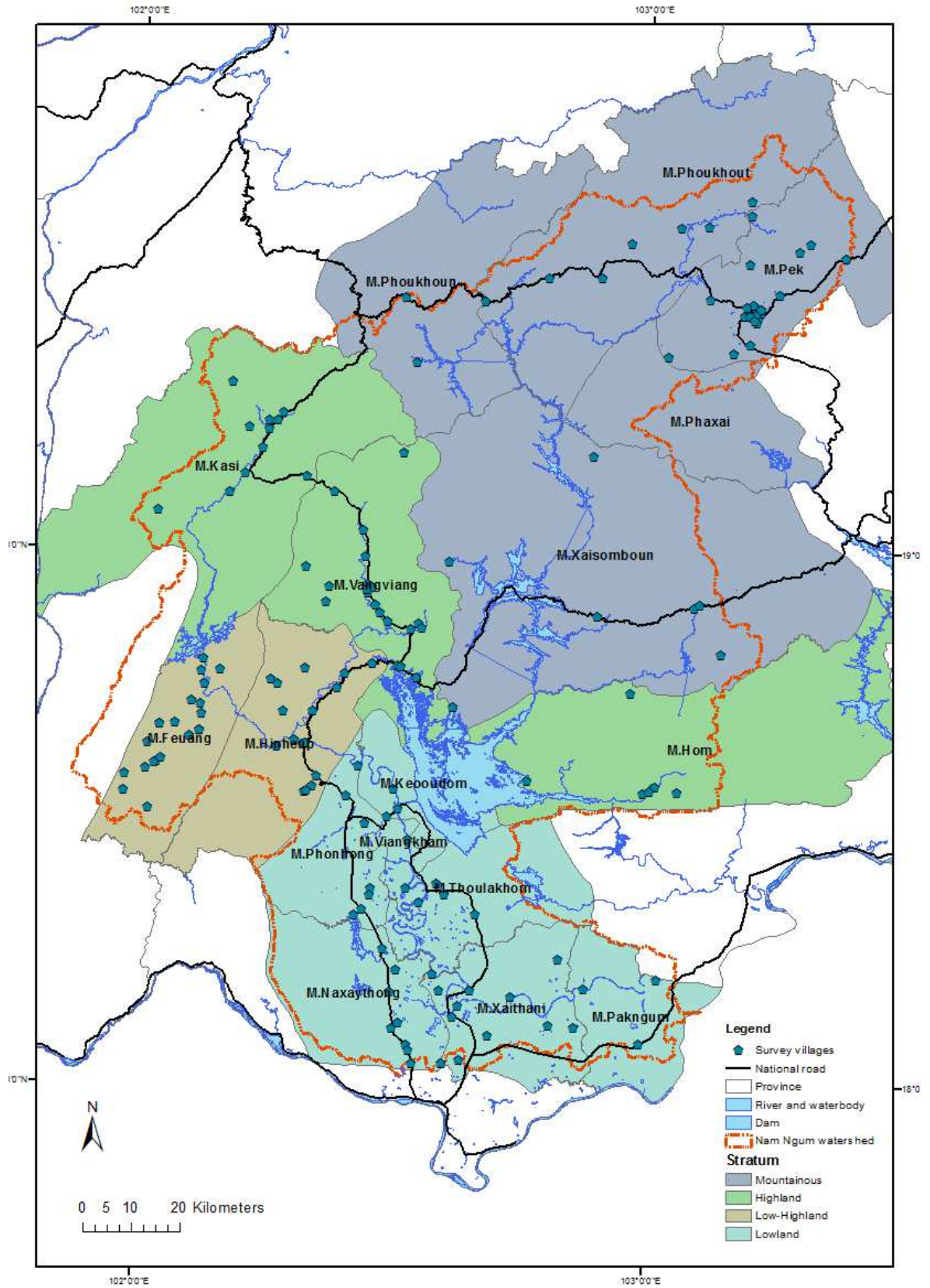
As explained in Section 3, we approached the nexus study using the case of Nam Ngum River Basin, which is where one of the oldest hydropower dams in Laos, Nam Ngum 1, is situated. Table 2 and Figure 5 provide the information of districts and villages covered in the current project. We distinguished the River Basin into four zones based on their topographic characteristics. At the beginning of the project, the Nam Ngum River Basin consisted of 19 administrative districts across three provinces (Luang Prabang, Xiengkhouang, Vientiane) and Vientiane Capital. In 2013, Xaysomboun district was administratively upgraded to a province, which resulted in creation of two new districts within the Nam Ngum River Basin including Longcheng and Annouvong. The stratified topographic zones were used to select household samples for the Basin-wide survey.

Table 2 Four Topographic Zones in Nam Ngum River Basin

Zones	Topographic characteristic	District (Province)
1	Mountainous region (above 1,000 masl)	Phoukhoun (Luang Prabang), Phoukhout, Pek, Phaxai (Xiengkhouang), Xaysomboun* (Vientiane)
2	Highland (500-1,000 masl)	Kasi, Vangvieng, Hom (Vientiane)
3	Lowland-Highland, Nam Lik valley (50-500 masl)	Hinheup, Feuang (Vientiane)
4	Lowland, Vientiane plane (below 50 masl)	Keooudom, Viangkham, Phonhong, Thoulakhom, Naxaythong (Vientiane), Sikhottabong, Xaythany, Pakngum (Vientiane capital)

* Xaysomboun district became a new province in 2013

Figure 5 Survey zones and villages



Source: ACIAR Livelihood Project, village location based on Agricultural Census (2011)

Spatial data collection and analysis

Spatial data collection and analysis was led by a group consisting researchers from the Faculty of Forestry (Sithong Thongmanivong) and the Faculty of Environmental Sciences (Phokham Lattachack), and the School of Geosciences (Yayoi Lagerqvist). The group used time series Landsat images (Landsat 5, 7 and 8) to analyse land use and forest cover change across the Nam Ngum River Basin between 1995 and 2014 (see Table 3).

We used unsupervised classification technique using Erdas Imagine Software and ArcGIS, and classified Landsat images into 50 clusters. This was further reduced to five major classes of forest and land cover including (1) dense forest, (2) old fallow (3) young fallow (4) crop land and (5) water body. These classes were further reduced to three main land cover classes including forest, non-forest and waterbody to further assess the patterns of land use change in the River Basin.

To understand the role of drivers such as demographic changes and resource development on land use transformation, we used information from Population Census (1995, 2005) and Agricultural Census (2011). Census data were used to understand the demographic trend in the River Basin during 1995 and 2011. Agricultural Census (2011) was also used to select survey sites for the Basin-wide household survey.

We further collected land lease and concession data from the Ministry of Natural Resources and Environment (2009), and records of resource-based investment from provincial departments of investment and planning office during the Basin-wide household survey carried out during January and May 2014. This information was used to understand the extent of resource development activities across the Basin.

Finally, to understand the linkage between land use change, livelihood, food security and nutrition, we generated village-based indices for land use and land cover change, food security and nutrition. Indices for food security and nutrition were generated using the household survey data collected during January and May 2014.

Table 3 Summary of spatial analysis and information sources

Key areas of analysis	Scale	Source of information
Land use change pattern	River Basin	<ul style="list-style-type: none"> • Landsat images (1995, 2000, 2005, 2010 2014)
Drivers of land use change	District, village	<ul style="list-style-type: none"> • Land Lease and Concession Data (2009) • Update of investment data district/provincial office • Population Census (1995, 2005) • Agricultural Census (2011)
Food security, and health	Village	<ul style="list-style-type: none"> • Community and household survey data (Jan-May 2014)

Quantitative data collection and analysis

We also carried out a large-scale household survey to understand key demographic, livelihood, food security, and health and nutrition status indicators for the Nam Ngum River Basin. This involved interdisciplinary team that consisted of Sydney School of Public Health (Michael Dibley, Jessica Hall), School of Geosciences (Yayoi Lagerqvist), National

Institute of Public Health (Sengchanh Kounnavong, Somphou Sayasone, Manithong Vonglokham), Faculty of Agriculture (Silinthone Sacklokham, Sayvisene Boulom, Lampheuy Kaensombath, Litoua Chialou).

As explained at the beginning of Section 5, we distinguished the River Basin into four zones based on topographic characteristic. In each of the four zones, a random sample of 40 village clusters were selected proportionate to population size based on the number of households in each village from the most recent Agricultural Census (2011). In each of the selected village, 23 households were randomly chosen. This approach produced a “self-weighted sample in each zone. A total sample of 3,379 households¹ were surveyed in 157 villages across the Nam Ngum River Basin during January and May 2014 by 4 teams of enumerators recruited through the National Institute of Public Health and the National University of Laos. Each of the 4 teams recruited consisted of 1 supervisor, 6 enumerators and 2 anthropometric measurers. An advanced team of 4 people was also recruited to move ahead of the main survey teams to meet with the head of the village to select the households to be interviewed and conduct the community level assessment form.

We revisited relevant survey instruments used in Laos and elsewhere by different organisation and researchers (e.g. Demographic and Health Surveys; UNICEF’s Multiple Indicator Cluster Surveys; WFP’s Comprehensive Food Security and Vulnerability Analysis; CPWF Mekong/IWMI’s Livelihood surveys, I-EEDD/WP5’s Livelihood surveys), and then constructed the outline and initial structure of survey instruments for our project. This was followed by consolidation of survey instruments in English language using Microsoft Excel followed by translation of survey questions into Lao language, which was then used to develop on-line survey forms with Dimagi/CommCare application for digital data capture on electronic tablets.

The survey instrument consisted of seven main components including (see also Figure 6):

1. Community Assessment Form (Respondent – representative of village)
2. Household Identification & Listing Form (Respondent -head of household)
3. Household Information Questionnaire (Respondent -head of household)
4. Men’s Questionnaire (Respondent - men 15-54 years resident in household)
5. Women’s Questionnaire (Respondent - women 15-49 years resident in household)
6. Under-Five Child Questionnaire (Respondent - women 15-49 years with under 5 years child/children)
7. Anthropometric Measurements (Participants – men and women of reproductive age, and their under 5 years old children)

The survey was divided into two phases. The phase with the advanced team and second phase with the 4 main survey teams.

Phase 1

The first phase involved the advanced team travelling to the village 1-2 days ahead of the main survey teams. During this visit the advanced team met with the head of the village to randomly select the 23 households to be interviewed within that village by the main survey teams and also to administer the community assessment form to the village head. Household lists for the survey were given to the village head to pass onto the main survey teams.

Phase 2

¹ Total of 3,680 households were sampled from the research site of which surveys were carried out with 3,379 households.

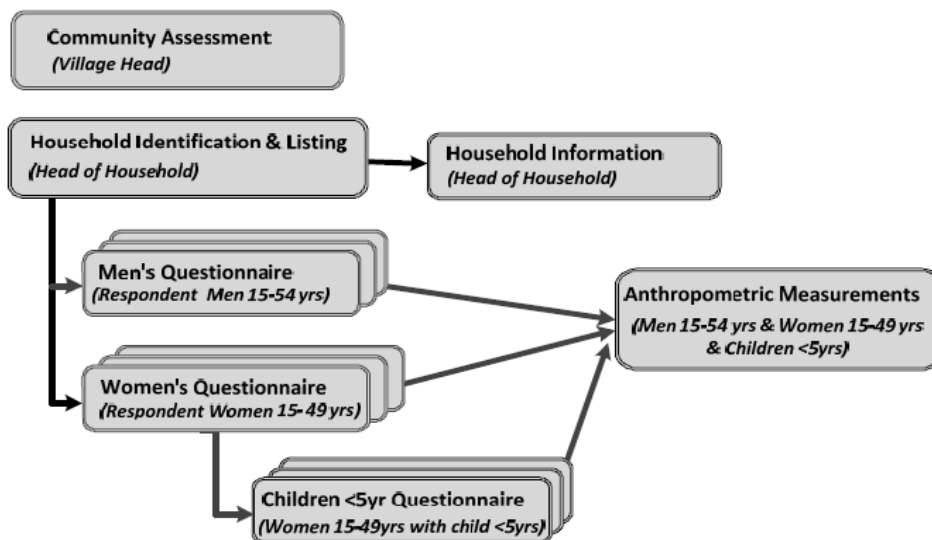
During the second phase of the survey the four main survey teams travelled to their allocated villages to administer the household questionnaires. In teams of two they visited the selected households and administered the Household identification and Household information forms to the head of the household. The men’s questionnaire was administered to all men of reproductive age, the women’s form was administered to all women of reproductive age and the child under 5 form was administered to the mother of the children under the age of 5 in the household.

A specially trained anthropometric team was stationed in the centre of the village to conduct the anthropometric measurements for all men, women and children eligible for measurement from the household. A cake of soap was provided to each family for their participation in the survey.

The survey teams spent 2 days per village collecting the data and returned to the district base camp every night or every second night to upload the forms they had collected to the server.

Each participating household was allocated a unique household identification number, and individuals within each household (participating in surveys 4-7) were listed as sub-cases with unique identification number consisting of the household identification number and their line number from the household listing form.

Figure 6 Structure of household survey



Once forms were submitted to the server, the data was retrieved from the Dimagi CommCare HQ website, downloaded into Microsoft Excel spreadsheet and then checked for errors and cleaned. The cleaned data set was then transferred into Stata 13 for analysis. Descriptive statistics examined to assess the distribution and emerging patterns of the data. Cross tabulations were further conducted to assess the bivariate associations between stunting, food security and selected independent variables, followed by multivariate analysis to assess the relationships between significant variables at the community, household and individual level.

Stakeholder discussions and qualitative data analysis based on case study of Muang Feuang

A series of stakeholder discussions were organised throughout the project period at different levels to facilitate discussions on critical issues of land use transformation and livelihood adaptations in the Nam Ngum River Basin.

At the national level, a basin-wide workshop was held in July 2013 to bring together key stakeholders from all provinces and districts of the Basin, from key resource sectors, from relevant ministries and from various international projects and organisations with relevant work in the Nam Ngum river basin. The workshop was run as a two-part process. The first involved local government staff from relevant departments to discuss the livelihood challenges faced in their districts and provinces in connection with resource pressures, and to explore the sources of those pressures. The second brought in national and international level staff and agency representatives.

At a local level, the project took Muang Feuang (Feuang District) as a case study, on the basis that it was a further microcosm within the basin, given the pressures faced as a result of both demographic growth through resettlement and of hydropower and other resource projects within the district itself. Focus groups, rapid rural appraisal and structured household interviews sought to better understand the conditions of different households in the area affected by resource development and land use change, and strategies taken by individual households to adapt their livelihoods. Regular consultations and stakeholder discussions were held at the District level. Within the district, a special focus was placed on Phonesavath and surrounding villages, which have had to adapt to particularly constrained land, forest and water access as a result of resettlement and land reallocation associated with hydropower development from Nam Ngum 2 dam. The project facilitated stakeholder consultation with the local district, village authorities, and the company responsible for resettlement and livelihood restoration, and members of the research team. The District assigned members of the District Office of Natural Resources and Environment to work with the team. In-depth surveys of 25 sampled households in Phonesavath explored the different adaptation strategies at the household level.

Table 4 summarises key activities. Activities were led by the Faculty of Environmental Sciences (Souphab Khouangvicht, Bae Phaexay) with involvement of researchers from Faculty of Agriculture (Avakat Phasouysaingam), Faculty of Forestry (Khamla Phanvilay), and School of Geosciences (Philip Hirsch, Natalia Scurrah).

Table 4 Summary of key activities

Date	Activity
3-7 April 2013	District stakeholder workshop (3 April) organised jointly by the Feuang district government and the National University of Laos followed by rapid rural appraisal and semi-structured household interview (4-7 April) in Phonesavath Village
30-31 July 2013	Basin-wide stakeholder workshop in Vientiane organised by the National University of Laos and the National Institute of Public Health
7-24 January 2014	Qualitative data collection training (7 January) and field work in Phonesavath village (9-13 January), meeting with Phonesavath village leaders and with representatives of district office (24 January)
7-8 August 2014	District workshop hosted by the Feuang district government, inviting representatives from district government offices, leaders of Phonesavath and surrounding villages, and representative of PT Company

Date	Activity
19-22 September 2014	Follow-up household interviews in Phonesavath and focus group interviews in surrounding villages (Navan and Sam Meun)
20-30 January 2015	Discussions with district authorities, and follow-up fieldwork in Navan and Sam Meun villages
26-29 January 2015	Field-exchange visit to Xekaman 1 dam and Sekong 3 dam in Southern Laos
July 2015	District workshop hosted jointly by the Feuang district government and the Faculty of Environmental Science

6 Achievements against activities and outputs/milestones

Objective 1: To identify and understand historical patterns of resource and demographic change and associated instances of critical resource pressure

Activity2	Outputs and milestones	Completion date	Comments
Activity 1.1.1 and 1.2.1 Identifying patterns of resource and demographic change and instances of critical resource pressure on livelihoods in Feuang District and Nam Ngum watershed.	Preliminary resource pressure map to inform site selection in Feuang District. (PC – Faculty of Forestry)	Jul 2012	Preliminary resource pressure map was used to determine activities outlined under Objective 2 and 3.
	Final resource map for villages participating in participatory action research. (PC – Faculty of Forestry)	Jun 2013	Spatial analysis and results are shared with local village to facilitate further discussions
	Final resource pressure map for discussions at district level workshop (PC – Faculty of Forestry)	Dec 2013	Results of spatial analysis and resource pressure maps are shared with local authorities in Feuang district.
	Research presentations (A – School of Geosciences, PC – Faculty of Forestry)	Jul 2014, Dec 2014, Aug 2015	Results of spatial analysis were presented and shared with research community at international and domestic conferences (July 2014, December 2014; August 2015).
	Final research seminar and presentations at relevant ministries (A – School of Geosciences, Sydney School of Public health, PC- Faculty of Forestry, Faculty of Agriculture, Faculty of Environmental Sciences)	Nov 2015	Research results were presented at key ministries (i.e. Ministry of Health, Ministry of Energy and Mines, Ministry of Agriculture and Forestry) in Laos to facilitate policy discussions (November 2015). It was suggested to produce a short policy brief, and organise semi-formal research presentation. This will be organised in February 2016 in conjunction with the final project review.
	Completed final report. (A – School of Geosciences)	Dec 2015	Final project report. Research teams will continue to complete journal articles and policy brief.

PC = partner country, A = Australia

Objective 2: To assess ways in which household/individuals experience and adapt their livelihoods in response to changing resource pressures

Activity3	Outputs and milestones	Completion date	Comments
Activity 2.1.1 Assessing ways in which households/individuals experience and adapt their livelihoods; and the social costs of adaptation	Survey preparation, including survey instrument, survey teams and training completed. (A – School of Geosciences, PC – Faculty of Agriculture)	Jan-May 2014	Sample selected based on spatial assessment. Survey instrument used to assess livelihood status of households and the social and economic costs of livelihood adaptation.
	1 st stage data compiled and shared at district workshop. (A – School of Geosciences, PC- Faculty of Agriculture, Faculty of Environmental Sciences, Faculty of Forestry)	Apr 2013	Introductory workshop in Feuang district to introduce research activity and activities.
		Apr 2013	Rapid rural appraisal in Phonsavath village, Feuang district. This exercise was useful in learning about the villagers' perspective of development in the village.
		Jul 2013	Stakeholder workshop in Vientiane inviting, district and provincial authorities of the Nam Ngum River Basin.
	2 nd stage data compiled. (PC- Faculty of Agriculture)	Jul-Aug 2013	Focus group interviews in Feuang district.
		Jan and Jun 2014	Household interviews in Phonsavath village, Feuang district.
		May-Jun 2014	Second stage data analysis in Sydney (in conjunction with AAF Round 14, Australia Awards Fellowship Grant from the Department of Foreign Affairs).
		Mar 2015	Draft abstract and outline of research paper prepared for the writing workshop (in conjunction with the Sydney Southeast Asia Centre's Capacity Building Grant).
	Preliminary report completed and shared at district (A – School of Geosciences, PC – Faculty of Agriculture)	Jan 2014	Preliminary findings of livelihood adaptation process was presented to the village cluster leaders in Phonsavath village and discussed with Feuang district authority.
		Aug 2014	Livelihood adaptations issues in resettlement village was discussed with Feuang district authority and company in charge of resettlement activities (PT Company).

Activity3	Outputs and milestones	Completion date	Comments
Activity 2.1.2 Assessing food/nutrition and health	Survey preparation including survey instrument and training completed. (A – School of Public Health, PC – Faculty of Agriculture and National Institute of Health)	Jan 2014	Research team identified and enumerator training completed.
	Household and community survey (PC- Faculty of Agriculture and National Institute of Health)	May 2014	Only one period of data collection for the household survey (January-May 2014). Period of May-October 2014 was spent to clean and compile data set.
	Preliminary data analysis (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture and National Institute of Health)	Jun 2014	Preliminary data analysis carried out in Sydney (in conjunction with AAF Round 14, Australia Awards Fellowship Grant from the Department of Foreign Affairs).
	1 st Writing workshop (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture, Faculty of Forestry and National Institute of Health)	Oct 2014	Writing workshop in Vientiane (in conjunction with the Sydney Southeast Asia Centre’s Capacity Building Grant).
	Research posters (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture, Faculty of Forestry and National Institute of Health)	Oct 2014	Presentation of preliminary result (poster) at the National Health Research Forum organised by the National Institute of Public Health.
	Research posters and presentation (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture, Faculty of Forestry and National Institute of Health)	Dec 2014	Organisation of panel presentation at the National Research for Development at the National University of Laos.
	2 nd Writing workshop (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture, Faculty of Forestry and National Institute of Health)	Mar 2015	Writing workshop in Vientiane (in conjunction with the Sydney Southeast Asia Centre’s Capacity Building Grant).
	Cleaned data set (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture)	Jul-Aug 2015	Data cleaning and analysis in Sydney
	Research presentation (A – School of Public Health, School of Geosciences, PC – Faculty of Agriculture, Faculty of Forestry and National Institute of Health)	Aug 2015	Organisation of panel at the European Southeast Asia Studies Conference in Vienna, Austria
		Nov 2015	Research seminar and presentation in Vientiane

Activity3	Outputs and milestones	Completion date	Comments
	Final report completed and presentation at the final workshop. (A – School of Public Health, PC – Faculty of Agriculture, Faculty of Forestry and National Institute of Health)	Dec 2015	Final report is completed. Research papers and policy brief will be completed by February 2016.
Activity 2.1.3 and 2.2.1 Collecting stories of livelihood adaptation	Fieldwork plan and training completed. (A – School of Geosciences, PC – Faculty of Environmental Science)	Jul 2012	Training is sufficient and is on time.
	Training for ethnographic writing completed (A – School of Geosciences, PC – Faculty of Environmental Science)	Jun 2014	Data analysis training was carried out in Sydney (in conjunction with AAF Round 14, Australia Awards Fellowship Grant from the Department of Foreign Affairs).
	Qualitative data collection	September 2014	In depth interviews with selected households in Phonesavath, focus group discussions with neighbouring villages (i.e. Navan and Sam Meun) in Feuang district.
	Monographs on livelihood adaptation. (A – School of Geosciences, PC – Faculty of Environmental Science, Faculty of Agriculture)	Jan 2014	Monographs of 25 households completed. Detailed analysis of 8 selected households.
	Presentation at district workshop. (A – School of Geosciences, PC – Faculty of Environmental Science, Faculty of Agriculture)	Aug 2014	Results of the detailed analysis were shared with Feuang district authority in August 2014

PC=Partner country, A=Australia

Objective 3: To employ a social learning process to build institutional capacity in facilitating livelihood adaptation at village, local government and watershed levels

Activity4	Outputs and milestones	Completion date	Comments
Activity 3.1.1, 3.1.2, 3.1.3, 3.2.1 Participatory action research to develop local solutions for	Preparation and site selection for participatory action research completed and presented at district workshop. (PC-Faculty of Agriculture, Faculty of Forestry)	Apr 2013	Sites and key participants for participatory action research were identified during a workshop in Feuang district.

Activity4	Outputs and milestones	Completion date	Comments
livelihood adaptation	Field visit and introduction to planning process completed. (PC-Faculty of Agriculture, Faculty of Forestry, and local community)	Apr 2013	Field visit in Phonesavath village was carried out following the district workshop to understand the broad history of the research site.
	First stage field visits (A – School of Geosciences, PC-Faculty of Agriculture, Faculty of Forestry, Faculty of Environmental Sciences and local community)	Jul 2013, Jan 2014, May 2014	Series of visits to Feuang district and Phonesavath village.
	Completion of plan and sharing of the experience at basin-wide workshop. (A – School of Geosciences, PC-Faculty of Agriculture, Faculty of Forestry, and local community)	Aug 2014	Issues of livelihood adaptations were discussed with Feuang district authority and PT Company.
	District consultation (A – School of Geosciences, PC-Faculty of Environmental Science)	Jan 2015	Discussion with Feuang district authority and PT Company.
	Second stage field visits (PC-Faculty of Agriculture, Faculty of Forestry, and local community)	Sep 2014, Jan 2015	Series of visits to Phonesavath and neighbouring villages.
	Study tour to Xekaman 1 dam and Sekong 3 dams in Southern Laos with Feuang district authority (PC-Faculty of Environmental Science)	Jan 2015	Exchange of experiences, reflections on resettlement.
Activity 3.2.2 and 3.2.3 Working with multiple-stakeholders to coordinate dialogues on livelihood adaptation	District workshop inviting other stakeholders. (A – School of Geosciences, Sydney School of Public Health, PC-Faculty of Agriculture, Faculty of Forestry, Faculty of Environmental Sciences)	Jul 2012	Appropriate stakeholders are invited and effective participation process is designed in the workshop.
	Project workshop (A – School of Geosciences, Sydney School of Public Health, PC-Faculty of Agriculture, Faculty of Forestry, Faculty of Environmental Sciences and National Institute of Public Health)	Jul 2013	Appropriate stakeholders are invited and effective participation process is designed in the workshop.
	Series of research presentations (A – School of Geosciences, Sydney School of Public Health, PC-Faculty of Agriculture, Faculty of Forestry, Faculty of Environmental Sciences and National Institute of Public Health)	Oct 2015	Research presentation at the National Health Research Forum hosted by the National Institute of Public Health.
		Nov 2015	Series of research seminar and presentations were organised in Vientiane.
Dec 2015	Research presentation at the National Research Forum hosted by the National University of Laos.		

Activity4	Outputs and milestones	Completion date	Comments
	Final stage of project documentation completed. (A – School of Geosciences, Sydney School of Public Health, PC-Faculty of Agriculture, Faculty of Forestry, Faculty of Environmental Sciences and National Institute of Public Health)	Dec-February 2015	Final report is completed. Policy brief will be completed by March 2016. Research papers will be completed by May-June 2016.

PC = partner country, A = Australia

7 Key results and discussion

Spatial analysis

Based on the interpretation of Landsat imagery, we detect loss of dense forest and old fallow forest across the Nam Ngum River Basin. The result indicates nearly 200,000 ha of forest loss between 1995 and 2014 (Table 5). Figure 7 indicates steady decline of dense and old fallow forests across the River Basin from over 70 percent to 60 percent of the total area. Old fallow forests or secondary forests have particularly declined since 2000. Figure 8 shows pattern of forest fragmentation and loss during 1995 and 2014.

Large tracts of forest was particularly lost in Mountainous and Highland Zones (Table 5). Figure 9 also indicates significant decline of forest in the Lowland Zone during 2000-2005. Although the overall trend suggests declining forest areas, Figure 10 indicates forest regrowth occurring in parts of Mountainous Zone including parts of Xiengkhouang, Luangphrabang provinces and Vientiane Municipality. Figure 11 further disaggregates forest loss by village across the River Basin and suggests varied patterns of land use change across the Basin. The pattern varies in association with resource development (e.g. hydropower) and improved accessibility (e.g. road networks). Time series demographic data also suggests high level of fluctuations of village numbers and population (Table 5), and indicate the growing population pressure particularly in Lowland Zone.

Based on the land use land cover change analysis we are also able to identify areas that have been frequently exposed to land use change (Figure 12). Areas experiencing high frequency of land use change tend to be areas proximate to population centres and along the major roads. In particular, areas surrounding Vientiane capital and provincial capital of Phonesavanh in Xiengkhouang province, experienced an increase in population density during the last two decades. We also observe dynamic land use changes occurring in areas proximate to hydropower dams (e.g. Highland Zone).

Results of spatial analysis indicates widespread pattern of deforestation and forest degradation across the River Basin. In particular, forest degradation and loss has been accelerating since the 2000, as numbers of resource-based investment activities (i.e. mining, hydropower, and plantation) operating in the area have increased. However, as highlighted by various studies (Schönweger et al. 2012; Suhardiman and Giordano 2014), information on investment activities are difficult to assess, as there is no systematic archive of investment data. Record of resource-based investment collected for the current study similarly indicates overlapping areas of resource development, and gaps in the record collected at different levels of government. The confusing and conflicting information on resource investment activities in the River Basin suggest the complex web of power play between various government agencies that have administrative authority to approve investment activities, as well as active roles played by private sector investors and developers, as well as members of local communities in transforming the landscape (see also Suhardiman and Giordano 2014).

According to the community survey, more than 60% of the households in Mountainous, Highland and Low-Highland Zones reported to have access to forest. The loss and degradation of forest land (both primary and secondary forests) as highlighted in the spatial analysis particularly affect communities of ethnic minorities that have relied on non-timber forest products for food and income generation.

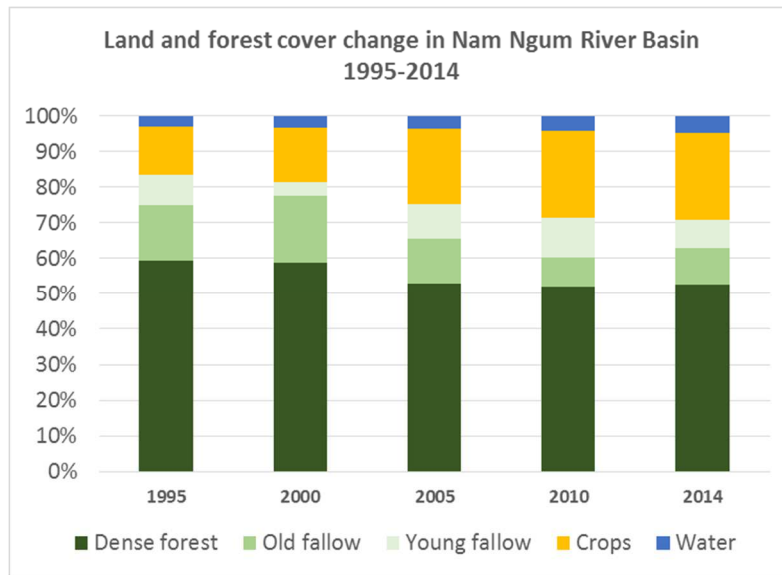
Although expansion of permanent crop land and young fallow suggest the increase of cash crop production, which accord with the current government policy to increase market integration of smallholders, the extent to which cash crop production is contributing to the household economy, food security and health needs to be examined more closely as cash crop production is particularly focused on non-food export oriented crops including rubber, cassava and jatropha, which require high level of agricultural inputs (i.e. seedlings, fertilizers, pesticides, and herbicides).

Table 5 Forest Change 1995-2014

Zones	Forest Loss (ha)
Lowland	33,483
Low-Highland	21,005
Highland	49,688
Mountainous	96,285
Total	200,461

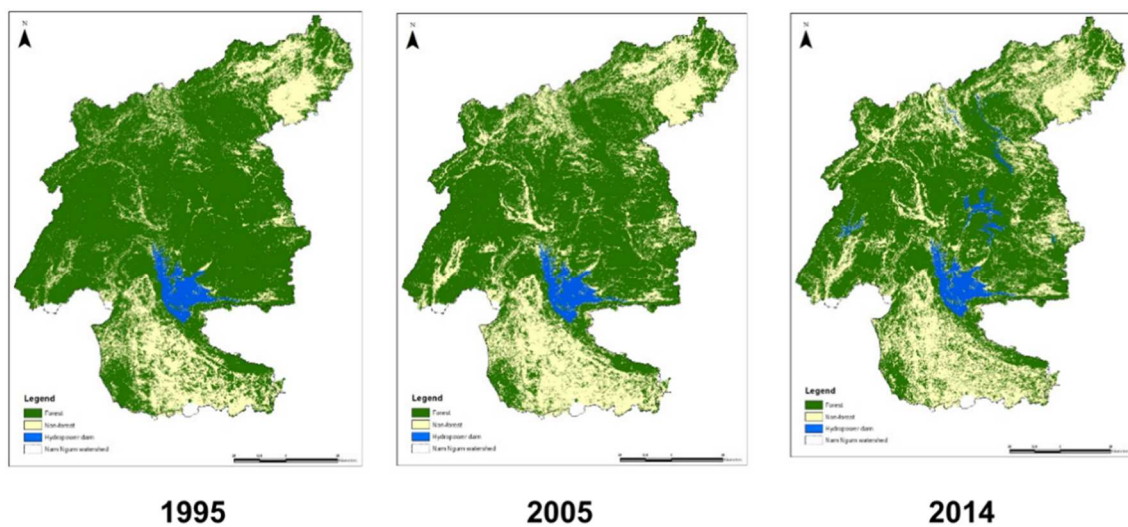
Source: ACIAR Lao Livelihood Project

Figure 7 Land and forest cover change: 1995-2014



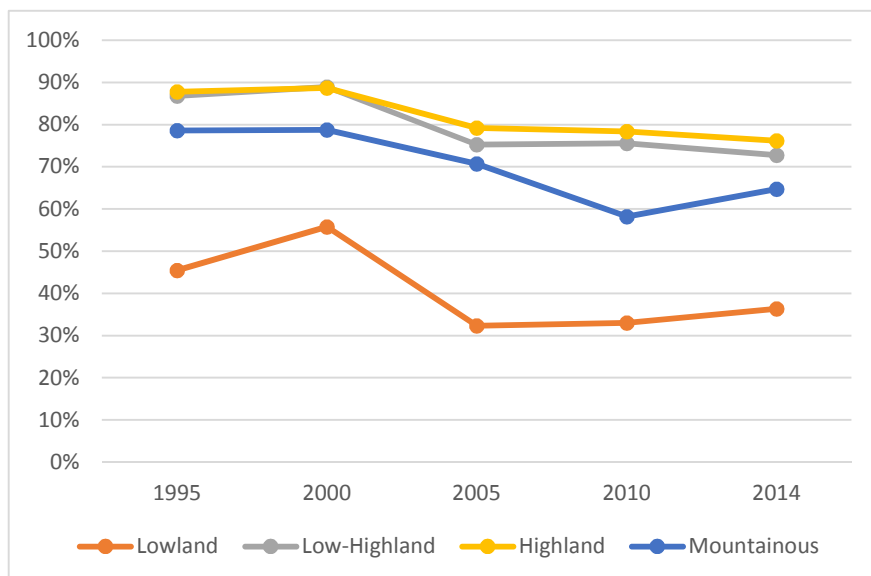
Source: ACIAR Lao Livelihood Project

Figure 8 Patterns of forest land use change: 1995-2014



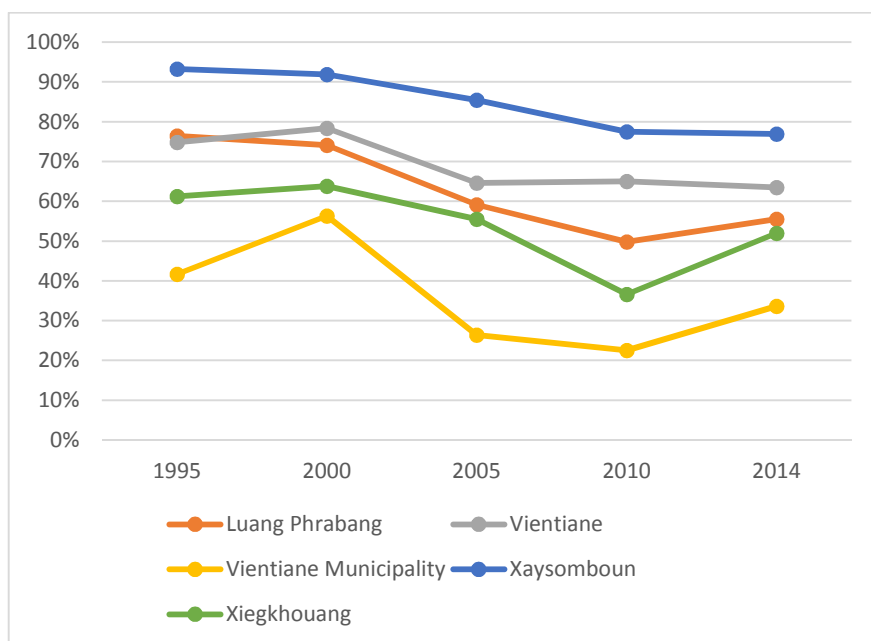
Source: ACIAR Lao Livelihood Project

Figure 9 Share of forest area by zone: 1995-2014



Source: ACIAR Lao Livelihood Project

Figure 10 Share of forest area by province: 1995-2014

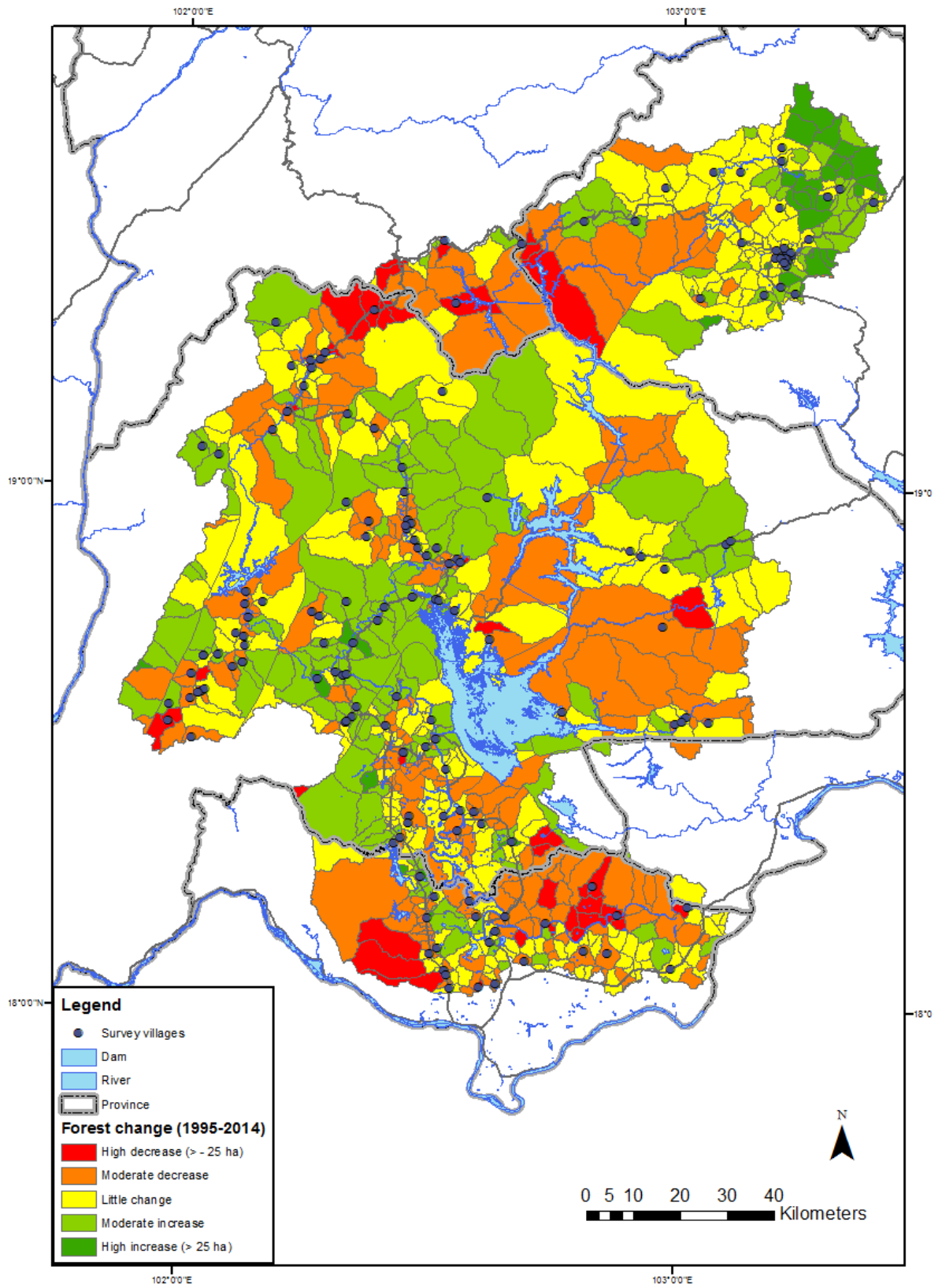


Source: ACIAR Lao Livelihood Project

Table 6 Demographic changes

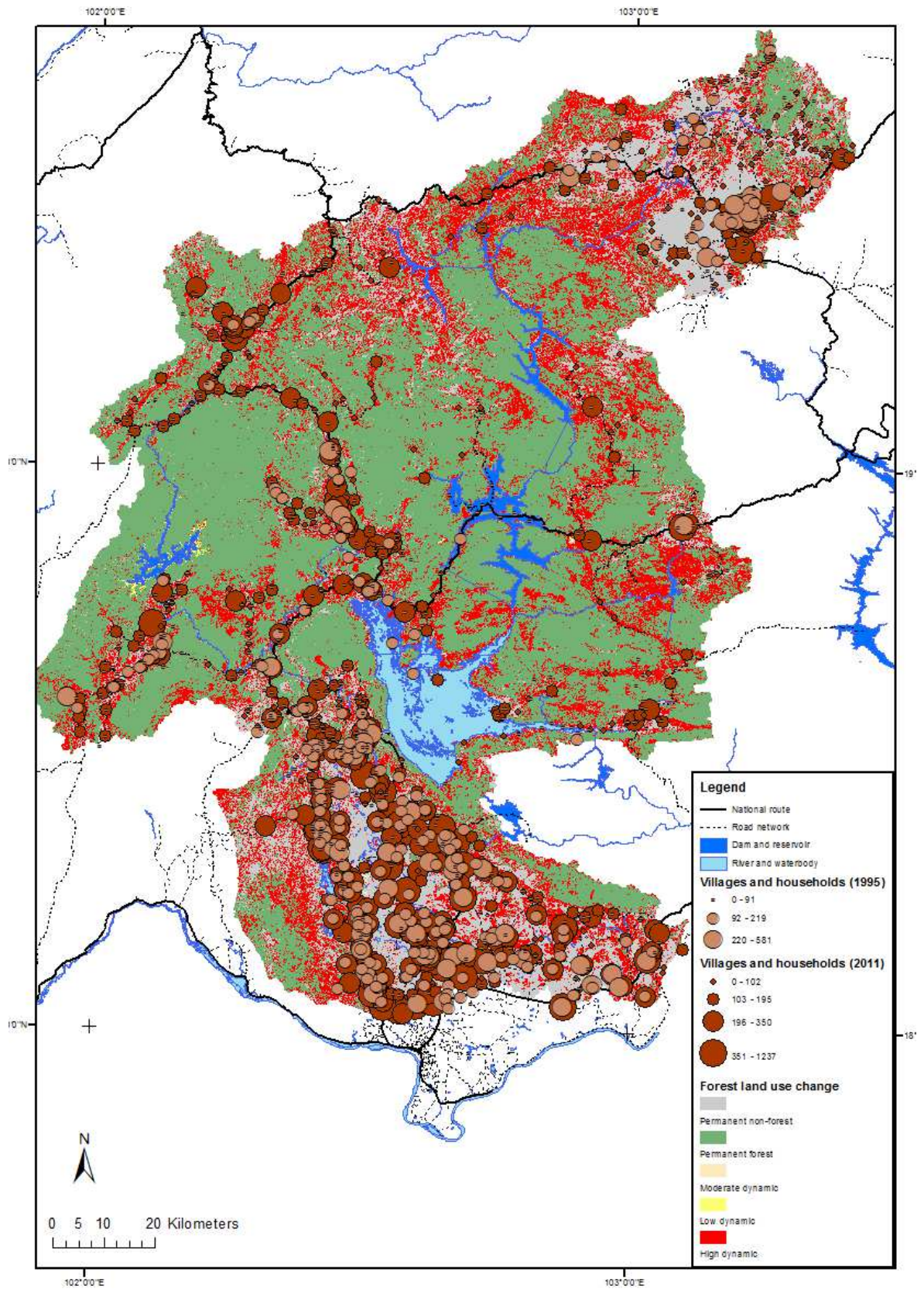
Year	No. of villages	No. Household	Population	Source
1995	615	46,011	300,008	Population Census
2005	851	-	655,986	Population Census
2011	691	110,724	-	Agricultural Census

Figure 11 Land use and forest cover change per village



Source: ACIAR Lao Livelihood Project

Figure 12 Dynamic patterns of land use change



Source: ACIAR Lao Livelihood Project

Quantitative data analysis

Livelihood

Descriptive analysis of livelihood data highlights the importance of agricultural activities (i.e. farming, livestock raising, and fisheries) for economically poor households (Figure 13) and households in rural communities (78 % of the relevant respondents over 3,200 households). By zone, more than 55% of households in the Highland Zone (i.e. Kasi, Vangvieng and Hom districts) are dependent on agriculture as primary livelihood activity (Figure 14). The household survey also highlights the diversity of activities that households are engaged in order to sustain their daily lives. In many instances, household members are engaged in farming and non-farming activities both in and outside of their own villages. Household livelihoods have moved away from being focused on subsistence based production system. At the same time however, agriculture still remains a source of primary and supplementary livelihood activity for households (Figure 15).

Figure 13 Households dependent on agricultural activity by wealth

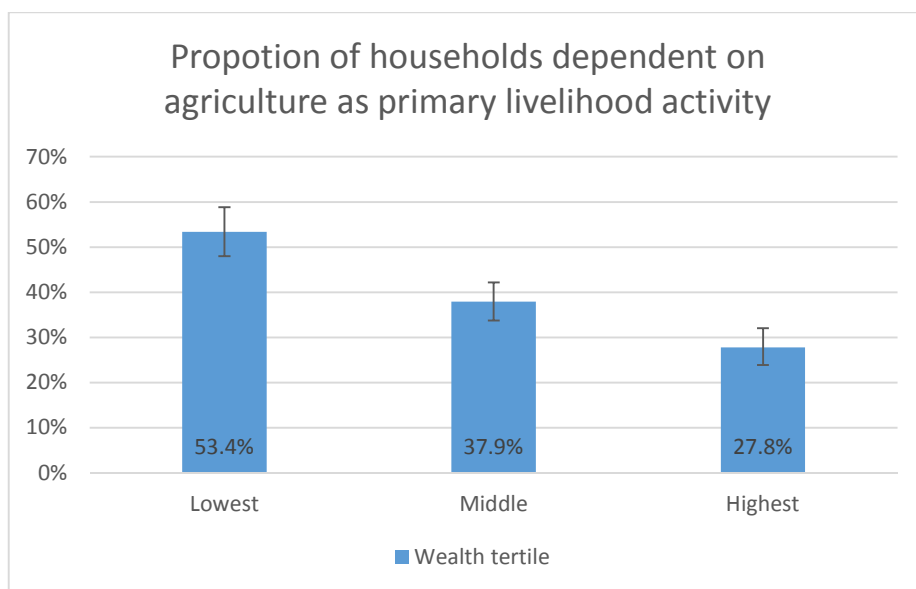


Figure 14 Households dependent on agriculture by zone

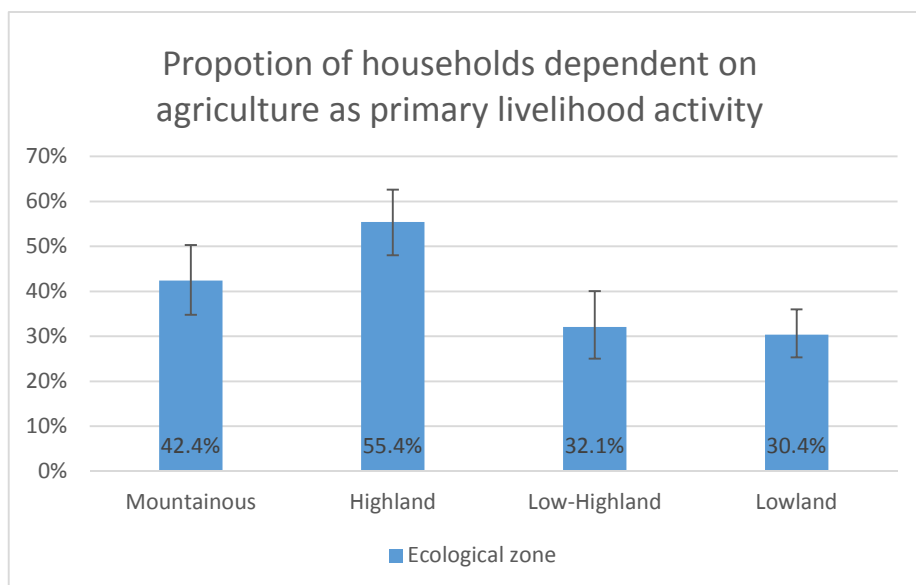
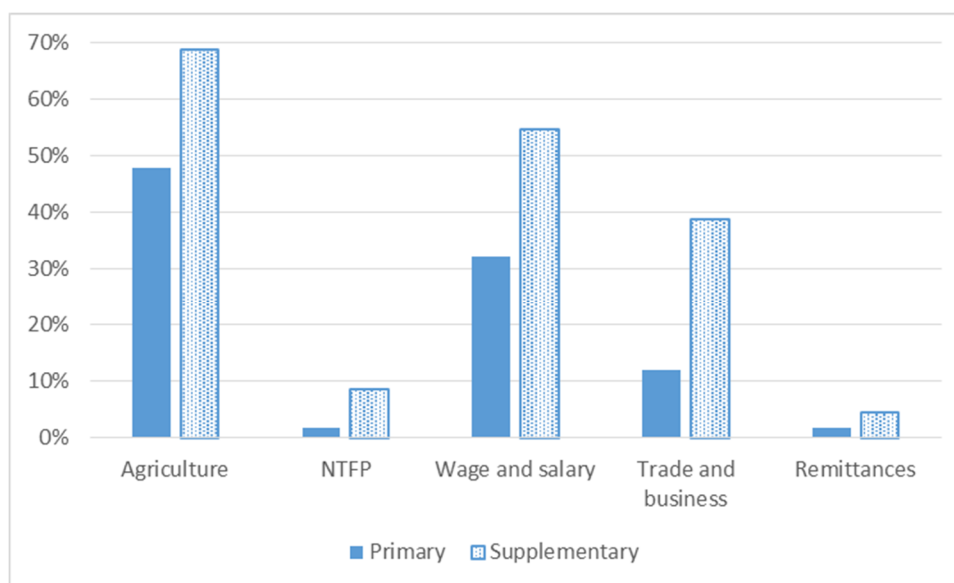


Figure 15 Primary and supplementary livelihoods of rural community

The survey indicates that majority of households across the Nam Ngum River Basin have access to land. Table 7 shows that proportion of households with access to land is the highest in Low-Highland Zone (i.e. Hinheup and Feuang Districts) at 86.4%. Average numbers of land plots and land size also mark the highest in the same zone. In contrast, landless households are the highest in the Lowland Zone, where average numbers of land plots and land size accessed by households are also the smallest: 1.8 plots and 1.5 ha respectively. By wealth, households in the highest wealth tertile have access to more land as shown in Table 8. Although most households in the surveyed communities have access to more than one plot of agricultural land, wealthy households tend to have combination of agricultural land including paddy field in the lowland, swidden field in the upland, as well as other agricultural land for crop production and grazing land.

With regards to land ownership, households have varying form of documents (i.e. title deed, temporary land use certificate, tax document) to claim their legitimate rights to use land especially for lowland agricultural fields. However, most households across the River Basin do not have any documents for agricultural land, particularly in the uplands. Households often make informal claims to such land by tilling and planting, and fencing. In the Nam Ngum River Basin, ambiguity of land ownership has particularly affected those households that were displaced by the construction of hydropower dam (e.g. Nam Ngum 2). Households without formal land documents were unable to claim financial compensation from the company for their loss of land.

Table 7 Average household land access by zone

Zone	No. of land plots	Total land size (ha)	No. of HHs	% of HHs with land
Mountainous	2.0	1.7	817	77.4 %
Highland	1.9	1.9	839	77.9 %
Low-Highland	2.4	2.9	783	86.4 %
Lowland	1.8	1.5	775	57.3 %

Table 8 Average household land access by wealth

Wealth tertile	No. land plots	Land size (ha)	No. of HHs	% of HHs with land
Highest	2.4	2.2	1072	72.2 %
Middle	1.8	1.6	1071	67.7 %
Lowest	1.5	1.5	1071	68.5 %

The survey also indicates that majority of households across the zones have access to livestock (Table 9), in particular, poultry which includes chickens and ducks. Proportion of households with access to large livestock (i.e. cattle, buffalo) and small livestock (i.e. pig, goat) are high in the Mountainous Zone (Phoukhoun, Phoukhout, Pek, Phaxai, Xaysomboun districts). This is due to their access to grazing land for livestock and cultural importance of the livestock. In contrast, households in the Lowland have less access to large and small livestock.

Table 10 shows that nearly all households across three wealth classes have access to livestock. However, there are some discrepancies on average numbers of livestock owned. For instance, wealthy households on average have twice as many (if not more) livestock across all categories, suggesting livestock and particularly large livestock as important household asset.

Table 9 Average livestock ownership by zone

Zone	Large livestock		Small livestock		Poultry		No. of HHs
	HHs with large animal	No. of large animal	HHs with small animal	No. of small animal	HHs with Poultry	No. of Poultry	
Mountainous	57 %	5.6	43 %	1.3	83 %	33.6	817
Highland	44 %	3.3	28 %	1.2	75 %	21.8	839
Low-Highland	44 %	3.1	24 %	1.3	86 %	27.6	783
Lowland	31 %	2.9	8 %	1.8	75 %	31.1	783

Table 10 Average livestock ownership by wealth

Wealth tertile	No. of large livestock	No. of small livestock	No. of poultry	No. of HHs	% of HHs with livestock
Highest	4.3	2.4	38.7	1073	97.6 %
Middle	3.8	1.0	27.3	1074	98.2 %
Lowest	2.4	0.8	18.8	1075	98.6 %

With regards to links between major livelihood asset (e.g. land, livestock) and nutrition, we observe only slight discrepancies between household ownership of land and stunting of children under five years, a marker of chronic under nutrition and potential food shortage (Figure 16). Similarly, we observe little direct linkage between nutrition status of children and household ownership of livestock. As livestock ownership is also associated with households' overall wealth, nutrition status of children is more closely linked with the overall household wealth.

Figure 16 Households with stunted children by access to land

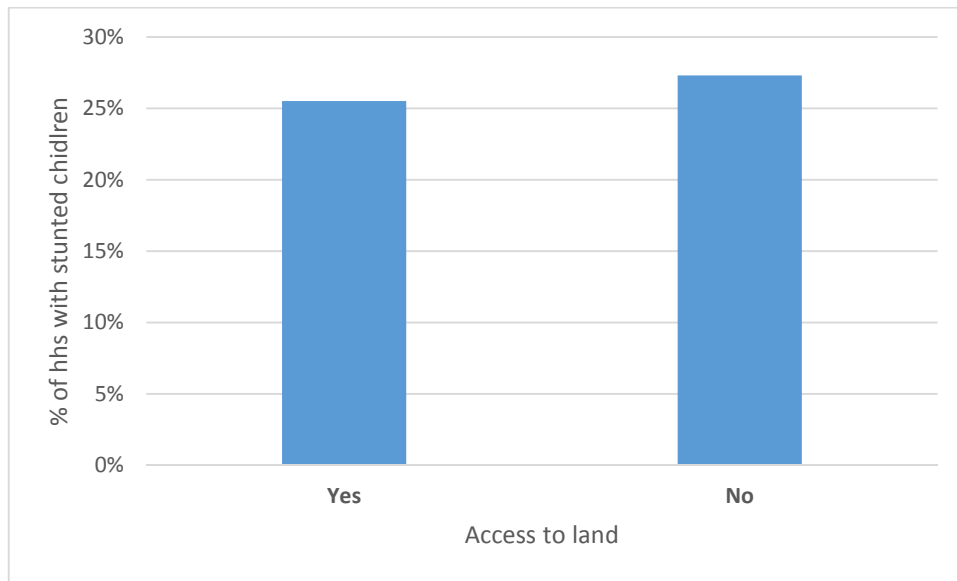
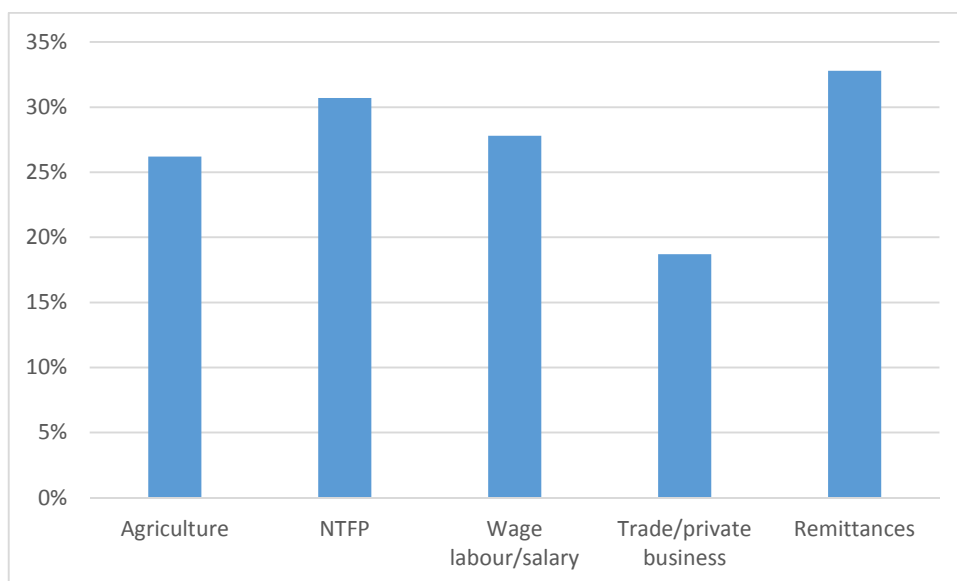


Figure 17 Households with stunted children by primary livelihood activity



Currently, we do not see a clear relations between primary livelihood activity of household and nutrition status of children under five years of age. As will be discussed in the

following section, prevalence of child stunting is higher among socio-economically poor households, and relatively small numbers of households among the poor are dependent on collection of non-timber forest products and remittances as their primary livelihood activity (Figure 17).

Nutrition, food security and self-reported wellbeing

In the current study, over 1,300 children’s anthropometric measurements were assessed as part of the household survey (see Section 5 for method of data collection). Based on the assessment of height for age of children under five years old, we observe that 29 % of children indicated moderate to severe stunting (low height for age, a marker of chronic under nutrition and food shortage) which is lower than the national average of 44% based on the Laos Social Indicator Survey 2011/2012. In our study site, we observe the highest proportion of stunted children in Highland Zone (i.e. Kasi, Vangvieng, Hom districts) as indicated in Figure 18 and higher proportion of stunted children among the ethnic minorities, particularly Mon-Khmer ethnolinguistic group (Figure 19). Child stunting is also more prominent among the economically poor households (Figure 20).

Figure 18 Stunting of children under five years old by zone (n=1,333)



Figure 19 Stunting of children under five years old by ethnicity (n=1,333)

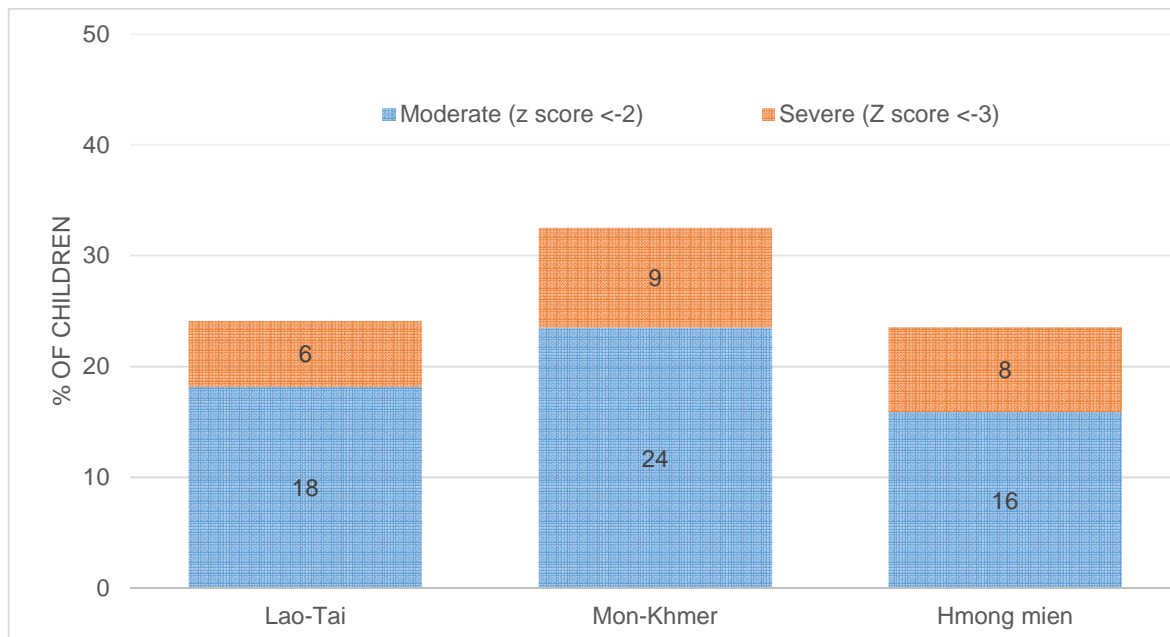
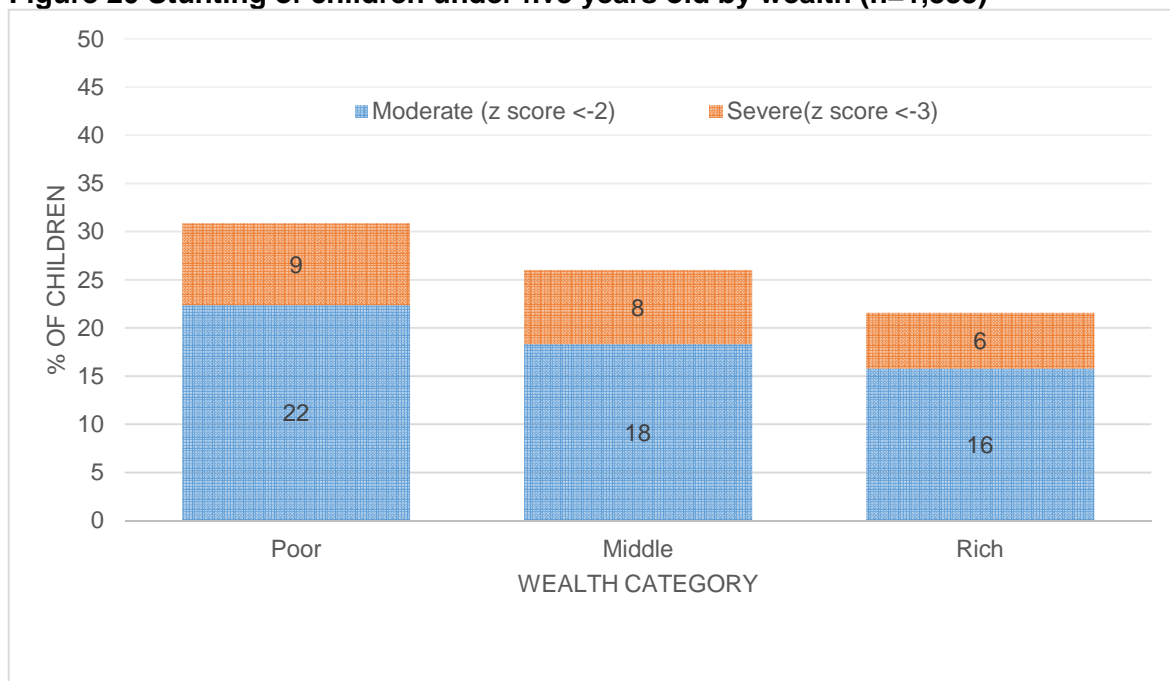


Figure 20 Stunting of children under five years old by wealth (n=1,333)



Our study also collected information regarding household access to food and their dietary patterns based on the frequency of food items consumed by households during the week prior to interview. This information was then used to calculate the household consumption score⁵. Although the majority of the households in the River Basin were assessed to have food consumption scores above the World Food Program’s (WFP) acceptable level, we observed proportionately low food consumption scores among the poor households (Figure 21). The WFP food consumption score has been shown in validation studies to be

⁵ We applied World Food Program’s method of calculating food consumption score. For further information on calculation of food consumption score, see WFP 2007.

positively associated with food energy consumed per capita per day, asset indexes that are proxy measures of household wealth, and total monthly household expenditures (WFP 2007, Wiesmann et al 2009). These studies also showed that the cut-offs recommended by WFP for determining levels of food insecurity greatly underestimated food insecurity as measured by calorie consumption per capita and that the weighting of the food groups did not improve associations with energy intake (Wiesmann et al 2009). It is important to note that the low prevalence of food insecurity we observed, based on these WFP cut-offs, may not fully reflect inadequate calorie consumption in the communities we studied. In our analyses rather than using the traditional WFP cut offs, we divided the food consumption score into tertiles or 3 equal parts classified into low, middle and high scores.

Figure 22 indicates that there are proportionately higher numbers of households from Mon-Khmer and Hmong-Mien ethnolinguistic groups that have been assessed to have low food consumption scores. In contrast, there were a higher proportion of households from Lao-Tai ethnolinguistic origin with higher food consumption scores.

Figure 21 Food consumption score by wealth (n=1,333)

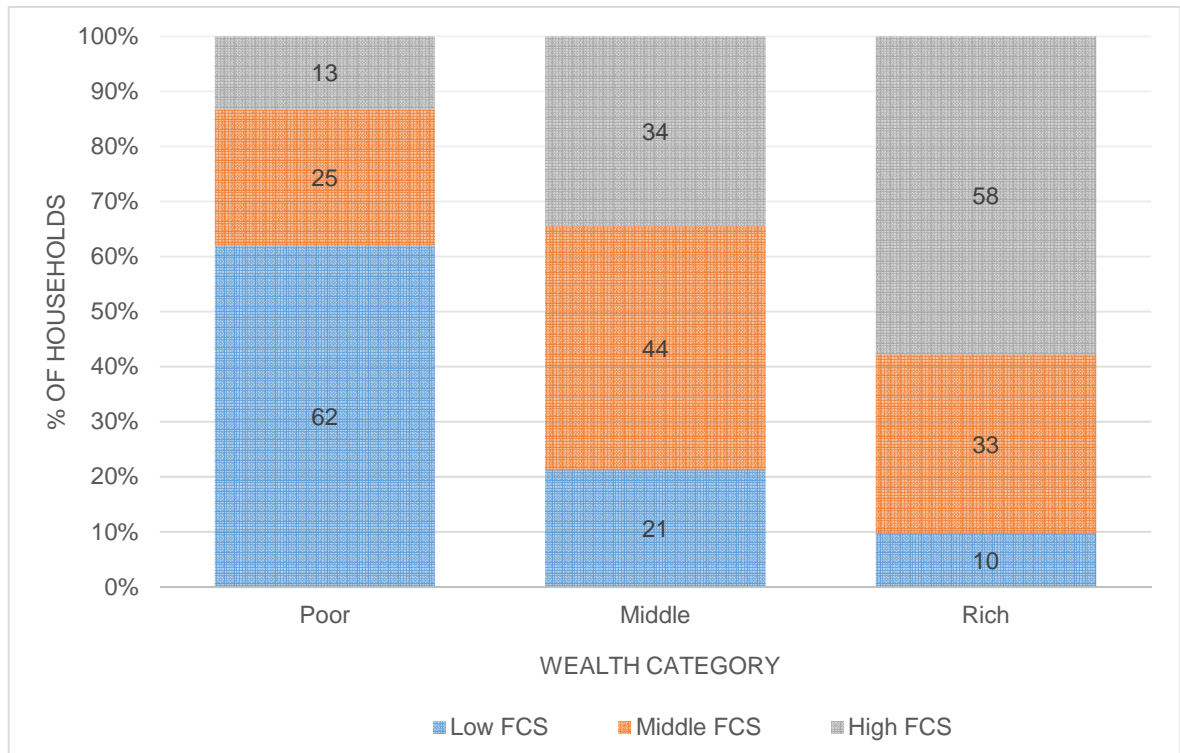


Figure 22 Food consumption score by ethnicity (n=1,333)

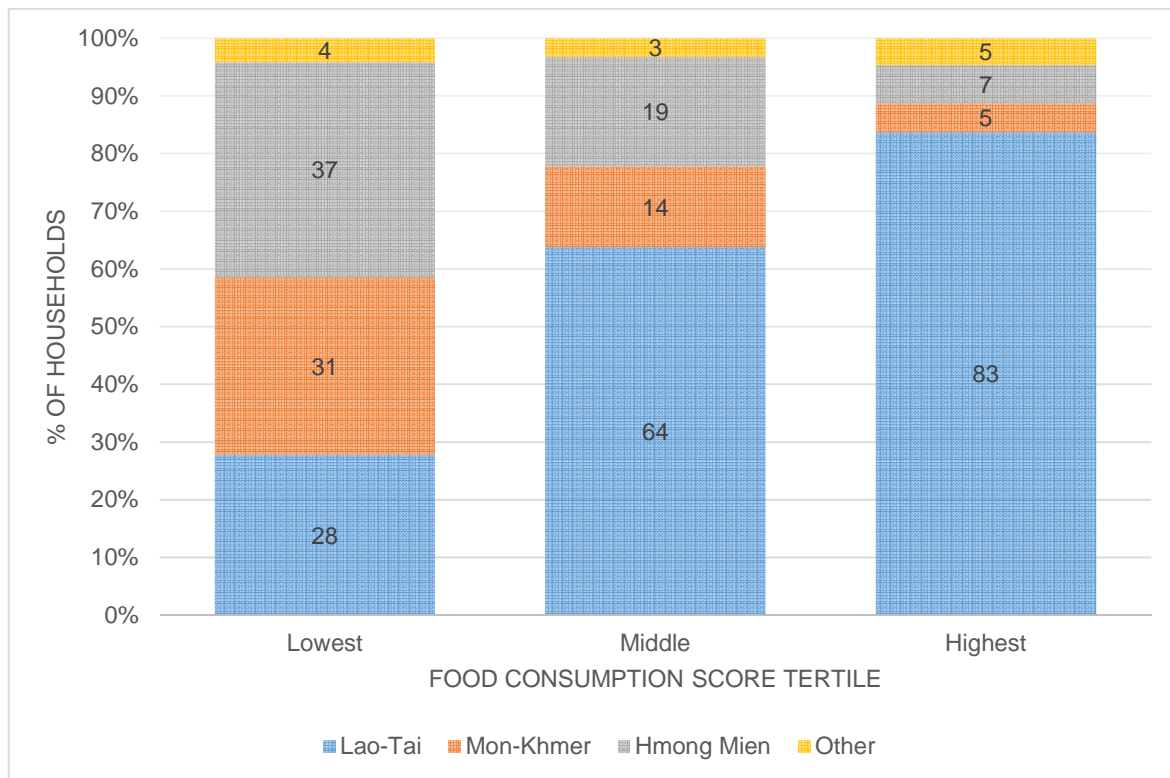
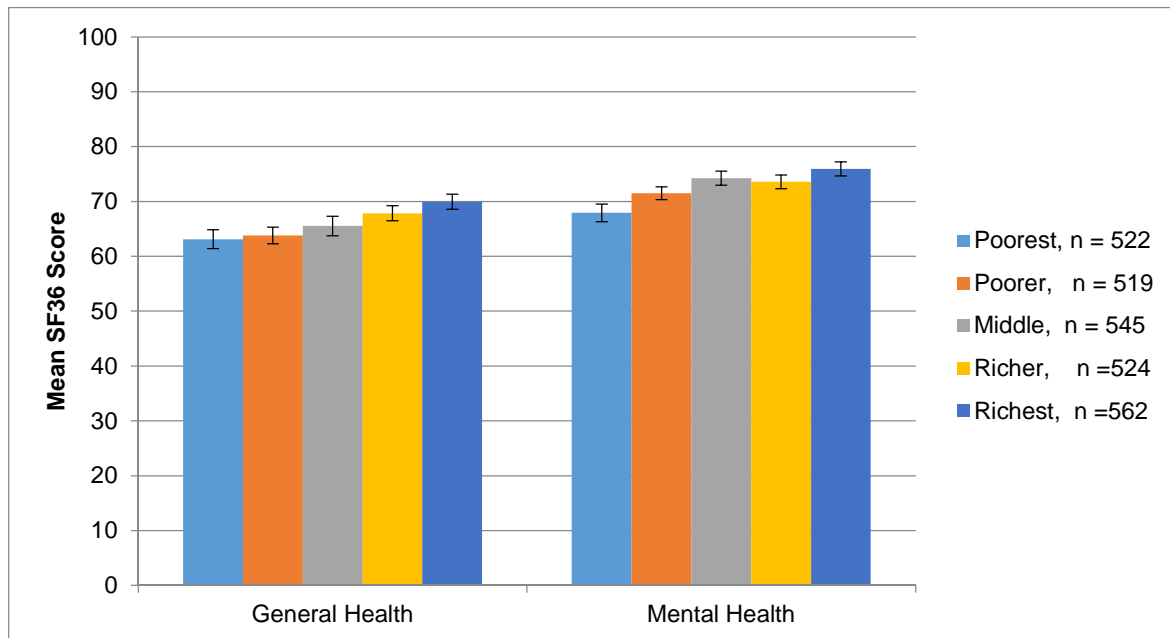


Figure 23 Wellbeing score of men and women by wealth



Finally, our household survey incorporated self-reported wellbeing assessment (SF-36) for male and female members of the households for the first time in Laos. This is one of the first application of the assessment. The SF-36 is a standardised questionnaire, which is widely used as a health-related quality of life measure. It measures health based on the individuals' perceptions of their health status and functioning. It is an alternative to the usual epidemiological health status measurements such as morbidity and mortality rates.

It consists of 36 questions that measure physical and mental health status in relation to eight health concepts:

- 1) physical functioning
- 2) role limitations due to physical health
- 3) bodily pain
- 4) general health perceptions
- 5) vitality (energy/fatigue)
- 6) social functioning
- 7) role limitations due to emotional health
- 8) general mental health (psychological distress/wellbeing)

A standardised protocol (Ware et al 1993) was used to score and sum the responses to each of the SF-36 items, which were expressed as a score from 0 to 100 for each of the eight concepts. Higher scores represent better self-perceived health. Summary scores were calculated as measures of physical and mental health dimensions underlying the SF-36 questionnaire.

Figure 23 suggests that men and women from economically poor households have lower average general and mental health score. However, the detailed context of wellbeing based requires further analysis of information and qualitative data collection.

Stakeholder discussions and qualitative data analysis

As highlighted in the Section 5, the project organised a series of workshops involving local government and communities in Feuang district to understand the critical issues of environmental change and livelihood adaptation processes. One of the first district workshops in Feuang District was organised during 3-4 April 2013 at the District Government Assembly Hall of the Feuang District. The workshop invited representatives of district government offices and representatives of local communities surrounding the new resettlement village to discuss the overall experiences and concerns over resource development and its impact on local livelihoods (Figure 22). During the workshop, the district governor highlighted the issue of environmental degradation and pointed out that resource scarcity is likely to affect villagers who rely and depend on its use on daily basis. The district is particularly faced with problems of forest encroachment due to expansion of commercial agriculture and logging, and in particular as a result of encroachment on neighbouring villages' forest lands by families in Phonesavath resettlement village who were not allocated land on which they could grow food. While it is necessary for district officials to protect and improvement the management of natural resources, they also felt the need to help villagers become less dependent on natural resources, by providing alternative sources of household income and livelihood opportunities.

Another problem, which was highlighted by different representatives of local government offices is the relocation of more than 1,000 households from areas affected by construction of Nam Ngum 2. The resettlement village, Phonesavath village, was created in 2010, and brought together villagers from over 13 villages located in former Xaysomboun district. While PT Company, which has been commissioned by the Nam Ngum 2 Power Company to oversee resettlement process have provided financial compensation, and other support activities such as livestock rearing and trade, vegetable gardening and sales at the local market, rubber plantation, fisheries, and weaving textiles, the majority of households indicated the continued struggle to adapt their livelihood basis in the new village.

Figure 24 District workshop, Feuang district, 3-4 April 2013



Photos: Y Lagerqvist

Following the workshop, rapid rural appraisal and semi-structured household interviews were carried out in the village (4-7 April 2013), during which the team consisting of researchers from the Faculty of Environmental Science and the School of Geoscience explored the history of village settlement, the institutional setting of the village, issues on environment and natural resource management, and livelihood constraints and opportunities with focus groups within the village, and interviewed selected numbers of households on their livelihood activities. The fieldwork initially highlighted issues related to land and water shortage, as well as limited economic opportunities in the resettlement village.

Figure 25 Fieldwork in resettlement village, 4-7 April 2013



Photos: Y Lagerqvist

The initial workshop and fieldwork was followed by a basin-wide stakeholder workshop during 30-31 July 2013. The workshop was co-hosted with the National University of Laos and the National Institute of Public Health, and organised in Vientiane capital to identify knowledge gaps on resource development, livelihood and food security, and to further discuss areas in which our research project can collaborate with relevant stakeholders. The basin-wide workshop provided a forum to exchange information and knowledge among various participants. On 30 July, research partners discussed key issues with district government representatives, followed by series of panel discussions on 31 July involving researchers and development professionals working on the issue of resource development and management in the Nam Ngum River Basin. The latter workshop particularly highlighted the importance of cross-sector collaboration and sharing of information across scale. These workshops further highlighted the importance of understanding multi-scalar factors that influence land use change process, and household economy. Furthermore, the workshops also highlighted the importance of engaging policy makers, and communicating research outcomes to inform policy decision making process.

During 9-13 January 2014, in-depth household interviews were carried out in the resettlement village in Feuang District. This was aimed to understand the process of livelihood adaptation process experienced by households. Through narratives of 25 households, i.e. on their resettlement history and processes of adapting their lives in the new environment, the qualitative study carried out for the project illustrates diverse household responses to resource constrained environment and suggests the need for resettlement programs to consider multi-local livelihood opportunities to facilitate livelihood adaptation process. The very different ways in which households of different socio-economic status have been adapting to the resource constraints imposed by the resettlement process, the extent to which those resettled depend on resources and opportunities outside the village area and often outside the district, and the interactions between the resettlement village and surrounding communities, all point to the need for facilitated adaptation that goes well beyond the livelihood support schemes being offered as the standard package by the resettlement company.

A final workshop in Feuang District was organised during 6-8 July 2015. This workshop was held at the request of the Feuang District Office and was organised by the Faculty of Environmental Sciences (National University of Laos) in order to provide capacity for the District authority to develop proposals seeking future funding to support the livelihood adaptation process in the local community, particularly with the prospect of the resettlement company's withdrawal from the area and its handover of responsibility for livelihood restoration to the District authorities. Two funding windows were identified for the workshop, which included the Lao-Australia Development Learning Facility (LALDF) and the Environmental Research Fund (ERF). The Director of ERF, Mr Soukata Vongvichit joined the workshop to present ERF. Unfortunately shortly before the workshop was announced LALDF was being closed down due to the Australian government's aid cuts.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Our study contributes to the growing body of nexus studies that seek to understand the complex multi-scalar linkages between resource development, and its effects on food, water and human health in the Mekong Region (Orr et al. 2012; Smajgl and Ward 2013; Middleton et al. 2015; Pittcock et al. 2015). Our research demonstrates in particular the effectiveness of working across institutions and disciplines (i.e. public health, agriculture, forestry, environmental science, and geography) to examine the issue of food security using multi-scalar and mixed method approach. In particular, our effort to visualise the spatial effect of resource development on environmental degradation and identification of communities experiencing weak food security and under-nutrition has helped to facilitate discussion with policy makers involved in improving the overall food security in Laos.

By incorporating both spatial and household survey data, the project produced baseline data for long-term monitoring of resource change and household health in the Nam Ngum River Basin. It also applied SF-36 questions for the first time in Laos to quantitatively assess subjective wellbeing.

As the dataset will be released publicly, this will allow for comparison with other case studies in Laos and beyond. The study further opened a new set of inquiry to examine the detailed context of weak food security and poor nutrition status among vulnerable population groups in a resource constrained setting. As such, the overall impact of the project's multi-disciplinary and mixed method approach is that it has provided a platform for future interdisciplinary research in Laos, as demonstrated by the various proposals developed for future research activities by project team members.

Finally, the digital data capture technique adopted by this project, provided invaluable lessons on survey design, delivery and data management. The lessons and experiences obtained from this project have since been shared and implemented to other research activities both within Laos and beyond. Such activities include the National Tobacco Survey, led by the National Institute of Public Health Laos and Household surveys conducted in Indonesia, Myanmar and Papua New Guinea. Increasingly research projects are shifting from paper based data capture to digital data capture, as one of the first projects to implement digital data capture in Laos, the methods and lessons learned from this project will serve as a useful resource for future research activities.

8.2 Capacity impacts – now and in 5 years

Our project implemented series of joint trainings and workshops with external financial support i.e. Data Analysis Workshop in Sydney during May-June 2013 supported by Department of Foreign Affairs and Trade of the Australian Government (through the Australia Award Fellowship Round 14), and a series of two Writing Workshops in Vientiane in October 2014 and April 2015 supported by the Sydney Southeast Asia Centre of the University of Sydney.

These trainings were essential in bringing research partners in Australia and Laos together to jointly discuss research process and key findings. They also helped to bridge organisational and disciplinary divides and strengthened participants' ability and confidence to work within a multi-disciplinary team. Ongoing participation of research colleagues in the workshops and trainings also helped to build trust and collegial relationship among the research partners both within and across disciplines.

The notion of trust and mutual respect is particularly important in strengthening the capacities of research partners to jointly organise workshops and research forums and communicate the project findings to a variety of stakeholders (local and central policy

makers, members of the local community, and the research community) in Laos and overseas. As a result of these events the project partners have been able to develop and refine their skills to adapt research presentations for different audiences.

While the issue of improving food security and nutrition continues to be a critical agenda in the national development of Laos, there is great potential for our research partners to continue to foster the collaborative relationships across the institutions to address these issues.

Lastly, the project was instrumental in building research capacity of Australian and Lao research partners. In particular, the project facilitated skill development of junior researchers in respective organisations. A range of skill development includes spatial data collection and analysis, as well as development and implementation of digital data capturing tools, management and analysis of data, and development of academic writing and research communication.

8.3 Community impacts – now and in 5 years

Beyond the contribution of knowledge to scientific community and development of research and communication skills of research partners, our study facilitated information exchange and discussions on development trajectories with key stakeholders including government agencies, local community and development organisations based in Laos.

Our research particularly demonstrated and highlighted the importance of multi-disciplinary collaboration, and the need to understand processes of resource development and its effect on human lives from multi-scalar perspective.

8.3.1 Economic impacts

Our study particularly highlights the overall economic importance of balancing development and management of natural resources. Although development of natural resources have contributed significantly to the steady growth of the national economy in Laos, the benefits of this achievement have not trickled down to the poor and socially marginalised population groups in areas proximate to the development activities. Indeed, there are key processes by which growth based on intensified resource development further impoverish more vulnerable resource-dependent households. Our study highlights that resource development projects spatially overlap given the fragmented powers of authorities that approve and allow various projects. This inhibits the implementation of frameworks such as integrated water resource management or river basin management that aim to improve the governance of natural resources at river basin level (Sari 2012; Back et al. 2011). Our study suggests the need to assess economic and environmental trade-offs of resource development projects beyond individual project level in order to fully assess the economic impact of resource development (See also Pittock et al. 2015; Winemiller et al. 2016).

Our study also highlights numbers of important insight onto the role of agriculture in household economy.

Firstly, our study suggests that the area of Nam Ngum has experienced particularly rapid population growth since 1995. Concentrations of population have accelerated urbanisation and development, thereby reducing forest and agricultural land in the River Basin, and transforming the role of agriculture. At the household level, livelihoods are no longer based on subsistence agriculture and households are no longer dependent on agricultural activities alone to support their family. For those households that continue to engage in agriculture, limited access to agricultural credit and market information were key factors that inhibited them from engaging in commercial agricultural activities. In addition, relatively low economic returns from agricultural activities continue to push households to seek economic opportunities outside of their village. These issues raise critical question

on the competitiveness of agriculture in Laos, as the country is incorporated into the ASEAN Economic Community.

Secondly, our survey not only highlights diversification of livelihood activities, but multi-local household livelihood activities. Qualitative data collection in Feuang district particularly indicated that households who are able to adapt in the resettlement village, where they are particularly faced with resource scarcity, often have means outside of the village that sustain their livelihoods. This suggests a need for livelihood adaptation programs (e.g. resettlement projects, agricultural improvement) to incorporate a more comprehensive understanding of household livelihood, and design household and community assistance programs that looks beyond livelihood opportunities in the village.

Thirdly, although our study indicates that agriculture is often not the primary and the only livelihood activity supporting households, for those that continuing to engage in agriculture as part of their livelihood strategy, they are increasingly applying labour saving agricultural inputs such as pesticides, and herbicides to compensate for the labour shortage in households and community. This is closely related to the need for households to diversify livelihood activities and seek opportunities outside of the village as highlighted above. However, most households that incorporate labour saving agricultural inputs do not have adequate information regarding the safe application of chemical inputs. This is further raising a critical question in local communities regarding the long-term costs and effects of intensive application of various chemical inputs on soil and human health.

8.3.2 Social impacts

The current study particularly points to the inequity that is produced alongside steady growth of economy based on resources sector. Although investment in resources sector (e.g. hydropower and mining) may have contributed towards aggregate economic growth in Laos, its benefits are not trickling down to the vulnerable population group even in communities that are relatively accessible and “developed.” Our study highlights that weak food security and under-nutrition among children is not only a pervasive problem in remote parts of the country. There are pockets of communities in areas that are relatively accessible and “developed” that are still suffering from poverty and poor health. Our study also indicates that improvement of income and material standards of households does not easily translate into improved nutrition status or wellbeing of the population. It highlights the inter-household discrepancies in nutrition status, and the importance of understanding detailed context of food and nutrition security. Furthermore, our study highlights that incidences of weak food security and poor nutrition status among children are more frequent in areas that are experiencing rapid environmental changes, and particularly prevalent among those households that are socio-economically poor and socially marginalised. These findings have facilitated further discussions on the need to examine persisting causes of poverty and poor health in different communities, and opportunities for development interventions that can help improve access to food and the basic nutrition status of individual household members in affected communities.

Finally, the project helped to facilitate discussions among the research partners on gender and socially sensitive approaches to survey, as we designed survey instrument that not only interviewed representative member of the household, but also separate surveys for men and women. Enumerators also received trainings on approaching members of different ethnic communities and gender in survey villages. Enumerators also reflected on the field experience and discussed with field supervisors and others for future reference. The project also opened up an informal dialogue on gender balance in work places in both Laos and Australia, and helped to strengthen the cross-institutional collaboration among female scholars involved in the project.

8.3.3 Environmental impacts

Our study contributes to the knowledge of land use transformation process and how environmental changes affect local communities. It also facilitated policy discussions at different levels of government from the district to the ministries. Our study suggests that while cascade of hydropower development and other investment in the resources sector (e.g. mining) contribute to the aggregate economic growth of country such as Laos, these development also contribute towards natural resource degradation (i.e. deforestation and forest degradation, loss of biodiversity). We concur with other studies that highlight the importance of accounting environmental costs of resource development (Orr et al. 2012; Winemiller et al. 2016), and the importance of environmental assessment that takes account of impacts beyond the site of individual projects.

The experience of our study highlighted the challenges and limitations of resource management frameworks such as the integrated water resources or integrated watershed management. Although different international and regional organisations have provided technical and financial support to the Lao Government to address resource use and management of the Nam Ngum River Basin since the 1990s, our study demonstrates that technical approach alone have had limited effects on transforming the actual use and management practices on the ground. In particular, our study highlights overlapping claims made by both state and non-state actors, and the difficulties of regulating resource use practices. Our efforts to organise series of small-scale stakeholder discussions and dialogues have facilitated exchange of detailed information, and helped to build and strengthen the relationship of trust between researchers and policy makers. In particular, at the district level, a series of participatory assessment in a resettlement village, has helped to facilitate a dialogue between the local community leaders and district administrative office to address the problem of drinking water for community members.

8.4 Communication and dissemination activities

Researchers involved in the project presented the current research in various academic conferences during 2013 and 2015 including:

Time	Conference	Location	Participants
19-21 April 2013	International Conference on Lao Studies	University of Wisconsin, Madison, USA	Philip Hirsch
29-30 April 2013	Oxfam Mekong Round Table	Canberra, Australia	Yayoi Lagerqvist, Natalia Scurrah
3-5 July 2013	European Southeast Asia Studies Conference	Lisbon, Portugal	Silinthone Sacklokham, Natalia Scurrah
1-4 July 2014	Carbon-Land-Property Conference	Copenhagen, Denmark	Yayoi Lagerqvist, Sithong Thongmanivong, Khamla Phanvilay
13-19 July 2014	World Sociology Conference	Yokohama, Japan	Yayoi Lagerqvist
17-18 October	National Health Research Forum	Vientiane, Laos	Yayoi Lagerqvist, Jessica Hall

24-26 November	Agri-food Conference	Sydney, Australia	Yayoi Lagerqvist
17-18 December 2014	National Research for Development Forum	Vientiane, Laos	Yayoi Lagerqvist, Philip Hirsch, Natalia Scurrah, Silinthone Sacklokham, Sayvisene Boulom, Phokham Lattachack, Avakat Phasouysaingam
11-14 August	European Southeast Asia Studies Conference	Vienna, Austria	Silinthone Sacklokham, Somphou Sayasone, Sengchanh Kounnavong, Sithong Thongmanivong, Khamla Phanvilay, Jessica Hall, Natalia Scurrah, Yayoi Lagerqvist, Philip Hirsch
12-14 October 2015	National Health Research Forum	Vientiane, Laos	Jessica Hall, Somphou Sayasone, Sengchanh Kounnavong, Manithong Vonglokham, Sithong Thongmanivong, Sayvisene Boulom
16-17 December 2015	National Research for Development Forum	Vientiane, Laos	Silinthone Sacklokham, Somphou Sayasone, Sithong Thongmanivong, Khamla Phanvilay

In addition to series of presentations as listed above, we also organised a series of in-ministry presentation during November 2015 at the Ministry of Health, the Ministry of Energy and Mines and the Ministry of Agriculture and Forestry. These small-scale in-ministry presentations were particularly effective and useful in exchanging information and facilitating discussions on ways research can contribute towards the current government agenda and strategy. We also organised a small research presentation for research and development community in November 2015, to share the research experience and key findings. The series of presentations and discussions in November 2015 helped to shape development of policy brief, and point out areas of future research (Appendix 1 Research Poster).

A final project review and research seminar will take place in Vientiane during 2016. Although the events were originally scheduled for 20-21 March 2016, it was mutually agreed by the research partners to further postpone the event until 30 June – 1 July 2016 to ensure participation of all core research partners involved in the project (Appendix 2

Schedule of the Final Project Review and Public Seminar). Between March and June 2016, the project partners continued to finalise policy briefs, and three main research papers. We aim to publish research papers during 2016-2017 through peer-reviewed academic journals (e.g. Ecology and Society, Singapore Journal of Tropical Geography). We also plan to share documentation on digital data capturing that was applied for the current project, and also stream line the survey data and make it available for use by other researchers and organisations.

9 Conclusions and recommendations

Our research aimed to address the following key questions:

- 1) *How can the livelihoods of people facing natural resources pressures be improved through a stakeholder-inclusive assessment of livelihood change and adaptation?*
- 2) *How can governance structures and institutions be strengthened through a process of social learning to adopt and upscale livelihood innovations that reduce people's vulnerability?*

In order to address these questions, our study carried out multi-scalar and multi-disciplinary research to understand the critical linkage between environmental change, and its impact on agricultural livelihoods, food security, Nutrition and wellbeing in the Nam Ngum River Basin. As highlighted in this report, our study demonstrates the rapid decline of forest across the River Basin due to combination of factors including increasing population density, resource development, and improved accessibility. However, the study also shows different patterns of land use change occurring in the River Basin, suggesting the need to better understand the detailed context and process of land use change and its effects on local people's livelihood.

The study shows that weak food security and child under-nutrition can still be observed in areas that are relatively accessible and considered "developed." The quantitative survey results also indicate that although households may have diversified their livelihood activities, and have access to agricultural land and livestock and food, these conditions do not easily resolve the problem of under-nutrition. In particular, child under-nutrition is prominent among the low socio-economic class of ethnic minorities in rural communities. Poverty and limited livelihood opportunities continue to inhibit the improvement of people's lives. This highlights the need for further study to understand the detailed context of securing food at household level and intra-household level access to food and consumption pattern. This includes understanding the seasonal differences of access to food, as well as types of shocks experienced by households and their coping mechanism. It is particularly important to understand the gaps in the overall acceptable level of access to food at household level, and persisting under-nutrition of children.

Our experience with the mixed method approach was particularly useful in examining the complex and inter-related problem of resource development, rural livelihood and food security at different scales. It demonstrated the importance of information across scale, and development iterative process to exchange relevant information and facilitate discussions. Building collaborative relation across different partners and stakeholders is an on-going process, and cannot be achieved through one-off workshops. Instead, chain of activities that involve different partners and stakeholders, information sharing and follow-up discussions were all essential part of the research process.

We would like to recommend to ACIAR that in the future, it would be useful and effective for its regional office to host in-country workshops on thematic issues and facilitate broader discussions on key issues that are high on the policy agenda such as food and nutrition security, and sustainable agriculture. This allows projects to learn from one another, and raises the overall profile of ACIAR's activities in Laos. It also creates much needed synergies across host organisations.

9.1 Conclusions

Our study extends the growing body of nexus studies that seek to understand the complex multi-scalar linkages between resource development, and its effects on food, water and

human health in the Mekong Region (Orr et al. 2012; Smajgl and Ward 2013; Middleton et al. 2015; Pittock et al. 2015). The current study was anchored in one of the critical River Basins in Laos, the Nam Ngum, where a cascade of hydropower development is occurring concurrently with other resource development activities such as mining and plantations. Nam Ngum River Basin has also been a focal area for experimenting with resource management frameworks, such as the integrated water resource management (IWRM) or watershed management, supported by international donors, development banks and the Government of Laos. Despite the decades of institutional support to promote conservation of natural resources, our study highlights limitation of resource governance in the Nam Ngum River Basin and the widespread resource degradation, and its effect on some of the most vulnerable population group.

The study has been particularly timely, as the Government of Laos is keen to achieve sustainable development pathways that not only optimise the economic use of natural resources, but which also ensure food and nutrition security for its population. This is a particularly pertinent issue in countries such as Laos, where the level of poverty is still high despite the achievement of steady economic growth during the last two decades led by export of natural resources, particularly hydropower-generated electricity and minerals.

Our study highlights that resource development such as hydropower and mining accelerate resource degradation, and negatively affect the wellbeing of the most vulnerable population groups. Our study points to widespread trend of deforestation and forest degradation in the River Basin since 1995. The degradation has accelerated in large parts since 2000, due to rapid urbanisation and expansion of resource-based investment activities. These factors have not only led to the loss of forest areas but also change in forest composition and agricultural practices of rural households. Loss of forest and agricultural land are deemed to affect local food security, by reducing areas of productive agricultural land and sources of wild food. These effects alongside the long-term effect on people's health are little discussed when assessing the benefit of resource development to the national economy.

The current project has produced unique baseline household data on livelihood, food security and nutrition, which allows for comprehensive cross sectional analysis of households and can be used as a baseline to monitor changes over time. The data set provides detailed household information on areas close to Vientiane Capital, which are often neglected from studies focused on poverty and health. Our study particularly highlights that even in areas that are accessible and close to the capital, pockets of communities continue to suffer from poverty and poor nutrition. The conditions faced in these communities vary given the topographic conditions, level of environmental degradation, history of human settlement and their access to livelihood asset and opportunities. Our household data set provides an interesting contrast to other surveys and studies carried out in less accessible rural countryside in Laos. It also indicates the importance of understanding the detailed context of poverty and poor nutrition in communities with different socio-economic backgrounds.

This findings from the quantitative and qualitative studies suggest highly diversified nature of smallholder households' livelihood basis in Laos. Many of the smallholders in the Nam Ngum River Basin already incorporate non-farm activities outside of their villages as important strategy to sustain their family life. This also means that households are often short of agricultural labour to maintain agricultural production. This not only affects the future pathway of agriculture in Laos but as more households' introduce labour saving agricultural technology, e.g. fertilizers, pesticides, and herbicides, it is also essential to understand the long-term effects of these inputs on soil and human health. This is an issue that local authorities and members of the communities are already raising concerns, but have received little attention from the research community.

Our study demonstrates the unequal effects of resource development. Despite the achievement of steady aggregate economic growth, and improvement of material standards of living, resource development, have triggered insecurities among some of the

more socially marginalised population groups. Economically poor households and ethnic minorities continue to suffer from poor nutrition and poverty. This raises the question of equity and the need to examine the detailed context of persisting poverty and poor health in local communities.

9.2 Recommendations

Issues such as food security and poverty, are broad based issues that require understanding at different scales. In order to address the issue, it is essential to understand the detailed context of the problem from different lenses.

In particular, as further natural resource developments go through the approval process in Lao PDR, it is important to explore resource pressures, livelihood impacts and anticipated nutritional outcomes in a more holistic and analytical manner than hitherto considered to plan for effective livelihood adaptation process. Such comprehensive understanding requires mixed method approaches that combine both quantitative measurements and qualitative information. The combination of both quantitative and qualitative methods will allow for longitudinal as well as cross sectional comparison of the intricate linkage between resource pressure, livelihood and human wellbeing. There is a great potential to build upon the current project to further understand the detailed context of food and nutrition insecurity in areas that are experiencing high level of resource pressure. This will allow for more nuanced understanding of constraints and opportunities faced by different communities, and thereby help design effective adaptation mechanism that are tailored to meet the needs of local communities. There is also a potential to apply the project methodology in post-facto evaluation of resource projects or river basins elsewhere in Laos and beyond in order to devise more effective and holistic adaptation support for households. Such evaluation will require involvement of key stakeholders including local governments, community members and the private project holders.

We see a great potential for a small-scale research activity (see Appendix 3 Proposal for Small Research Activity) that builds on the outcomes of current three year project, which can further enrich the understanding of the local contexts of poverty, weak food security and under-nutrition. The proposed small research activity can elucidate seasonally different coping mechanisms adopted by various population groups across the country, which can further inform the development of targeted intervention programs.

Through our research experience, we also find that it would be highly useful if ACIAR's regional office can organise thematic workshops where we can learn from the experiences of other projects operating in the same country or region and also to raise awareness of key issues. Such workshops will also improve the overall profile of ACIAR projects in country and regions, and help to bring synergies across projects without exhausting the government and research counterparts in country.

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10.2 List of publications produced by project

Lagerqvist, Y. F., S. Thongmanivong, and K. Phanvily (In progress). *Fragmented resource governance: the case of managing the Nam Ngum watershed*.

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11 Appendixes

11.1 Appendix 1:

Research poster for the Ministry of Health

Land use change, food security and nutrition nexus

Case study from the Nam Ngum Watershed in Lao PDR

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Research aim

To assess links between land use change, food security and nutrition status of households in a watershed experiencing population and development pressures.

Research questions

- How do factors such as population & resource development influence land use change?
- What is the status of nutrition well-being among mothers and children under five years old? What factors have high associations with child under-nutrition?
- What is the level of food security among the households and how does this relate with assessment of nutrition well-being?

Methodology

- Spatial analysis:** Land use & cover change analysis from 2005 to 2015 using ERDAS IMAGINE Ver.9. Five land use classes were verified based on ground-truthing in 2014. Visual interpretation was applied to correct for errors e.g. cloud cover. Change detection analysis reduced land use classes to non-forest & forest categories to identify areas of high land use change using Arc GIS Ver.10.2.
- Household survey:** A cross-sectional survey was conducted using a cluster sampling methodology to collect data from a representative sample of 3680 households in four different geographic areas in the Nam Ngum watershed. Data was captured infield using mobile digital devices with CommCare and use of STATA13 for data analysis.

Study site

Nam Ngum watershed:

- Hosts cascade of 6 hydropower dams.
- Covers 16,906 sq km
- Topographic features ranging from Vientiane plain in the lowland to mountainous plateau of Xiengkhouang
- Includes 23 districts in 4 provinces & Vientiane Municipality
- 691 villages and 110,720 households (Agricultural Census in 2011).

Map 1: Nam Ngum Watershed

Fig 1: Structure of household survey forms

Results

- Forest in the watershed decreased from 43 to 26 % between 2005 and 2010. (national average, 46 and 33 % respectively).
- High population and investment growth has significant impact on the land use (23 % of land in the watershed has been allocated to resource-based investment activities by 2010)
- Using the WFP food consumption score, poorer households and ethnic minority groups were found to have lower levels of food security.
- Among children under the age of five, 29% were found to be stunted. The highest prevalence of stunting was found in the Highlands area, a rural region home to a number of ethnic groups including Khmu, Hmong/Yao and Lao.

Map 2: Prevalence of child under 5 stunting by forest cover change 2005-2010

Fig 2: Child under 5 stunting prevalence by topographical zone, wealth category & ethnic group

Fig 3: Food security in tertiles by ethnic group & wealth category

Conclusions

- The Nam Ngum Watershed has experienced substantial environmental change since 2005.
- Food security overall is low based on WFP food consumption score and mainly a problem for the poorest households and ethnic minority groups (Mon Khmer, Hmong Mien).
- Child undernutrition is highest in highland areas, among poorer households, ethnic minority groups and overlaps with areas of high forest cover change.

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11.2 Appendix 2:

Final Project Review and Public Seminar

30 June – 1 July 2016, Vientiane

To conclude the three year research project funded by ACIAR focusing on food security, nutrition and livelihood adaptation process in resource constrained context (hereafter, Lao Livelihood Project), a series of two final events i) final project review, and ii) public research seminar are organised during 30 June and 1 July 2016 in Vientiane.

First event, final project review, is targeted for ACIAR representatives, and involves core research partners involved in the project, as well as key representatives from the central government agencies (i.e. Ministry of Health, Ministry of Agriculture and Forestry, Ministry of Energy and Mine, and Ministry of Natural Resources and Environment). The review will focus on research activities and key findings, and reflect on the ways in which research can contribute towards policy decision making.

Second event, public research seminar, is targeted for members of key government agencies as well as development and research organisations in Laos that are working on issues related to food security and natural resource management. Our main goal of the seminar is to share our research experience and key findings, and to facilitate targeted and constructive discussions on ways research can contribute towards policies and development interventions that aim to improve human wellbeing in the context of constrained access to natural resources.

1) *Final Project Review (Thursday, 30 June, afternoon at the National Institute of Public Health)*

Main objective:

- To review and reflect on main research outcomes of Lao Livelihood Project together with ACIAR, research partners and respective ministry representatives in Laos.

Expected outputs:

- Overall assessment of research project.
- Identifying future opportunities for research and development

Key audience:

- Representatives from ACIAR Office and Australian Embassy in Laos
- Representative of NUoL, Academic Office
- Representative of NIPH
- Representative from the National Nutrition Committee (Core technical group members)
- Representative from the Ministry of Health (Department of Health and Hygiene)
- Representative from the Ministry of Agriculture and Forestry (Department of Planning)
- Representative from the Ministry of Energy and Mines
- Representative from the Ministry of Natural Resources and Environment

2) *Public Research Seminar (Friday, 1 July, afternoon, second floor of the Monument Books, Baan Mixay, Vientiane)*

Main objectives:

- To share key research findings of ACIAR Lao Livelihood Project to a community of professionals working on issues of food security and natural resources to demonstrate the ways in which issues of food security, nutrition and rural livelihood intersect and bear social, environmental and economic effects at multiple scales.
- To facilitate discussions on pathways through which evidence-based research can help to effectively support policy development process in Laos.

Expected outputs

- Feedback on research, and wider application of methods and/or knowledge generated by the project.
- Identification of future areas of research collaborations and development interventions.
- Build broad network of professionals and researchers focusing on issues of food security, nutrition and natural resource management.

Key audience

- Development agencies/professionals working on issues of food security, nutrition and natural resource management.
- Research agencies addressing the issues of food security and resource management.

The main format of the research seminar will be presentation of research followed by a discussion session led by key discussant.

11.3 Appendix 3:

Proposal for Small Research Activity

Background and Justification

As Laos sets its sights on graduating from least developed country status by 2020, malnutrition and food security remain a major public health and broader developmental and humanitarian concern for the country. This is demonstrated by recent assessments in the Lao Social Indicator Survey (LSIS), which show that 22% of the population are undernourished. LSIS also indicates high level of stunting (low height for age) among children under five years of age at 44%, which suggests prevalence of chronic under nutrition despite the rapid growth of the national economy in Laos.

Understanding food security requires looking beyond rice sufficiency and at secure access to a wide range of nutritious food compatible with food preferences, as well as means to produce and consume food. Food security is thus not merely about volume of food, but also about accessibility to nutritious food, safety and quality of food, and stability of the

food system. Policy makers often use the terms food security and nutrition security interchangeably, however the issue of food security and nutrition needs to be further examined in detail. The question of access to food requires examining access to not only food but also means of producing and purchasing food. It also requires consideration into intra-household distribution of food. However, access to food is merely one part of nutrition security. In fact, the issue of under-nutrition in particular encompasses other issues including care, health and hygiene.

Based on household survey carried out for the Lao Livelihood Project (ASEM/2009/055), we assessed the level of household's food security by using the Food Consumption Score (FCS), a composite index that provides insight into diversity of food items and frequency of consumption and the relative nutritional importance of food groups. According to our assessment, households across the Nam Ngum River Basin generally have acceptable level of food security (FCS>35 at 96.8 percent and 3.2% considered food insecure). However, despite the relatively acceptable level of food security, a quarter of children sampled during the survey indicate stunting, a marker of chronic under-nutrition. The level of stunting is particularly high in the Highland Zone where resource development has transformed the agricultural landscape and the livelihood basis of households. It is also higher among the poor and ethnic minority groups including Khmu and Hmong.

Although the survey covered more than 3,300 households across 157 villages in the Nam Ngum River Basin, it did not further examine qualitative, subjective, and narrative accounts of how food and nutritional insecurity is experienced or explained by different individuals during different seasonal periods. There is great potential to fill this gap by following up the household survey in the Nam Ngum River Basin with targeted qualitative interviews and ethnography.

Aim and Research Questions

The key goal of the proposed small research activity is to facilitate policy dialogue on food and nutrition insecurity in Laos through evidence based research. By directly building on the research outcomes of Lao Livelihood Project, the proposed small research activity aims to complement and enhance the understanding of food and nutrition insecurity, and underlying conditions. We aim to apply ethnography and qualitative methods in selected communities of the Nam Ngum River Basin where household surveys were conducted for Lao Livelihood Project to understand people's perceptions on food and nutrition insecurity, and their perspectives on underlying factors that cause such insecurity and shape health outcomes. Furthermore, using the qualitative methods, we aim to understand the seasonal discrepancies in coping mechanisms.

Research questions that will be addressed in the small research activity include the following;

- 1) Among those households that were assessed as suffering under-nutrition and/or food insecurity in the Nam Ngum River Basin, how do households (and the members) perceive their level of access to food during different times of the year? What are coping mechanisms for households suffering under-nutrition and/or food security?
- 2) How do people living in households suffering under-nutrition and/or food insecurity explain the causes of such insecurity, and how is current insecurity placed within longer term household trajectories of food and nutritional security?
- 3) How do households' experiences with agricultural and livelihood changes during the last decade influence their access to food and nutrition status?

Project benefits

The proposed research will highlight the existing gap in policies that aim to address food and nutrition security in Laos, and provide ways to bridge the two issues through contextualised understanding of food and nutrition security using case studies from the Nam Ngum River Basin. The research will contribute to the national and local level dialogue on improving people's access to food and their nutritional status. It will also bring an important qualitative and longitudinal dimension to complement Lao Livelihood Project that is based on cross-sectional quantitative household data.

Partnerships

The project will build on the research partnership established through Lao Livelihood Project which includes the National Institute of Public Health and the National University of Laos. Detailed case studies will be carried out in communities suffering high level of food and/or nutrition insecurity in the Nam Ngum River Basin.

11.4 Appendix 4: Reflections on research outcomes (July 2016)

Following the final project review workshop and public seminar held in Vientiane during 30 June – 1 July 2016, research partners reflected on key outcomes of the project with participants, including the ACIAR program manager and two external reviewers.

There are five main outcomes of the project, which includes the following:

- 1) Increased appreciation for multi-disciplinary approach. Interdisciplinary and cross institutional collaborations are often easy said than done despite its importance in addressing complex problem. The project not only successfully brought together researchers from different disciplinary background to examine the linkage between resource development, livelihood and food security, but strengthened collaborative relationship between researchers and facilitated cross institutional learning. The project enabled researchers from different organisations with different disciplinary background to respectfully work with one another to better understand the complex problem of resource development, food security and human wellbeing. The project's multi-disciplinary orientation further enabled our group to communicate widely across a range of stakeholders including central government ministries mandated to address issues of resource development and management, food security and nutrition.
- 2) Stakeholder engagement in discussions on food security, nutrition, and livelihood adaptation in resource constrained environment. Our research not only facilitated flow of information across different stakeholders, but sparked conversations across agencies on key challenges of balancing the need for resource development, and ensuring food security and wellbeing of socially vulnerable population. We were able to discuss sometimes sensitive issue of livelihood adaptation in areas affected by large-scale infrastructure development such as hydropower dams with key government stakeholders including central government ministries (i.e. Ministry of Energy and Mines, Ministry of Natural Resources and Environment, Ministry of Health, Ministry of Agriculture and Forestry) and their line agencies in district and provincial offices.
- 3) Building knowledge and expertise on new data capturing technique. Our project built capacity of researchers to collect household data using digital data capturing technology. The project pioneered household survey using CommCare application, and the experience has enabled Lao and Australian researchers to further apply the technique to other surveys in Laos and beyond.
- 4) Outreach. The project also helped key researchers to further develop teaching programs that involve study research in the research site (e.g. Bachelor's student

research programs led by the Faculty of Environmental Sciences and Faculty of Agriculture), as well as field-based learning programs organised by the School of Geosciences and the Faculty of Forestry of the National University of Laos.

11.5 Appendix 5: Plans for action to December 2016

Numbers of activities will be carried out until December 2016 to conclude the Lao Livelihood Project. These activities include;

- 1) Follow-up qualitative study in areas with high level of child under-nutrition (see separate proposal document for qualitative study);
- 2) Final write-up of research papers and publication in peer-reviewed journals;
- 3) Presentation of research findings at national research forums in Laos (i.e. National Health Research Forum in Savannakhet, October 2016; and National Research for Development Forum in Vientiane, December 2016).