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## Developing Improved Farming & Marketing Systems in Rainfed Regions of Southern Lao PDR

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## 2 Executive summary

The lowland and upland farming systems of rainfed southern Lao PDR have been identified as having elevated risk of hunger and rising rural poverty. The Government of Lao PDR recognises the south as an agricultural economy in transition, with a need to ensure that the poor participate in and benefit from the transition process. Increasing the supply of food and generating income from these systems is constrained by low fertility soils, weed competition, production and market risk (including drought and flood) and increasing cost of labour. Ineffective value chains and poor market access, inappropriate product quality, lack of infrastructure, extension and policy support impede farmers' efforts to change their farming systems. Risk-averse producers have little incentive to invest in better production and higher inputs.

Nevertheless, the lowlands and uplands in the south have potential for market surplus in rice, other crops and livestock, and therefore, a better understanding of regional market potential and comparative advantage is important. In the southern rice-based systems, there are opportunities to intensify and diversify the production systems with livestock and other crops, through the development of new technologies, and the adaptation of knowledge from the northern uplands of Lao PDR and neighbouring countries. Through better understanding and use of water resources, there is the opportunity to explore the use of supplementary irrigation to secure rice-based systems against drought, and improve prospects for short-duration post-rice crops and forages for livestock production in lowlands and uplands.

A multidisciplinary research team from institutions in Lao PDR, Australia and the Consultative Group on International Agricultural Research (CGIAR) centres, established strategic and adaptive field research in the provinces of Savannakhet and Champassak, on-station and on-farm during wet and dry seasons during 2010 - 2013, and conducted associated synthesis activities with the following objectives:

- Diagnosis and integrated assessment of farming and marketing systems
- Optimisation, testing and adaptation of crop and livestock technologies and new marketing and extension approaches
- Sharing of knowledge and pilot scaling out of varieties, crop and livestock technologies and marketing approaches
- Alleviation of constraints posed by drought and uncontrolled flooding

The analysis of farmers' value chain and marketing operations, and synthesis of best-bet technologies, commenced with transect analysis from lowlands to uplands, and from subsistence to commodity agriculture. Systems research focussed around several hubs in Savannakhet and Champassak provinces. Adaptive on-farm research was established on approximately 300 farms in ten villages associated with these systems hubs to improve productivity and income from diversified systems in the lowlands and uplands, including attention to the priority poor upland districts of Xepon, Phin and Nong. These adaptive research trials focused on approaches for securing the wet season rice crop, assessing critical resources (water availability and market chains), and options for diversification (maize, short-duration post-rice crops such as pulses, vegetables and forages), and the integration of ruminant livestock. On-station trials were established to understand the interactions underpinning these diversifying mixed-farming systems. A concurrent focus on capacity building and co-location of international staff in-country lead to enhanced capacity, improved outputs and effective synthesis and delivery of project outputs.

## 3 Background

### 3.1 Partner country and Australian research and development issues and priorities

In both Lao PDR and Australia there are some important agricultural development and food security issues which are complex and require systems research to understand constraints and develop solutions for impact on rural livelihoods and the national economy. Rural development in southern Lao PDR is confronted by a problem complex of extensive poverty, poor soil and water resources, sparse infrastructure, and weak institutions and market access, for which individual disciplinary research is of limited value. Such complex challenges require a multi-disciplinary approach to improve livelihoods. Increased production and sustainable development are important goals of the Lao PDR Agricultural Strategy to 2025, along with commercialization of smallholder agriculture

#### 3.1.1 Lao poverty and the regionalisation of the economy

Lao PDR has a population of 6.8 million, growing rapidly at 2.3% per annum. The population density is the lowest in Asia (29 persons/sq.km) but due to mountainous terrain the majority of land is unsuitable for food crop production other than by shifting cultivation (Roder 2001), making the lowland plains of southern Lao PDR (Savannakhet and Champassak) particularly important for national food security. About 70% of the population lives in rural areas, although the rate of urbanisation is high. There is also considerable movement of population between rural districts, especially from uplands to lowlands. The rapidly growing and urbanising population implies an increased demand for rice, projected to be 3.6 million tons by 2020 (Shrestha et al. 2006), an increase of 80% over current production levels.

The economy of Lao PDR is still largely agrarian and subsistence-oriented. Agriculture accounts for about 40% of GDP and 80% of employment, and over 70% of agricultural production is non-traded. In particular, rice production has been primarily a subsistence activity, with limited local or export trade; only 8% of rice production is marketed. Farmers have tended to rely on livestock and non-farm activities for cash income. Opportunities for greater diversification of these rice-based systems need further exploration. About 30% of the population was below the poverty line in 2005, with the greatest concentration of poverty in southern Lao PDR (Savannakhet, Saravane, Champassack, Sekong and Attapeu provinces). There is a marked contrast between the prevalence of poverty and the absolute numbers of poor: whereas most of the poor live in the southern lowlands, the highest rates of poverty (as a proportion of district population) occur in the uplands, especially the southern uplands. Recognising these relationships, there was a need for transect analysis, from lowlands to uplands, and from subsistence to commodity agriculture.

The economy of Lao PDR is becoming increasingly commercialised and integrated into the Greater Mekong Subregion with the majority of trade occurring with Thailand, Vietnam, and China, particularly rice and cattle from the northern provinces. The emerging private sector in Lao PDR is being encouraged to take a greater role in agricultural processing and marketing, though there are still issues of ensuring adequate information flows, dealing with regulatory constraints, and enforcing fair and transparent contractual arrangements. Regional integration has involved a surge of foreign direct investment (FDI) in both small- and large-scale commodity production (notably rubber), with Chinese firms the major investors in the north and Vietnamese firms obtaining extensive land concessions in the south (Manivong 2007). In addition, Thai agribusiness firms have been contracting supplies of maize, soyabean, and other crops from Lao farmers in more accessible areas. Laos has also recently joined the World Trade Organisation, and in

2015 the ASEAN Economic Community was established, which will change the regional market structure, with implications for trade and investment (Prakash and Isono, 2012), including for trade of agricultural produce, including SPS and product quality.

Regionalisation of the Lao economy is set to continue as highlighted by the projected road and rail networks, with scheduled routes to be developed linking Savannakhet and Champassak provinces with Thailand and Vietnam. Consequently, southern Lao PDR is an agricultural economy in transition, and the Government of Lao PDR recognises the need to ensure the poor participate in and benefit from the transition process.

The growing regional economy has increased the demand for labour in commercial agricultural ventures, factories, and cities, both in urban Laos (Vientiane, Savannakhet) and in Thailand. This has drawn labour out of rural areas, especially in the south, increasing the cost of farm labour in an already labour-constrained rural economy. During the period of the SLP, daily wage rates for agricultural labourers in southern Laos doubled. While wage migration during the dry-season slack period has been common in the rainfed districts, the increase in outmigration from the south means that reduced labour availability and increased labour costs are becoming significant production constraints, both for rice cultivation and livestock production, and lead to increasing incentives for labour saving technologies such as conservation agriculture and agricultural mechanization.

Although Lao PDR achieved self-sufficiency in rice production in the early 2000s (with annual availability of about 250 kg per capita), this is not evenly distributed across the country. The five southern provinces of Lao PDR accounted for about 44% of national rice production in 2007. Of the estimated 350,000 ha of rice-land harvested in 2007 in southern Lao PDR, 8% is irrigated lowlands, 88% was produced in the rainfed lowlands, and 3% in the rainfed uplands. Rice surpluses in Savannakhet, Champassak, and Saravane make up most of the national rice surplus (Schiller, 2009). Despite this the neighbouring provinces of Saravane and Sekong are among the most food insecure households. This results from poor infrastructure and institutional barriers that restrict trade, and additionally, many households lack sufficient income to purchase rice. Whilst past investment has been made in capacity building to resolve these issues the institutional and legal framework for agricultural development in southern Lao PDR is very weak.

### **3.1.2 Crop agronomy, soil, and water**

Rainfed areas in southern Lao PDR frequently suffer from significant incidences of both drought and floods. Drought is a regular occurrence throughout the rice-growing areas of Lao PDR especially on upper terrace fields and the uplands, and farmers in rainfed lowland consider drought their most consistent production constraint (Khotsimuang et al. 1995). The soils in this region are predominantly loams, sandy loams and sands, and are particularly drought prone (Lathvilayvong et al. 1996). Some presence of salinity problems has been reported in southern Lao PDR but the extent of this problem is unclear. Both early and late wet season droughts occur and can severely affect rice production (Fukai et al. 1998). Early season drought usually occurs from mid-June to mid-July as the monsoon changes from southeast to southwest. Late-season drought occurs if the regular monsoon rains end early. In 8 of 12 years between 1991 and 2002, significant rice areas in the Mekong Valley were destroyed by temporary flooding of the lowest lying fields (Schiller et al., 2009). As submergence often extends beyond 1 week, total crop loss may result. Low levels of soil fertility are another major constraint to improved rice yields in southern Lao PDR and fertilizer application is essential to achieve and maintain higher yield levels (Linguist and Sengxua, 2001). However, farmers are reluctant to invest in fertilizers, partly because drought or submergence may negate the impact of increased fertilizer application, but mostly because of volatile prices, often very unfavourable input/output price ratios, and weak market access (Newby et al., 2014). Therefore, farmers need knowledge and tools to adjust their crop management to site-specific bio-physical and socio-economic conditions. The risk of occurrence and the geographical extent of drought,



submergence, and salinity needs to be better quantified and mapped so that appropriate response options can be well targeted.

Reduced labour availability and increasing labour costs are becoming significant production constraints. The consequent shift from traditional transplanting to direct seeding and, potentially mechanisation, brings additional production constraints, including unreliable crop establishment, reduced nutrient availability, and increased weed competition, for which appropriate management must be developed. In the uplands, reduced labour availability impacts on weed control and timely farming operations. Greater integration of knowledge into intensification and diversification practices for the montane lowlands is essential to reduce pressure on the fragile sloping uplands. Hydrology interacts with every system component across the transect, requiring careful management of varieties (for drought escape and avoidance, and submergence tolerance), and land preparation and levelling to lower the production risk for rice and other post-rice crops such as vegetables, pulses and forage.

The described problems of poor soils, droughts, floods, and labour scarcity are not new in southern Lao PDR, and considerable research on improved management has been conducted in the past. However, technologies developed often remained single components without being assembled into an integrated management approach, recommendations were often too rigid and not adjusted to the highly diverse rainfed environments and comprehensible extension materials for farmers and village-level extension staff are hardly available. In addition, a range of new technology options has become available to address major constraints in new ways. New flood-tolerant rice varieties based on the Sub1 gene have been developed and were tested on a small scale in Champassak province. They are now available for wider testing and for dissemination to suitable target areas in this project. Soil improvement by clay amendment has been shown to increase the effectiveness of fertilizers and increase yield on soils with very low clay content. But system and soil characteristics affecting the adequate and cost effective use of this technique need to be determined and evaluated under farm conditions. A systems context is essential to ensure upland challenges are not considered in isolation.

Significant system improvement is also possible by new opportunities for supplementary irrigation. Some irrigation already exists in the area, using water collected and stored in small on-farm reservoirs and water pumped from rivers (low-lift pumps) and/or groundwater. More opportunities may exist to tap new water resources for additional irrigation, but the availability of surface and groundwater resources needed to be quantified and mapped. An array of water-saving technologies has been developed to assist farmers in using scarce irrigation water wisely in rice production, such as adapted cultivars, sound field water management (good land preparation and levelling, establishing field channels for water conveyance), the technology of Alternate Wetting and Drying (AWD), and aerobic rice. Supplementary irrigation also increases opportunities for a post-rice vegetable, pulse, or forage crop (enhancing the viability of rice-livestock systems). Such increases in cropping intensity have occurred in most rice-based farming systems throughout Asia. Adaptive research can identify and site-specifically adapt the most promising water-management technologies and cropping systems in the target areas. Sound community-based management of water through farmer-user groups can help make the best out of available water and facilitate the adoption of water-saving technologies.

### **3.1.3 Livestock and forage**

For rice-deficit households in both the lowlands and uplands, livestock production provides a major source of cash income and the greatest potential for poverty reduction and enhanced food security. However, issues of feed availability, low labour productivity, poor quality output, and lack of infrastructure limit market earnings. Traditionally, rice production and small livestock like chickens and ducks ensure household food security, while pigs and large ruminants (cattle and buffalo) provide cash income, draught power for



land preparation, and manure for soil fertility maintenance. Livestock sales often account for 50% or more of farm-derived household cash income and ensure households have a capital reserve in times of need. The by-products of rice production include rice bran, which is the single most important feed for poultry and pigs, and rice straw, which ensures that cattle and buffalo can survive the rice growing season and the long dry season. The complexity of the rice based system is increased by different labour and decision-making roles of women and men.

Livestock productivity in traditional management systems is low and requires high labour inputs. Women are responsible for small livestock (poultry and pigs), while men are responsible for cattle and buffalo. Managing and feeding pigs is time consuming, so women may spend 2–3 hours a day collecting and preparing feed. Introducing a forage legume can reduce this time by 50%, while doubling pig productivity as limited feed is the main reason for low livestock productivity. Farmer control of local feed is restricted to rice straw, while households compete for grazing of common land. Given the poor nutritional quality of rice straw, livestock have poor body condition and are susceptible to diseases.

With the proximity of increasingly affluent population centres in south Vietnam and Thailand, Lao PDR is ideally situated to benefit from increased demand for meat. City markets like Ho Chi Minh City increasingly demand high quality cattle (<4 years of age, minimum weight 350kg and a body condition score of 4), which currently is beyond the capacity of smallholder farmers in southern Lao PDR. Within Lao PDR and neighbouring countries, local and regional markets may accept smaller and older cattle at reduced prices, provided they are in good body condition (a score of 4 or 5). In northern Lao PDR, farmers who fatten cattle for 2–3 months before sale using on-farm forages can obtain an additional A\$50–100 for these fatter cattle from local traders. Improved production and quality of feed, its timely allocation for fattening, and improved livestock hygiene and management should improve livestock body condition and corresponding incomes for farmers. This project aimed to identify the most appropriate fodder options given competition for water within the rice based systems. Wet and dry season options, for farm-grown fodder include growing small areas of forage grasses on fallow or marginal paddies or dry areas to plug the feed gap, supplemented by forage or dual-purpose legumes after rice, perhaps with supplementary irrigation. Forage legumes may improve soil fertility, with livestock providing manure for post-rice vegetable or forage crops, however optimal allocation of scarce water between these competing uses will need to be explored.

There are still significant knowledge gaps surrounding existing rice-livestock farming systems, their production constraints and opportunities, the different labour and decision-making roles of women and men, and the potential for the development of rice and livestock value chains within and beyond Lao PDR that will have significant impacts on rural poverty and food security in the south. Technical options for improving feed supply for large ruminants (such as intensively managed grass plots for stall-fed cattle) have proven successful in upland environments in northern Lao PDR and central Vietnam, but these needed to be tested and adapted to conditions in southern Lao PDR. Growing forages in lowland fields is a relatively new concept and there is limited experience with broadly adapted forage varieties in northeast Thailand and Cambodia. A comprehensive evaluation of forage germplasm was needed to find suitable varieties for southern Lao PDR; both grasses and legumes, including dual-purpose legumes, that can make use of residual soil moisture after rice and provide valuable feed for the dry season.

### **3.1.4 Knowledge sharing and scaling out**

There is a lack of extension capacity and knowledge of rice and livestock technologies at the extension and farmer level in southern Lao PDR. At the national level, a Lao Rice Knowledge Bank has been developed and holds general information on best management practices for rice aimed at farmers and extension specialists: (<http://nrrp.nafri.org.la/>; <http://www.knowledgebank.irri.org/regionalSites/laoPDR/default.htm>). The Lao Extension Approach (LEA) developed and implemented by the Department of Agricultural Extension

and Cooperatives (DAEC) sets out three levels of the extension service: DAEC is the top level, then the Provincial Agriculture and Forestry Extension Offices (PAFES) and District Agriculture and Forestry Offices (DAFO). The Village Extension System involves three groups of people, including village extension workers.

Although LEA quotes sound extension methodology, e.g., 'bottom up where farmers identify problems through the existing participatory mechanism' there is a lack of knowledge of rice and other crop and livestock technology at the PAFES, DAFO and village levels. There are many reasons for this. District Extension Officers have multiple roles in extension and regulatory functions, so they are largely administrative, rarely visit the fields, and lack knowledge and credibility. Their wages are very low at \$US50/month, which results in their spending time on their own farms or in other work. Thus, the current system prevents them being effective in the transfer of rice and livestock technologies.

Some transfer of technology in new rice varieties and seed replacement and nutrition has been provided by the Thasano and Phone Ngam Rice Research and Seed Multiplication Centres in the provinces, via individual research officers and non-government projects. Despite some good training in extension methodology provided in previous projects, the main and unsatisfied training requirement was in crop and livestock and train-the-trainer methodology, which was a focus of this project.

The International Centre for Tropical Agriculture (CIAT), along with NAFRI and provincial and district partners has managed several forages and livestock projects in northern Lao PDR and there are many skilled extension workers who have received training in participatory approaches of developing and extending agricultural technologies, and technical skills in forage agronomy, utilisation, and animal nutrition. These were called upon as trainers and mentors for extension workers in this project. Examples of successful livestock development in northern Lao PDR were used for study visits by extension workers and farmers, and 'Best practice guides' and other extension materials were adapted for conditions in southern Lao PDR. As livestock form an integral part of the rice system, and changing livestock feeding regimes may have implications for rice production, the opportunity existed to combine extension and farmer training for rice and cattle/forage production. Increased NAFRI support to its research centres in the south, via relocation of staff and appointment of new research officers from this project increased capacity in the provinces.

### **3.1.5 Australian rice research**

Although the irrigated rice-based mixed farming system in Australia differs in scale from smallholder rainfed rice-livestock systems in southern Lao PDR, a number of critical issues are common. Reduced or no supply of irrigation water, a need for greater water productivity, and a shift to direct seeding techniques with delayed permanent water or alternate wet and dry systems, are common to both the Lao and Australian rice production context. These result in similar challenges of unreliable crop establishment, reduced nutrient availability, higher production risk with transient drought events under non-permanent flooding before panicle initiation, and consequently, much greater threats from weed competition, and exposure of adverse subsoils through land levelling. While contrasts exist in land holdings, capital reserves and mechanisation, complementary facilities for experiments ensure that lessons will be potentially adaptable from one system to another.

Within the Australian rice system, the largest impact from projected climatic change is likely to be from reduced supply of irrigation water. Projected reductions in Murray-Darling stream-flows of 16–25% by 2050 and 16–48% by 2100 are likely to result in similar levels of reduction in rice production, under current production and water use systems (Gaydon et al 2008). Additionally, climate variability is another factor which can reduce water supply and is the cause of a major drought which has affected southern NSW between 2002 - 2009. In order to meet the rice industry target of 800,000 tonnes per season, there

is a need to develop rice-farming systems which use less water and have improved water productivity, i.e. tonnes per megalitre.

Adaptations to save water include earlier-maturing varieties with shorter growing seasons, varieties with drought tolerance, the use of low water use soils and alternate wet and dry (AWD) irrigation systems with intermittent irrigation. The drying of soil between flush irrigations reduces evaporative demand compared with the normal permanent water system.

A major issue affecting the use of AWD systems is the low tolerance of current varieties to low temperatures during microspore. This necessitates the application of a water depth of 20 to 25cm at microspore which protects the rice from cold. Hence permanent water has to be applied about 7 days prior to the panicle initiation stage to enable the raising of water depth to 20–25cm. Trials conducted in the early 1980s and early 2000s timed flushes on a set 50–60mm ET interval and saved 10–15% water. Thus the potential water savings is from sowing to just prior to panicle initiation. This adaptation of AWD for Australian conditions is termed delayed permanent water (DPW).

The use of the AWD system raises several issues and uncertainty with the management of the delayed permanent water system. Early maturing varieties have lower water use than long season varieties, but their biomass may be more reduced than in the long season varieties. It is not known at which flushes and growth stages to apply nitrogen, as intermittent flushing will mean larger losses of early-applied nitrogen and the Near Infra-red (NIR) tissue test is of limited value for making nitrogen recommendations when permanent water and nitrogen are applied close to panicle initiation. While anaerobic processes in ponded water systems allow higher levels of available phosphorus, aerobic conditions reduce phosphorus availability, so under a DPW system, there may be a need for additional phosphorus. Since the Delayed Permanent Water (DPW) rice system uses drill sowing some rice growing systems, e.g. non-lasered layouts with poor drainage and/or sodic soils, are unlikely to be suited, so there is a need to investigate suitable soil types and layouts in relation to agronomy.

Grass weed control is a significant challenge and will be much more difficult with a DPW water system than the existing early ponded system. This is due to the rice crop remaining aerobic until permanent water is applied at the panicle initiation stage, allowing grass weeds to germinate and grow in competition with the rice. Lastly rice development is usually delayed when rice is moisture stressed. Delayed permanent water slows down crop development and the greater the stress between flushes the longer the delay, so the crop is irrigated for a longer period, delaying harvest and reducing potential water savings.

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### **3.2 Research and/or development strategy and relationship to other ACIAR investments and other donor activities**

The project developed following consultations with the Government of Lao PDR. Following the Ministry request to ACIAR to focus its research in the south, a series of activities were developed to shape the project in consultation with Lao PDR partners, including a Scoping Visit in May 2009, a Field Assessment and National Workshop in August 2009, and Consultations in October 2009, February 2010 and March 2010, which resulted in the NAFRI being designated as the facilitating agency for Lao PDR.

The rice and livestock research components of the project built on the long experience and results of previous projects in Lao PDR and neighbouring countries. The project also tapped into the Irrigated Rice Research Consortium (IRRC) and the Consortium for Unfavourable Rice Environments (CURE) for acquiring new technologies for testing. Both networks are mechanisms to disseminate and share knowledge on improved rice production practices in Asia, and they are active in the country and the region. The project linked with and provided additional scaling-out of technologies to the CIAT Forage

Program, related ACIAR projects and activities occurring through the World Bank, ADB and IFAD (Table 1).

A focus of the crop research component was on farmer-participatory adaptive research on farm to complement the multidisciplinary systems strategy. The project assessed, adapted, and assisted farmers with adopting improved rice management technologies (using appropriate and high-yielding improved varieties) to alleviate water shortages (drought), flooding, and labour scarcity. Activities were conducted on different toposequence positions to determine the hydrological regime and soil fertility in Champassak and Savanakheth provinces. Concurrently researchers worked within existing livestock systems, introducing forages to catalyse the transition of farmers from subsistence based farming, to more sustained production, and measuring the relevant market and livestock husbandry approaches during the process. More in-depth on-station experiments were established to understand interactions and risk and provide improved management recommendations to feed into these adaptive trials. The project specifically built on and expanded the on-farm participatory activities initiated in the wet season of 2009 on yield response of improved varieties to water regime and nutrient availability occurring through CSE/2006/041. The project also linked with activities which previously occurred in north-east Thailand (LWR1/1996/096) where soil amelioration through clay additions were previously piloted. Extension materials were produced in Lao language.

Besides building on the results of other ongoing and completed ACIAR and non-ACIAR projects in the region (a sample of key projects is listed in Table 1), the project used various approaches to collaborate with major ongoing and planned development projects in south Lao PDR, linking with local NGOs and organisations at the local level. In Savannakhet province links were facilitated by the creation of a local Agri-network, established by project staff to share information and identify areas of common concern.

**Table 1 The relationship to other projects**

Project	Relevance and potential linkages
CSE/2006/041 Increased productivity and profitability of rice-based lowland cropping systems in Lao PDR	<p>The results of intensification and diversification of irrigated rice-based cropping systems in the lowlands (Vientiane, Savannakhet, Champassak) can be used, especially knowledge of farmers' preferences of improved rice varieties, direct seeded rice performance, and drought risk assessments. This project will expand the strategic water-fertility-risk trials for 2 years more. Linkages will be organized through workshops for sharing experience and shared staff in Vientiane and Savannakhet.</p> <p>The results and Ricecheck methodology from the rice direct seeding technology transfer project for dry season irrigated crops were linked and utilised for the wet season Ricecheck activity. The Ricecheck component of CSE/2006/041 commenced in the 2008/09 season and is a 3 year project based in Savannakhet province. However, results were not satisfactory within the SLP and Ricecheck was not pursued after 2011.</p>
ASEM/2005/124 – Extension Approaches to scaling out livestock production in northern Lao PDR.	This project provided lessons on extension approaches for livestock that were applicable for this project. Opportunities for training and use of extension tools and methods were explored.
Rice Productivity Improvement Project (World Bank)	Variety identification, seed multiplication, and variety and fertilizer demonstration, with a project extension service to support the demonstration and scaling out of project technologies in South Lao PDR. SLP gained experienced staff who had worked with this project.
Sustainable Natural Resource Management and Productivity Enhancement Program (ADB, IFAD)	The project focused on lowland and upland community based income generation/development activities in south Lao PDR, including in common districts. Links with this project included staff training, joining cross-site visits for farmers, joining the agri-network set up by the SLP, and financial support to conduct further research for promising technologies (direct seeding , short duration mung bean).
LWR/2008/019 Developing multi-scale climate change adaptation strategies for farming communities in Cambodia, Lao PDR, Bangladesh and India.	The project sought to adapt and apply tools/methods to select and assess adaptation strategies for rice-based cropping systems, especially for water management in Savannakhet province in southern Lao PDR, using 2 districts: one drought-prone, and one with access to supplementary irrigation. There were complementary interests in evaluating management strategies, developing capacity, and disseminating knowledge to farmers and policy makers. These links were undertaken by Lao project staff working in both projects.
ASEM/2011/075	The project aims to enable DAEC to support Provinces and Districts to provide effective extension delivery to smallholder farmers. Interaction with key staff has informed extension approaches within SLP.

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## 4 Objectives

The overall aim of the project was to improve food security and rural livelihoods in the rainfed uplands and lowlands of southern provinces of Lao PDR. This aim was met through the following objectives and activities:

- 1. Diagnosis and integrated assessment of farming and marketing systems**
  - 1.1. Review and synthesise existing research, technology, and best-bet management options for rice based farming systems, including supplementary irrigation, diversification, and risk management
  - 1.2. Analyse structures and trends in the regional economy, market potential and comparative advantage and assess alternative scenarios for income, production risk, marketing risk, gender impact, and food security
  - 1.3. Develop a practical typology of farm households and their crop and livestock productivities, livelihood strategies, and decision-making
  - 1.4. Develop and apply appropriate social and economic metrics for the ex ante and ex post evaluation of technologies, and monitor adoption and impacts of technologies
  - 1.5. Map and characterize the value chains including export chains with special consideration to quality and Sanitary& Phytosanitary measures (SPS) for rice and livestock from the research area and identify potential points of intervention
  - 1.6. Understand local networks of social and economic relations affecting access to and collective management of farm resources and access to markets
  - 1.7. Identify and evaluate changes to policy settings to improve the feasibility of potential improvements to farming systems and rural livelihoods and disseminate results to policy makers
- 2. Optimisation, testing and adaptation of crop and livestock technologies and marketing/extension approaches**
  - 2.1. Design integrated best-bet management options for rainfed transplanted and direct-seeded rice and selected post-rice crops with farmers (including the use of appropriate machinery); execute and evaluate participatory and adaptive experiments; and, in seasonal iterations, adapt and fine-tune best-bet management options oriented towards conservation agriculture.
  - 2.2. Conduct on-farm and on-station experiments to refine the basis of systems understanding with a particular focus on crop, soil, and water interactions. Specific research topics include soil amendment options and respective threshold boundaries, improved cultivars, establishment-weed interactions and their consequences, and optimized rice-forage-livestock systems.
  - 2.3. Identify potential livestock feeding and management options, and adapt and evaluate these with farmers at key sites using action research-learning cycles.
  - 2.4. Identify productive forage species adapted to the specific lowland and upland conditions of southern Lao PDR, quantify year-round fodder availability, and investigate forage conservation options, in on-station experiments and with farmers at key sites.
  - 2.5. Test and evaluate the potential for new cooperative production and marketing arrangements in the selected villages
- 3. Sharing of knowledge and pilot scaling out of varieties, crop and livestock technologies and marketing approaches**

- 3.1. Organize annual learning workshops to share experience across research projects and development initiatives in southern Lao PDR
- 3.2. Develop practical 'RiceCheck' guidelines for rainfed rice in southern Lao PDR in an iterative process with farmers and village extension staff
- 3.3. Integrate results and outputs from the project into Decision Support Tools and Knowledge Bank
- 3.4. Build capacity for NAFES of DAFO, PAFO and NGO staff and farmer-trader associations to scale out interventions.
- 3.5. Conduct on-farm demonstrations to integrate and deliver research findings.
- 3.6. Develop and adapt extension materials, including for the ADB-IFAD SNRMPEP funded development activities.
- 3.7. Assess the effectiveness of pilot scaling out, including decision support, on-farm demonstrations and the additional opportunities potentially provided by linkage with the ADB-IFAD projects.

#### **4. Alleviation of constraints posed by drought and uncontrolled flooding**

- 4.1. Assess seasonal water availability (rain, surface- and groundwater), and identify and map areas prone to drought, flooding, and salinity.
- 4.2. Conduct on-farm trials on the use of integrated water-saving technologies, (e.g., alternate wetting and drying, delayed permanent water, aerobic rice, supplementary irrigation), to secure the wet season rice crop, and improve the success of short-duration, post-rice crops (including forage/fodder crops) to diversify and intensify the production system and increase livestock production.
- 4.3. Evaluate and disseminate new submergence-tolerant rice varieties (including the Sub1 gene) together with the adjusted resource management recommendations as mitigation options in flood-prone areas.
- 4.4. Strengthen community water management schemes and enable adoption of water saving technologies at system or community level.



## 5 Methodology

In order to seek a systems understanding of rice-based mixed farming systems in lowland and upland southern Lao PDR, a multidisciplinary team was assembled from Lao PDR, Australia and the CGIAR. The research involved transects from lowlands to uplands, from the Mekong River to the Vietnamese border, and from subsistence to commodity agriculture. Along that transect, surveys and household studies provided context concerning rural livelihood, resource availability and market access. On farm-adaptive research at the farm scale was underpinned by on-station experiments seeking process-level understanding. The project structure was designed to identify priorities, to explore options to address these priorities, facilitate synthesis of component interactions across scale, discipline and commodity, and feed these outputs into application and knowledge sharing activities, as shown below in Figure 1.

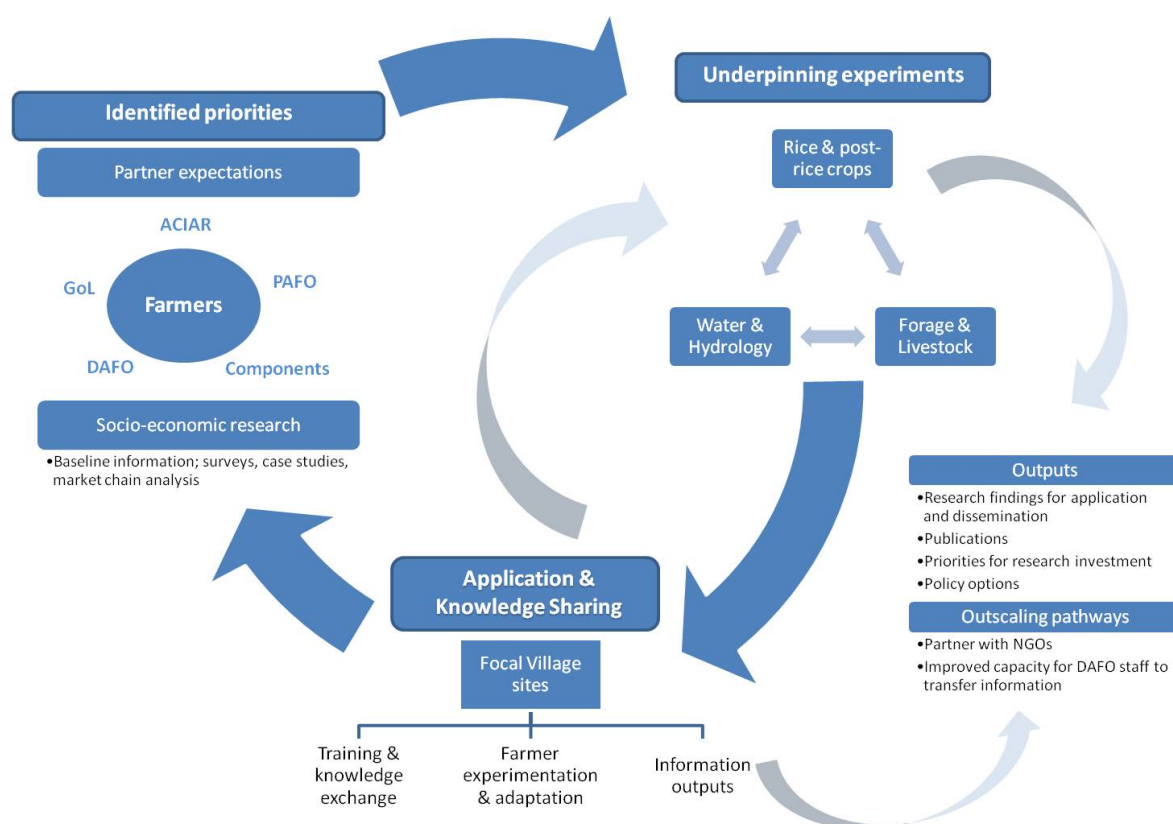


Figure 1 A diagrammatic representation of the project's integration pathway.

### 5.1.1 Geographical Focus

**Transects:** To capture the range of smallholder, rice-based farming systems in southern Lao PDR, research focused on key sites along two transects from the Mekong floodplain in the west to the sloping uplands in the east. Along these transects there is variation (not necessarily continuous) in a) the relative importance of lowlands and uplands (including flat and sloping uplands), b) the potential for supplementary irrigation, c) the potential for ruminant production, d) the availability of off-farm work, e) the accessibility of different crop and livestock markets, and f) subsistence to commodity agriculture. Socio-economic research focused on these key sites but also extended more broadly, both by examining farming systems that are more remote from east-west road links through the consideration of wider (including trans-boundary) movement in labour, investment, and commodities.

**Research Hubs:** Six research hubs were selected, used as Focal Village sites for project integration. At these hubs, in-depth trials were conducted to screen technologies and understand the interactions underpinning management decisions. Participatory, adaptive research with farmers commenced immediately using currently-known, best-bet recommendations for rice-livestock systems, involving 300 farm households in ten villages associated with the research hubs (**Activity 1.1.**).

### 5.1.2 Research on Production and Marketing Systems (Objective 1)

**Review and Synthesis (Activity 1.2).** At the regional scale, a review and synthesis of trends and shocks assessed the likely direction and uptake of new practices and activities in rice-based farming systems over the next 10 years. These include a) demographic trends (population growth and migration) in relation to on-farm labour availability and opportunity costs, b) the increasing 'marketisation' of the rural economy, including the emerging role of agribusiness actors from within and outside the country, and c) changes in the scale and type of agricultural land use (e.g., industrial crop plantations). A qualitative and quantitative analysis will be conducted of existing and potential value chains for rice, non-rice crops, and livestock on a regional scale. This will involve interviews with actors at various stages of the respective chains to trace input and commodity flows within and beyond the region. The focus will be on points of intervention that increase both the value of the chain as a whole and the value realised by farmers.

**Typologies and Household Surveys (Activity 1.3):** Spatial analysis of existing data developed agro-ecological 'recommendation domains' based on characterisation of soil and land types, rainfall, irrigation resources, transportation, and market accessibility, now and within the next 10 years to take account of, for example, planned new road links within the transect zone. Socio-economic characterisation of household types within these zones used rapid appraisal techniques, focusing on access to land, labour, water, livestock, machinery and the mix of enterprises and livelihood activities.

These data were used to develop a typology of farm households and to select case-study households from within the 10 village sites for in-depth study of decision-making, gender roles, strategies for dealing with risk, factors affecting the adoption of different activities and farm practices, interactions between activities (e.g. off-farm work and dry season cropping), and likely development pathways. These households were revisited towards the middle and end of the project to provide 'panel data' on change in livelihood outcomes. The typology was also used as the basis for a stratified random sample baseline survey of farm households to record current farm practices and productivity in the crop and livestock sub-systems.

**Case Studies (Activity 1.4):** Households are embedded in formal and informal networks of social and economic relations at the local level. Drawing on the household typology, the analysis of livelihood strategies, and the market surveys, appropriate measures of the social and economic desirability of proposed and potential changes to the farming system were developed. These included partial and whole-farm budgets, with careful attention to decision-making criteria (e.g. returns to labour, gender impacts, seasonality, food security, risk, timing and level of cash flows).

**Institutional and Policy Settings (Activity 1.5, 1.6 and 1.7):** Based on the preceding analyses and a review of current policies affecting agricultural development in southern Lao PDR, policy options were considered by the project team.

### 5.1.3 Research on Technologies and Institutions (Objective 2)

Testing and adaptation of crop and livestock technologies consisted of a mix of on-station research and farmer-participatory adaptive research in selected villages.

Best-bet management practices for transplanted and direct seeded rice, supplementary irrigation, and soil management were tested evaluated and improved in on-station and farmer led experiments (**Activities 2.1, 2.2 and 2.3**). More in-depth on-station trials were executed for understanding the interactions underpinning management decisions. For example, the effect of switching to direct seeding and its subsequent influence on nutrient availability, weed competition and the plant's capacity to adapt to anaerobic conditions was tested using Lao cultivars, for which there is currently limited data. Such improved knowledge enhances confidence in scaling out resulting technologies and increases the likelihood of adoption. Quantification of risk associated with technology change, and how farmer livelihood may be affected, was critical, including the impact on productivity, reliability, quality, timeliness, and market risk.

In Australia the project investigated the water savings obtained from different irrigation techniques (including Delayed Permanent Watering) and the interactions of irrigation method with variety, nitrogen and weed control.

Using participatory research methods within the 10 village case study areas, farm-grown fodder options were introduced, based on experiences from northern Lao PDR and neighbouring countries. Forage benefits to animal growth, reproduction, mortality and sale values were monitored with owner participation (**Activities 2.4 and 2.5**). This was supplemented by evaluation of forage germplasm for lowland rice conditions as most experience is from upland areas. On-farm evaluations by all stakeholders was used to integrate options into the farming system including optimising use of additional feed resources to maximise returns from animal production, and maximising the synergistic relationships between forage-livestock and rice production. New potential markets and marketing arrangements were explored with these same groups (**Activity 2.6**). Synthesis of crop-livestock technologies was pursued through integrated on-farm trials in key Focal Villages, and in building capacity for project staff (NAFRI, PAFO, DAFO) in strategic systems thinking.

#### 5.1.4 Knowledge Sharing (Objective 3)

Learning workshops were conducted frequently on topics agreed by the project teams, including an initial synthesis of technologies/modalities (**Activity 3.1**). These included technical, professional and extension themes. The principle underpinning the 'Ricecheck' approach in Australia was applied, but later abandoned due to poor results in the southern Lao context (**Activities 3.2 and 3.3**). Specific training events were designed and implemented for government and non-government extension staff, on an as-needs basis (**Activity 3.4**). The focus of these training events evolved with the project and with staff needs. Development of suitable extension tools coupled with improved extension capacity was assessed, including linkages with consultants and PAFO and DAFO extension officers' ability to assist scaling out of technologies identified in this project. Improved extension capacity was applied by local extension staff through development of their own locally relevant extension plans. Farmers participated through on-farm research, and cross-site visits to relevant project sites and others, placing an emphasis will be on the use of "doing" and "observing" techniques.

#### 5.1.5 Water Resources Assessment and Management (Objective 4)

Water availability, reliability and quality were assessed through a mix of on-ground works and desktop studies. Available hydrological and meteorological data was analysed for trends in water availability and quality. With a paucity of local data, other avenues were explored, including using remote sensing data, monitoring local groundwater bores, and installing paired observation wells to understand aquifer behaviour and groundwater resources. Improved water reliability has the potential to raise equity issues in

communities. Water access and management have to be improved in a participative way, involving the community at the onset, including at the initial water resources assessment stage (**Activity 1**). A study of water users groups at the village level was undertaken to explore existing arrangements. Water availability, access and use (surface and groundwater) and farmers' perceptions were surveyed to understand patterns of use and future plans.

### 5.1.6 Project Governance and Management

**Project Management Committee (PMC).** The PMC was co-chaired by NAFRI (Oversight Coordinator) and CSU (Project Leader) with membership from different sections of NAFRI and the Provinces. The PMC met annually to endorse the workplan and budgets for the forthcoming year including plans and allocations for research, travel, training for each participating institution. The PMC maintained contact electronically at other times.

**Technical Groups.** Technical groups were formed as required around each component to ensure that design, implementation and analysis met the requirements of all collaborators. These groups worked closely together and reported at the annual planning and review meeting, and provided the material required to formally report to ACIAR in May of each year of the project and to other institutions as required.

**Inception/Planning/Review Meetings:** In an integrated farming systems study, the linkages between the components need to be facilitated. The inception and annual review and planning meetings were important venues for these linkages to be made and strengthened. These links were also explored in Focal Village sites established within key project sites. Related projects were invited to participate in the annual review meeting, to ensure familiarity with their progress and results, and to explore any collaborative opportunities that arose.

**Workplan and Budget Arrangements:** The workplan for each year was defined during the annual planning and review meeting, and as a result, the operating and travel budgets for the year were allocated and funds released to team leaders and provinces. This ensured that budgets to support priority activities were identified across the whole project, with teams drawn from the range of personnel available, including mid-level and junior NAFRI, provincial and district staff.

## 6 Achievements against activities and outputs/milestones

### *Objective 1: Diagnosis and integrated assessment of farming and marketing systems*

no.	activity	outputs/ milestones	completion date	comments
1.1	Review and synthesise existing research, technology, and best-bet management options for rice-based farming systems, including supplementary irrigation, diversification and risk management	Report on best-bet management options and development modalities for lowland and upland mixed-farming systems, differentiated by farm typology, and suitable for use by ADB-IFAD SNRMPEP and WB RPIP	Y1, Q3	<p>Commencement was delayed by lack of availability of key personnel in Laos before the end of October 2010. Commencement of ADB-IFAD SNRMPEP was also delayed, while WB-RPIP was cancelled. Best-bet technologies were identified at ARPM in March 2011. Village level studies were completed, including identification of farm typologies.</p> <p>At MTR 2012, best-bet technologies were refined for implementation at the six focal villages under Knowledge Sharing, according to typology. This activity is now Milestone 3.5</p>
1.2	Analyse structures and trends in the regional economy, market potential and comparative advantage and assess alternative scenarios for income, production risk, marketing risk, gender impact and food security.	Alternative scenarios until 2020 for income, production risk, marketing risk, gender impact, food security determined.	Y1, Q4	Detailed market chain reports were prepared for rice, cattle, pig, banana and yangbong commodities. These were presented at annual meetings, and disseminated to relevant stakeholders.
1.3	Develop a practical typology of farm households and their crop and livestock productivities, livelihood strategies and decision-making.	Simple typology & characterisation of farm households; mapped and characterized value chains for rice and livestock.	Y2, Q2	<p>Household surveys completed at identified villages across the transect.</p> <p>Data analysis and reporting completed, with the typology of farm households presented at MTR 2012 (30 pages).</p> <p>Value chains characterised for rice, cattle, pigs, banana and yangbong.</p>
1.4	Develop and apply appropriate social and economic metrics for the ex-ante and ex-post evaluation of technologies, and monitor adoption and impacts of technologies.	Documented local social and economic networks.	Y3, Q1	<p>Analysis and documentation of social and economic networks and market and value chain were completed, and a detailed report was provided at MTR 2012 (58 pages).</p> <p>Priority then shifted to active monitoring of farmer perception and adoption of selected technologies and their impact. This work is now under milestone 3.5</p>

1.5	Map and characterise the value chains, including export chains, with special consideration to quality and SPS for rice and livestock from the research area, and identify potential points of intervention.	Feasible policy options to improve farming systems and rural livelihoods.	Y5, Q4	<p>Policy options were being analysed based on evidence accumulated from activities in the project, with initial reports presented at ARPM in April 2013, and final reports prepared for the External Review in August 2013.</p> <p>Detailed market chain reports were prepared for rice, cattle, pig, banana and yangbong commodities. These were presented at annual meetings, and disseminated to relevant stakeholders.</p>
1.6	Understand local networks of social and economic relations affecting access to and collective management of farm resources and access to markets.	Social and economic metrics for the evaluation of technologies and monitoring of farmers adoption and impact.	Y2, Q2	<p>Surveys conducted, including data analysis and reporting.</p> <p>Greater attention was then paid to technology evaluation and farmer perception, in association with demonstrations at focal villages under milestone 3.5</p>
1.7	Identify and evaluate changes to policy settings to improve feasibility of potential improvements to farming systems and rural livelihoods, and disseminate results to policy makers	Alternative policy settings identified to remove bottlenecks and facilitate opportunities	Y5, Q4	<p>Results from initial farm surveys were presented for discussion at MTR 2012. Data analysis and identification of policy options continue, for initial reporting at ARPM in April 2013, and with final reports being prepared for the External Review in August 2013.</p> <p>Policy analysis for lowland rice production presented in local and international conferences and meetings, journals (including the Lao Journal of Agriculture and Forestry) and reports.</p>

PC = partner country, A = Australia



**Objective 2: Optimisation, testing and adaptation of crop and livestock technologies and marketing/extension approaches**

no.	activity	outputs/ milestones	completion date	Comments
2.1	Design integrated best-bet management options for rainfed transplanted and direct-seeded rice and selected post-rice crops with farmers (including the use of appropriate machinery), execute & evaluate participatory and adaptive experiments; and, in seasonal iterations, adapt and fine-tune best-bet management options oriented towards conservation agriculture	Robust and farmer-tested management options for rainfed transplanted and direct-seeded rice and post-rice crops. The options help farmers to address the most important site-specific production constraints.	Best-bet options available in Y1, fine-tuned management options ready in Y5, Q4	<p>On-farm experiments with rice conducted in wet season, and in post-rice crops and forages in dry season. Data from previous experiments available with initial reports on farmer preference, which were translated in MTR 2012 to best-bet management options for evaluation at focal villages with Knowledge Sharing. Integrated activities designed and implemented in Dry Season 2012-13 and Wet Season 2013 at Focal Village sites, with input from all components.</p> <p>Working in focal villages with farmers in a participatory manner allowed assessment of suitability and adoption of technology, and of farmer perceptions. The project delivered robust, farmer-tested technologies, including preparation of context-specific extension materials.</p>
2.2	Conduct on-farm and on-station rainfed experiments to refine the basis of systems understanding with a particular focus on crop, soil, and water interactions. Specific research topics include soil amendment options and respective threshold boundaries, improved cultivars, establishment-weed interactions and their consequences, and optimized rice-forage-livestock systems	Improved systems understanding of lowland and upland systems, and new technologies and system solutions; clearly defined technologies for each research area developed, tested and evaluated;	First set of trials finalized and analysed in Y2, revised/ fine tuned trials finalized in Y5, Q4	<p>Substantial research evidence was generated through the first two years of the project, with significant reports presented at MTR 2012 re major activities, nutrient management, variety evaluation, soil amendments, water management, and forage assessment.</p> <p>Cross-site analyses were conducted for nutrient-water studies, and for variety evaluation.</p> <p>Detailed reports were prepared for the External Review in August 2013.</p> <p>Six technical papers were published in the Lao Journal of Agriculture and Forestry in 2014.</p> <p>Identification of systems links was explored and documented in a series of workshops in 2015.</p>



2.3	Identify potential livestock feeding and management options, and adapt and evaluate these with farmers at key sites using action research-learning cycles	Best-bet livestock feeding and management options identified. Best-bet livestock feeding and management options, that result in improved animal growth rates and off-take rates, adopted by farmers at key sites	All years	<p>Identification of options commenced by choosing likely grass and legume forages to evaluate. The initial problems were seed availability and viability, lack of experience in forage management, and especially in seed harvesting techniques, among district staff. These identified deficiencies were addressed by training and site visits, including greater engagement of provincial and district staff</p> <p>Experiments were successfully conducted from year 2 onwards at a wide range of sites. Farmers responded positively to forage evaluation and livestock feeding activities, so a solid foundation for the component was laid by MTR 2012, with the 21 page report. Data were then synthesised for reporting to the External Review in August 2013, and were published in the Lao Journal of Agriculture and Forestry.</p>
2.4	Identify productive forage species adapted to the specific lowland and upland conditions of southern Lao PDR, quantify year-round fodder availability, and investigate forage conservation options in on-station experiments and with farmers at key sites	Productive forage species adapted to the specific lowland conditions of southern Lao PDR identified. Seasonal feed supply improved and implemented by farmers at key sites	Y3, Y5, Q2	<p>Seed increase, training of district staff, and forage evaluation conducted.</p> <p><i>Paspalum atratum</i> and <i>Panicum maximum</i> 'Mombasa' gave good results on better soils in flood prone or waterlogged conditions. Mulato 2 established well in areas of moderate soil acidity and nutrient availability, and persisted well in the dry season. Cayman, as one of the newer varieties, showed promising results under waterlogging on very poor soils. Some new <i>Brachiaria brizantha</i> and <i>B. humidicola</i> varieties were tested and showed some interesting traits, such as silkiness and weed suppression potential, but could not compete in terms of yields with the released materials.</p>
2.5	Test and evaluate the potential for new cooperative production and marketing arrangements in the selected villages	Effective new farmer cooperative arrangements for cost-price risk and market access ongoing	Y5, Q2	<p>Assessment of cooperative production and marketing arrangements in selected villages was conducted under Socio-economics, and later, was pursued under Knowledge Sharing.</p> <p>In particular, engagement with local NGOs, millers, colleges and companies lead to the exploration of opportunities for improved market access and response to market signals, as well as to options for the management of such groups.</p>

PC = partner country, A = Australia

**Objective 3: Sharing of knowledge and pilot scaling out of varieties, crop and livestock technologies and marketing approaches**

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Organize annual learning workshops to share experience across research projects and development initiatives in southern Lao PDR	Annual learning workshops to share experience across research projects and development initiatives in south Lao PDR	Each year	Specific technical trainings by component have been conducted throughout the project. These included study trips such as forage visits to Xieng Khuang province (for DAFO and farmers), and international tours to Cambodia and Thailand.  Successful trainings have been held regularly in Savannakhet and Champassak, to share experience and build expertise in experimental management, data collection, financial reporting for district staff. A nice working relationship has evolved among the teams.
3.2	Develop practical RiceCheck guidelines for rainfed rice in southern Lao PDR in an iterative process with farmers and village extension staff	'RiceCheck' guidelines for rainfed rice in south Lao PDR	Y2	Rice-check analysis commenced in Savannakhet villages in 2010 wet season, and continued in limited fashion under irrigation only in 2010/11 dry season, and 2011 wet and dry seasons. Results were reported at MTR 2012, and emphasis then shifted to knowledge sharing with other components, especially via on-farm demonstrations and outscaling.
3.3	Integrate results and outputs from the project into Decision Support Tools and Knowledge Bank	Extension materials including Lao PDR Ricecheck, the Lao PDR Rice Knowledge Bank, and other dissemination and extension products	Y5, Q4	Extension materials (posters, pamphlets, t-shirts, promotional videos) were developed, especially for use in conjunction with on-farm demonstrations and outscaling with partner projects.  The project established six Focal Villages by Typology across the provinces for integrated technology demonstrations, training, monitoring and evaluation, with all components supporting these critical activities.
3.4	Build capacity for NAFES of DAFO, PAFO and NGO staff and farmer-trader associations to scale out interventions.	Sixty trained NAFES of DAFO and PAFO extension staff and of NGOs	Y2	A number of trainings were conducted with DAFO and PAFO staff, responding to project needs as well as skills gaps identified by DAFO staff. Such trainings ensured skill development and familiarity with experiment protocols for successful implementation in future, with continued supporting visits from NAFRI and international staff. A survey of project staff and farmers showed substantially improved capacity, with influences on working ability and relationships between farmers and local staff.

3.5	Conduct on-farm demonstrations to integrate and deliver research findings	Demonstrations established and extension and farmer inspections held	Y2, update Y5, Q4	This revised milestone was a key initiative following ARPM/MTR 2012, with Knowledge Sharing and the other research components agreeing to implement six Focal Villages to integrate findings from research conducted. This occupied much time and effort over the final years of the project, including associated efforts to monitor and evaluate farmer perception, adoption and impact. Such focal villages were a focus for research, training, demonstration, delivery and adoption.
3.6	Develop and adapt extension materials, including for the World Bank RPIP-supported extension staff and ADB-IFAD SNRMPEP funded development activities.	Adapt extension materials specifically for the WB-RPIP and SNRMPEP ADB-IFAD	Y5, Q4	A list of best-bet technologies was identified, and refined at MTR 2012. WB-RPIP was cancelled, and SNRMPEP delayed, so alternative outscaling arrangements were needed, including a more direct engagement of knowledge sharing with other components in a participatory on-farm fashion. Links with SNRMPEP were pursued at the provincial level, with joint trainings, cross-site visits and financial support for research activities. In particular, outscaling was built upon our six focal villages, together with extension materials developed, and using linkages with all available agencies to get messages out. There was considerable success in engaging locally with NGOs, seed companies, local industries, and University colleges for outscaling, including the establishment of an Agrinetwork in Savannakhet.
3.7	Assess the effectiveness of pilot scaling out, including decision support, on-farm demonstrations and the additional opportunities potentially provided by linkage with the WB and ADB-IFAD projects.	Effectiveness of outscaling of research results determining through surveys of extension agents, farmers and NGOs	Y5, Q4	Scaling out using on-farm, village level trials and demonstrations was a focus, including farmer discussion groups and cross-site visits between relevant sites, and with other local agencies (NGOs, government departments, universities, colleges). A survey was conducted to assess farmer experiences with the on-farm research process, and a paper was published in the 2015 Australian Agronomy Conference.

**Objective 4: Alleviation of constraints posed by drought and uncontrolled flooding**

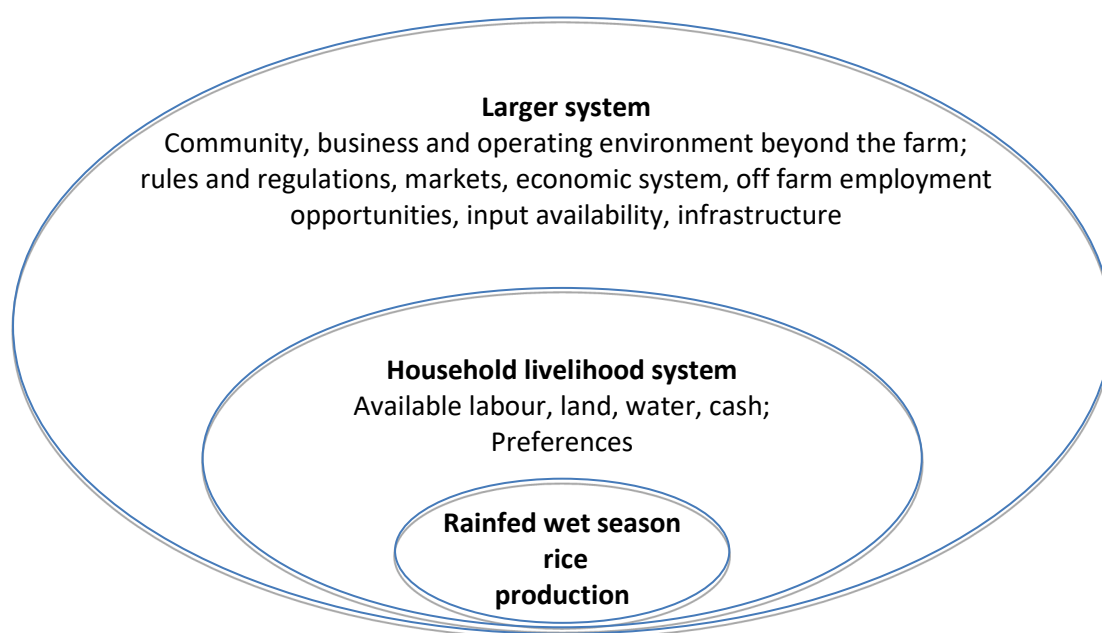
No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Assess seasonal water availability (rain, surface- and groundwater), and identify and map areas prone to drought, flooding, and salinity.	<p>Hydrological, hydrogeological and meteorological data compendium.</p> <p>Maps of drought, submergence and salinity for the target area.</p> <p>Seasonal water availability map.</p> <p>Knowledge transfer and capacity building.</p>	Y5, Q4	<p>The water component was late in establishment, although a feasible plan was established. The appointment of a new component leader, and four field visits in 2011, including a major joint visit to field sites in Champassak in November 2011 to develop a comprehensive workplan, confirmed the implementation protocols and devised a reporting strategy, which set this activity back on track. Engagement of a Postdoctoral Fellow in Nov 2012 ensured implementation in key sites.</p> <p>Major gaps in data were identified, and subsequently at MTR 2012, budget was allocated to install bores, monitoring equipment and met stations. This allowed the estimation of groundwater availability and behaviour for Soukhouma district, Champassak, for greater understanding of regional groundwater hydrology.</p> <p>Water availability protocols were put in place, with a greater emphasis on use of Thavone Inthavong's model focusing around key sites used by other components, to build understanding of water and hydrology in southern provinces of Savannakhet, and especially Champassak. This work exhibited close cross-component collaboration.</p> <p>Some mature water management technologies (AWD, aerobic, submergence tolerant rice) were passed to Knowledge Sharing for on-farm demonstrations.</p>

4.2	Conduct on-farm trials on the use of integrated water-saving and water-productive technologies with irrigation (e.g., direct seeding, alternate wetting and drying, delayed permanent water, aerobic rice, and supplementary irrigation) to secure the wet season rice crop, and improve the success of short-duration, post-rice forage/fodder crops to enhance the feasibility of increasing livestock production	Opportunities for the use of water-saving technologies identified and integrated management solutions for rice and post-rice crops (especially fodder crops for livestock keeping) available, using co-located experiments with Activity 2.2 where possible	Best-bet options available in Y1, fine-tuned management options ready in Y5, Q4	<p>On-farm experiments on rice, post-rice crops and forages in the dry season were conducted, utilizing a range of hydrologic options, including access to small pumps, channels, on-farm storage, and surface water, where available. In particular, data on plant available water were recorded in a number of experiments. Available data were assembled with the available knowledge for best-bet options, and were report for MTR 2012.</p> <p>Close linkage between crop and water components with joint use of sites provided benefit. Joint site visits by the entire hydrology/water team have improved linkage, and coordination with other components, for mutual benefits. Advanced technologies have been passed to Knowledge Sharing, e.g. AWD.</p>
4.3	Agonomic evaluation and dissemination of new submergence-tolerant rice varieties (including the Sub1 gene) together with the adjusted resource management recommendations as mitigation options in flood-prone areas	Submergence-tolerant rice varieties identified and disseminated	Identified varieties in Y1 and varieties disseminated in Y4	The project was instrumental in validating TDK1sub1 as an acceptable flood tolerant variety in flood-prone sites. The project also made a significant dissemination of the variety in 2012 (seeds distributed to 300 households). Farmers who received the seed kits were surveyed to determine performance of the variety and its further dissemination; performance was generally favourable, and 60% farmers had re-planted in the subsequent wet season.
4.4	Strengthen community water management schemes and enable adoption of water-saving technologies at system or community level.	<p>Report on existing group and community arrangements and policies affecting water use and management in case study villages.</p> <p>Socially and economically viable technologies identified.</p>	Y5, Q4	<p>Community arrangements were collected under the socio-economic studies in villages, and were accessed by the hydrology/water team in conjunction with socio-economic partners, in order to complete the case studies. Data analysis and reporting were completed for MTR 2012, with an 80 page report presented (Honours thesis).</p> <p>Surveys were undertaken to understand groundwater use and perceptions of future trends in groundwater use, including options for water savings. The results were published in the Journal of Water Resources Development.</p>

## 7 Key results and discussion

### 7.1 Introduction

This project '*Developing Improved Farming and Marketing Systems in Rainfed Regions of Southern Lao PDR*' was established as a large, multi-disciplinary project that worked across the farming system in crop agronomy, livestock production, water and hydrology, socio-economics and marketing and knowledge sharing. Given the array of research undertaken, there was a need to synthesise the range of activities covered by such a large project. There are different ways to do this, and during the main delivery phase of the project, integration of project activities was conducted at several levels, both technically (on-farm) and in project management approaches (Section 7.6); and later within a conceptual framework described here in reporting a comprehensive summary of project outputs (Section 7.6.2). This results and discussion section is structured in such a way that it follows a systems approach to synthesising project outputs. Figure 2 shows a series of nested systems, which includes rainfed wet season rice production as the basis, within the household livelihood system; both of these operate within a larger non-farm environment, including the village and local communities, market systems, geo-political and supporting structures and functions.



**Figure 2 Nested systems in rural development; building on core elements**

Individual activities are described within a framework that considers first the existing situation, including household livelihoods and the development of a practical typology approach, an economic analysis of lowland rice based farming systems, and the wider market chains that surround them. This analysis clearly defines the wet season rice crop as the central feature of the farming system in southern Laos, around which many of the key production decisions are made. The subsequent section describes project work to secure this wet season rice production, both in lowland and upland regions. Complementing this work are options to build diversity within the system, in terms of significant effort devoted to understanding local hydrology and water resources, and diversification of the system through forage production as a foundation for livestock production, and post-rice cropping options. In conjunction with the technical trials described, a series of capacity building approaches were embedded within the project.

### 7.1.1 Project evolution

The project was formulated between May and December 2009, in response to the request of the Lao Minister of Agriculture that ACIAR forms new projects in southern Laos, and under the newly-approved group of food security projects for Mekong and South Asia. The project was scoped in May 2009 and at a MAF/NAFRI workshop in August 2009, which included all project partners, to identify the key research themes. The project formally commenced on 1 December 2009. A detailed planning workshop was convened in NAFRI, Vientiane in August 2010, following project signoff in May 2010.

The overall aim of the project was to improve food security and rural livelihoods in the rainfed uplands and lowlands of southern provinces of Lao PDR. This aim was to be met through the following four objectives:

1. Diagnosis and integrated assessment of farming and marketing systems
2. Optimisation, testing and adaptation of crop and livestock technologies and marketing/extension approaches
3. Sharing of knowledge and pilot scaling out of varieties, crop and livestock technologies and marketing approaches
4. Alleviation of constraints posed by drought and uncontrolled flooding

Operationally, the project sought to meet these four objectives through activities in the following technical components: Agronomy, Livestock, Socio-Economics, Water Management and Knowledge Sharing. Note that for operational reasons, Objective 2 (research on agronomy and forages) was managed as two components, with project leadership responsible for overall management and integration of these components to meet project objectives.

Following project sign-off in May 2010, experimentation commenced in the 2010 wet season, with activities initially focussed around disciplinary components. Nevertheless, the project did feature a transect from lowland to upland, and from commodity to subsistence, including a number of poor districts. The design featured adaptive on-farm research in villages of Outomphone, Phalanxay, Xepon, Phin and Nong districts of Savannakhet province, and Phonthong, Soukhouma and Moulapoumouk districts of Champassak province. This provided a basis for socio-economic and marketing surveys, underpinning research, knowledge sharing and scaling out of technologies. It quickly became apparent that some changes were required to properly position the project for effective delivery.

Firstly, effective integration and delivery required a more proactive approach, and this is discussed further under both Knowledge Sharing (10.10) and Integration Frameworks (10.13). The efforts of the socio-economic team to identify a series of agro-economic typologies provided a framework for identification of eight focal villages as hubs for technology integration, capacity building, knowledge sharing and outscaling. For the Knowledge Sharing component, this required a shift away from the Rice-Check model to one drawing from all aspects of the project, with all components working together. This fundamental shift in philosophy has driven a greater focus on integration and delivery as the project has progressed.

Second, to achieve this integrative focus has required changes to project staff, training, and collaboration across components. Leadership was switched in Hydrology/Water to facilitate closer linkages with other components, and a time frame to technology delivery. In particular, there was a need to strengthen activities in the provinces, and this has been achieved by co-location of experienced national and international staff with their counterparts there. These include the Research Fellow in Knowledge Sharing in Savannakhet, and the Postdoctoral Fellow in Hydrology/Water in Champassak, supported



by a NAFRI Research Officer and an AVID volunteer in Knowledge Sharing in Champassak.

Third, these transitions represent a desire by contributing institutions to be willing to work across traditional boundaries of discipline, to co-operate with others, and to be willing to contribute beyond research to delivery as well. This process has demonstrated a demand for relevant training in support of this process, and this project has been instrumental in delivery of significant capacity building at all levels in the project, from technical and scientific, to collaborative and social, to managerial, budget and reporting (Section 7.5). Even apart from technology delivery, this is a lasting legacy of this project.

Finally, it must be emphasised that such benefits can only be derived from large integrated projects, and preferably with sufficient continuity through time. The larger project can invest in placing staff in the provinces, and in providing the training and support needed. But this does not happen overnight. The changes discussed have represented a continuing evolution, which should continue to provide cumulative benefits into the future.

As the project evolved, several no-cost extensions were made (Variance 4 (January – November 2014) and Variance 5 (December 2014 – October 2015)), which allowed the project team time to focus on synthesis and delivery of project outputs, finally realised in late 2015 (described in more detail in Section 7.6.2). This summary time allowed the project team to explore project outputs in the context of the farming system more deeply, looking for links within and between technologies, and framing these links in the context of the wider system, to consider which additional stakeholders might be engaged for change. This has formed a sound base from which to proceed with the subsequent, complementary project (CSE/2014/086) ‘Crop-livestock systems platform for capacity building, testing practices, commercialisation and community learning’.

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## **7.2 Farming household and market analysis: setting the scene**

### **7.2.1 Typology of Farm-Households and Livelihood Strategies**

Farming systems in southern Laos vary widely. The factors influencing this variation include the biophysical environment (slope, soils, water sources, and rainfall), ethnicity and culture, access to markets and extension, and government policies and priorities. At the broadest scale, southern Laos contains three distinct land types: irrigated lowlands, rainfed lowlands, and uplands. In general, the lowlands are found along the Mekong corridor, transitioning into the sloping uplands in the districts bordering Vietnam (in Savannakhet) or Thailand (in Champassak). However, single villages along this transect contain households in different agro-ecological zones. For example, a village with access to irrigation may also contain households that rely on rainfed lowland rice production or upland cropping systems. Moreover, a single household may have access to resources in more than one of these land types, engaging in both lowland and upland cropping activities and managing livestock within the mosaic of land uses.

In addition to this biophysical variation, a range of distinctive ethnic groups occupy the region, including members of the Tai-Kadai (Lao, Phutai) and the Mon-Khmer (Katang, Makong, Tri, Suay, and Taoy) ethno-linguistic families (Chazee 2002). The variations in farming systems mirror this socio-cultural spectrum – the Lao and Phutai commonly cultivate lowland rice while the Katang and related groups mainly practise upland farming.

Villages within the region also have varying access to roads and markets, from those located along major roads linking them to regional markets within the Greater Mekong Sub-region, to those located several hours from the district centre for which travel by vehicle is difficult during the wet season. At the same time, villages face varying degrees of external pressure, such as plantation concessions that reduce access to land formerly

used for livestock grazing or collection of forest products, and have different opportunities for off-farm and non-farm employment.

These farming systems are not only diverse but dynamic, with households continually adapting to constraints and opportunities arising from the rapid development occurring within Laos and the wider region. However, the ability of households to embrace these opportunities varies widely. Some households can readily adopt new practices while others may struggle to do so and may in fact experience a 'backwash effect' as others progress (e.g., when some households establish commercial crops on communal farming land, depriving other households of the use of that land).

One objective of the Project was to conduct an integrated assessment of the farming and marketing systems in the region with a view to diagnosing key constraints to improved rural livelihoods. To this end the project aimed to 'develop a practical typology of farm households and their crop and livestock productivities, livelihood strategies, and decision-making.'

## Methods

The development of the household typology was part of a five-phase process describing the socio-economic input to farming systems development within the Project. The first three phases relate directly to the development of a household typology, though that is not their only output. The fourth and fifth phases relate to the appraisal, monitoring, and evaluation of technical, organisational, and policy interventions. Full details of the methods are described in Working Paper 1 (available on request).

### • Typology

The reconnaissance led to the identification of six broad village types or agro-economic zones that form the basis of the household typology in Savannakhet. In Champasak, the project districts include the first three village types, but there is still a transition into upland forested areas that are important for livestock-raising and NTFP collection.

- Irrigated lowlands (IL)
- Rainfed lowlands with supplementary irrigation, or semi-irrigated lowlands (SIL)
- Rainfed lowlands (RL)
- Transitional (lowland and upland) (TRAN)
- Diversified uplands (DUP)
- Remote uplands (RUP)

The household survey was conducted in 10 villages in Savannakhet and 6 villages in Champasak Province that were originally visited as part of the reconnaissance survey. Analysis of the survey data reveal wide variations in access to resources, the portfolio of activities that households engaged in, resource utilisation in each activity, and the livelihood outcomes such as self-sufficiency and household income.

Within each zone households were first classified according to their access to assets (paddy land, water, labour, machinery). Household livelihood strategies were subsequently analysed, e.g., whether household resources (mainly labour and capital) were directed into non-farm activities, migration, or agriculture. Four broad types of household orientation were developed – **labour-oriented households, subsistence-oriented households, semi-commercial (market-oriented) households, and households with diversified livelihoods**. Table 2 presents some of the sub-categories of each household type. Two additional types that were difficult to classify were added. Lowland NTFP-dependent households were not self-sufficient in rice and used income from NTFP sales as the primary income source to make up the shortfall. In this way they are similar to labour-dependent households. The livestock keeper group was added to capture households that had a large number of large ruminants (over 10 head) but were

not managing them in a way that would allow them to be classified as livestock specialists (i.e. still free-grazing, low-input systems).

**Table 2 A typology of households and livelihood strategies**

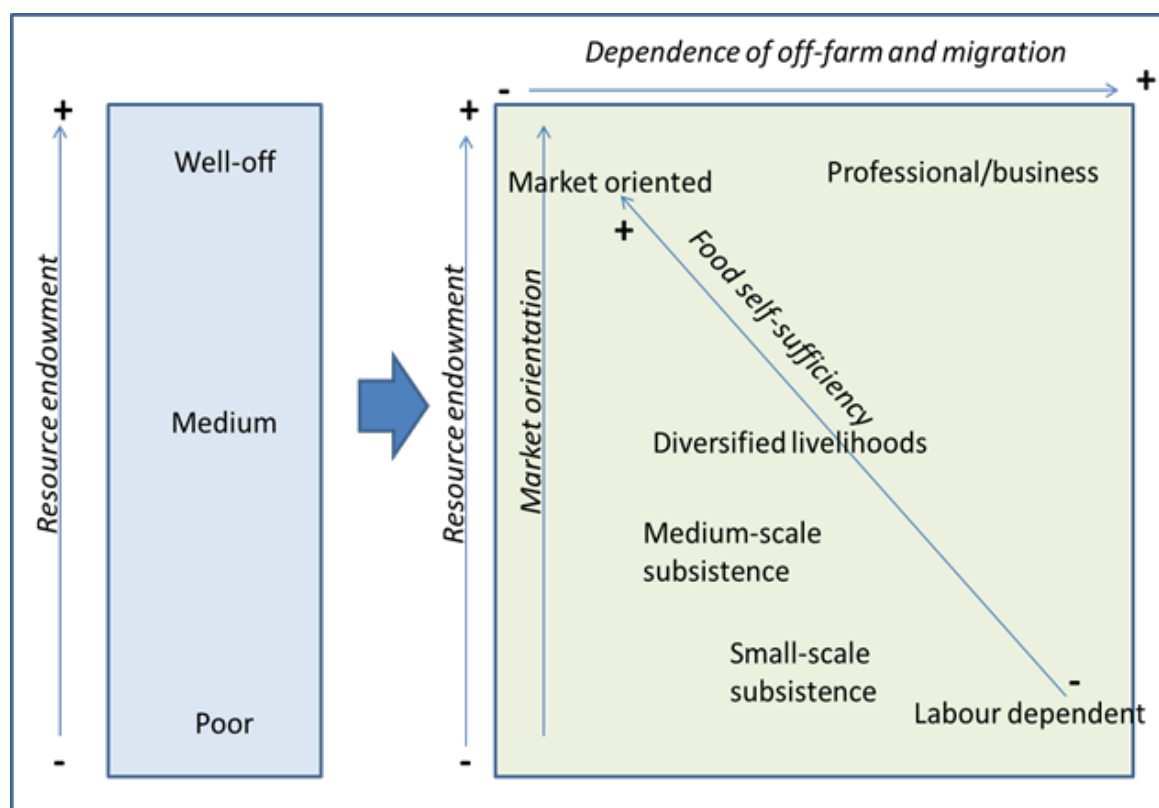
<b>Labour-oriented households</b>	<b>Subsistence-oriented farming households</b>	<b>Semi-commercial farming households</b>	<b>Diversified households</b>
Remittance-dependent households	Small scale lowland rice households	Rice specialists (sell at least 20% of production)	Diversified livelihoods (agricultural, non-farm, and migration activities)
Off-farm labour dependent households	Medium scale lowland rice households	Cropping specialists	
-----	Lowland diversified cropping households	Livestock specialists	
Salary earners, businessmen	Swidden households	Agroforestry households	
	Upland/lowland farming households		
	Lowland NTFP dependent		
	Livestock keepers		

The distribution of households between each household type is presented in a forthcoming Working Paper. However, this provides only a snapshot for 2010 with households moving between types each year. While the structural characteristics of the household (resource endowment) are important in determining the livelihood outcome of a household, the emergence of non-farm opportunities both in Laos and neighbouring countries has meant that households have become increasingly diversified, with livelihoods less determined by the original resource endowment. The typology above allows households to move between orientations over time. The case studies (Phase 4) were used to describe some of these transitions including migration strategies and the use of remittances (see Manivong, Cramb and Newby 2012).

The difference between structural typologies and a more functional typology is illustrated in Figure 3, which provides a classification of lowland households. Further analysis of the data will be published in a forthcoming working paper. This paper shows the probability of livelihood outcomes based on different household strategies and the constraints to adopting an alternative strategy, e.g., insufficient land, no access to water.

### • **Technical and Policy Options**

A summary of technical and policy options was developed based on the provisional typology and is presented in Table 4 of Working Paper 1. The household types are first grouped according to their dominant livelihood strategy: A. Subsistence-oriented, B. Market-oriented, C. Labour- or migration-oriented, D. Diversified households (combining two or more strategies). These orientations overlap with the six agro-economic zones or village types. The types are further differentiated by the asset base of the household, as with small-scale and medium-scale rainfed lowland farmers. Table 4 briefly characterises the types and suggests intervention options for crops, livestock, water, and institutions as a basis for discussion within the project team.



**Figure 3 From a structural to functional typology of lowland households**

### Conclusion

Six key agro-economic zones were established across the two transects largely based around access to water and village accessibility. These factors are out of the control of individual farmers. (2) The survey revealed the variation in access to resources within these agro-economic zones. This includes constraints such as land area, access to water, labour availability, access to physical capital and financial capital. (3) Many households have diversified their livelihoods with increases in opportunities for non-farm and migration activities. This provides some buffer to households with limited resources. For others wages and remittances contribute to working capital for livelihood investments. (4) Households change livelihood strategies throughout time. Livelihood development is possible through a range of development strategies including – intensification, agricultural diversification, and livelihood diversification. In some years households may need to increase off-farm activities to make up shortfalls due to production shocks. For some households income from remittances can be used to increase capital (land, a tractor, a pump). In other cases it is likely that households will remain labour-dependent or exit agriculture over time.

### 7.2.2 Economic Analysis of Lowland Rice Production

This analysis was based on data collected in several phases of field work over 2011-12 in the irrigated and rainfed lowland agro-ecological zones, including key informant interviews with district agricultural staff, village group discussions, household surveys, and household case studies. The analysis was based on data from six villages in Outomphone, Phalanxai, and Phin Districts in Savannakhet and six villages in Phonthong and Sukhuma Districts in Champasak. The household survey was carried out with 30 randomly selected households in each village, making 360 households in all. Case studies were conducted with 13 households in Savannakhet and 18 households in Champasak. Survey and case study data were supplemented with project and historical agronomic trial

results in order to construct model budgets for various input scenarios. Sensitivity analysis, threshold analysis, and risk analysis were conducted for each scenario.

In total, 96% of households grew paddy rice in the 2010 wet season (WS 2010). The mean area cultivated was 2.1 ha and the mean yield was 1.7 t/ha, below official figures and well below the policy target of 4 t/ha. Only 40% of surveyed households who were growing paddy rice sold any, with the rest either producing rice exclusively for home consumption or buying rice to cover a deficit. Some households sold rice after harvest to pay off debt and re-entered the market later in the year to make up shortfalls. In general, the data suggest that the majority of households remain largely subsistence-oriented and are willing to trade-off yields with paddy area to meet household requirements, limiting the incentive for intensification.

The traditional production system that relied on draught animal power for land preparation, traditional varieties, and organic fertiliser has almost completely disappeared. Only 11 of the 347 households that were growing paddy rice had not adopted any of the three main technologies – mechanised land preparation, improved varieties, or inorganic fertiliser.

**(a) Mechanisation.** Off-farm migration is affecting the availability of household labour and the cost of hiring labour. Wage rates varied from 25,000 to 50,000 kip/day depending on location, season, and activity. However, even in remote Phin District, the wage rate for transplanting had reached 50,000 kip/day (AUD 6.25). Hence mechanisation of rice production is occurring, with 75% of survey households using two-wheel tractors for land preparation rather than draught animal power. While the technology is not divisible like seed or fertiliser, the extent of adoption is not surprising given the versatility of the tractors and the extent of labour saved in both production and non-production activities. Other forms of mechanisation were less common, with the first transplanters, drill seeders, and harvesters only beginning to be utilised in the past few years and only in small areas. Currently, in order to minimise cash outlays, households tend to extend the period of transplanting and utilise the declining household labour resource rather than hire labour or transplanters (with obvious tradeoffs in terms of yield).

**(b) Varieties.** The majority of households now grow at least one improved variety, with the area of traditional cultivars contracting. The adoption of improved varieties has occurred at similar rates among different farm size classes. While the survey data suggest that adoption has been more widespread in Champasak than in Savannakhet, it is suspected that many respondents were calling the early released varieties, such as TDK1, by local names and now considered them to be “traditional” varieties.

**(c) Fertiliser.** The use of both organic and inorganic fertilisers has been promoted in Laos for many years. Recommendations were formulated that required relatively low investment and used nutrients with maximum efficiency, based on the three fertilisers that are more widely and readily available. The use of small amounts inorganic fertiliser had expanded to around 80% of surveyed households, but only around 18% of households were applying fertiliser to seedlings plus a basal application to the main field plus a top-dressing. The level of use remains well below recommended rates, reflecting the high cost of purchasing inputs, the limited access to credit, the high level of production risk, and market uncertainty should a surplus be produced. The overall average rate was 15-5-1.5 kg/ha of NPK – well below the conservative recommendation of 60-[8/26]-25 kg/ha NPK (with the P rate varying according to soil texture). Households with larger areas applied lower rates because they required less fertiliser to meet self-sufficiency and lacked the economic incentive to lift production further.

To help understand the adoption patterns of fertiliser, four scenarios were developed based on household survey data and field experimental results. These representative budgets were first developed using average values for prices and yields, then sensitivity and risk analyses were applied. The key indicators used to capture farmers’ decision criteria with regard to input use were the net returns to household resources (NRHR), with

no costing of household labour or land, and the net returns to household resources per day of household labour (NRHL).

**Scenario 1 (No-Input)** – Yield estimates were based largely on experimental results in which no inorganic fertiliser is added to the transplant crop. This represents around 30% per cent of survey households. Both survey and experimental results show wide variation in the yields obtained, but an average yield of 1.5 t/ha was assumed.

**Scenario 2 (Low-Input)** – This is based on the current low-input system practised by many households. It assumes that households use organic fertiliser to establish seedlings and then apply 1 bag (50 kg) of 16-20-0 as a basal application, followed by a top-dressing of 1 bag of urea. An average paddy yield of 2 t/ha was estimated.

**Scenario 3 (Medium-Input)** – This was developed using the current broad recommendation of 60-13-25 kg/ha of NPK, applied through a basal application of 15-15-15 (200 kg/ha) with the remaining N coming via top-dressing with urea. The yield assumption was based on adjusted experimental results (allowing for the well-known yield loss when moving from small to large plots), giving an average yield of 3t/ha.

**Scenario 4 (High-Input)** – This is based on project experimental work in the two provinces where a high rate is used in an attempt to achieve the Government target yield of 4 t/ha. The current trials have site-specific application rates with no replications and therefore it has been necessary to develop an average treatment with a rate of NPK of 120-60-60 kg/ha, resulting in an estimated yield of 3.5 t/ha, based on results for the 2011 wet season.

The results of the enterprise budgeting and sensitivity analysis suggested that households may be willing to adopt the Medium-Input scenario, provided they are satisfied with a return on additional working capital of between 50 and 100%. It is very unlikely that a household would adopt the High-Input scenario, given that returns to both land and labour decline compared to the Medium-Input case. However, this analysis is based on averages that ignore both production and market risk. Risk analysis was conducted to assess the stability of the results to fluctuating paddy prices and uncertain yields.

Across the scenarios, the probability that NRHR was positive was between 90 and 100 per cent, with yields high enough to at least pay for cash costs (fertiliser, fuel, and seed). However, the probability that the NRHL was above 30,000 kip/day ranged between 51 and 59%. That is, growing rice in all scenarios was only better than wage-earning in around 60% of iterations. If a higher wage rate (50,000 kip/day) is considered, this falls to less than 20%. In only 54% of iterations was there a positive marginal benefit in moving from the No-Input to the Low-Input scenario. Similarly, it was beneficial to move further to the Medium-Input scenario less than half the time. This suggests that, if households can achieve self-sufficiency, they may be willing to accept lower average returns to avoid the risk of losing out on investing in higher input levels.

Superimposing the cumulative distributions of the returns to household labour for each scenario shows that the Low- and Medium-Input scenarios display first-degree stochastic dominance over the High-Input scenario, while the No-Input scenario displays second-order stochastic dominance (that is, assuming risk aversion) over the High-Input scenario. In other words, the High-Input scenario does not stand up in the risky environment of the rainfed lowlands.

In conclusion, the survey evidence shows that households in the rainfed lowlands continue to manage rice production systems that are largely subsistence-oriented. The adoption of new technologies has been important in helping households meet self-sufficiency objectives and has enabled some to produce a small surplus. Despite this, rice production remains an economically marginal activity that is under increasing pressure from rising costs, particularly for labour. Rural livelihoods in the study area have become increasingly diversified, with households allocating labour to a range of alternative farm and non-farm activities. However, paddy rice production continues to be the platform on



which these other livelihood activities are based. The development and adoption of technologies that enable households to achieve self-sufficiency in a labour-efficient manner are important to improving household welfare in this context.

The budget models show that, given their resource endowments and the high degree of production and market risk they encounter, households in the rainfed lowlands have been rational in adopting a low-input system rather than intensifying rice production to achieve government yield and production targets. As the costs of labour continue to increase, technologies that improve labour productivity and enable labour to move off-farm are likely to be adopted more readily than technologies that seek to intensify production. In the same way, the development and adoption of improved varieties that are well adapted to abiotic and biotic stresses and reduce risk in specific environments can potentially improve the profitability and stability of the lowland farming system. Moreover, it has long been argued that improving the efficiency of fertiliser application is more important than increasing absolute fertiliser rates. While the improvements in profitability that these technologies bring may induce some intensification, the strategy of diversifying livelihoods while maintaining a largely subsistence-oriented rice production system is likely to persist. While this may not help lift rice production to reach national targets, it is likely to improve the livelihood outcomes of the numerous households living in this marginal environment.

### **7.2.3 Analysis of Marketing Chains**

The study of marketing chains in Savannakhet Province, with special focus on rice, large ruminants and pigs, was realized in September 2011. The objective of the study was to collect a basic data throughout the marketing chain in order to identify main actors in the chain and understand their function, interaction and requirement. The data was collected using a participatory approach consisting of semi-structured interviews. The information gathered from the first interview was then used to identify secondary respondents who were linked to the other actors in the marketing chain. In total, 136 people have been interviewed. The survey team consisted of 8 people from two institutions. The first institution was the Faculty of Agriculture of National University of Laos (NUOL). The second institution was the National Agriculture and Forestry Research Institute (NAFRI). The study was conducted in five districts of Savannakhet Province (Outoumphone, Phalanxay, Phin, Xepon and Nong). The main findings from the study were summarized below.

### **Overview of Trade Situation in the Study Area**

All individuals involved in trade in the study area should be licensed. Whenever the products are moved between districts or provinces a movement permit was required. This permit was obtained from the district or provincial trade office (DICO/PICO). Farmers in studied area sold their agricultural products through four markets: (i) local market in the district level, (ii) inter-district market, (iii) inter-province market, and (iv) cross-border trade market. Among these channels, the trade between districts was the more important.

In term of agricultural production, rice, cattle, buffaloes and pigs were main commercial products in studied area. Approximately 15% of total rice production in Savannakhet Province is commercialised. Most rice is mainly sold to the domestic market at provincial level. A few quantities were exported to Vietnam. For the livestock trade, approximately 5% of total large ruminants and 20% of total pig production were sold in 2010. Cattle, buffaloes and pigs produced in study area were mainly consumed in the province, especially in the district level. The study products (rice, large ruminants and pigs) play an important role in the economic activities for farmers in the study area. Rice is perceived by farmers as their major income of household. Besides, the livestock was considering as a



family cash-flow for pigs and a family saving for the large ruminants. A big size of herd indicated a large asset that farmers can use when they need.

### ***Rice Marketing Chain***

The major actors involved in the rice marketing chain in study districts (Outhoumphone, Phalanxay, and Phin) were producer, collector, rice miller and rice retailer. For the whole picture of rice marketing chain, there were no formal horizontal and vertical linkages between the actors in the chain. Farmers sold their production separately through their own connections. The rice mill owners purchase the rice individually without the collective marketing even if they formed the group. Some information on inputs (seed, fertilizer and pesticide) and price flows from traders to farmers, but only on an ad-hoc basis as the flows of information are based on personal relationships rather than the real market information.

Paddy rice leaving farms went through two channels: (i) Farmers sold their paddy rice to local collectors who sold them wholesale to local rice millers. This channel represented 36% of paddy rice sold from the studied area, and (ii) Farmers sold their paddy directly to local rice mills who sold the rice wholesale to large rice mills outside districts. The polished rice is sold to retailers and consumers. This was the most important channel of rice marketing chain which accounted for 76%. In 2010, the quantities of rice transaction from the study area were approximately 4,145 metric tons.

The farm gate price of rice had a seasonal fluctuation since 2009. The price was hike during the harvest season of 2010 and was fall down in the harvest season of 2011. The price of rice peaked in 2010 at 7,000 to 9,000 kip per kg for polished rice, depending on grade, while paddy rice rose to about 4,000 kip a kg. In 2011, the selling price of polished rice was at 5,500 to 6,000 kip per kg. The hike price was due to the export to neighbouring countries, the purchase of rice for southern flood victims and rice hoarding in preparation for upcoming wet season rice production. The fall in rice price was due to the government ban placed on rice exports after local people were affected by flood. The ban aimed to assure the domestic demand.

The study area had an advantageous geographical position for the expansion of rice exportation to Vietnam as it is located on road linked the study area to Vietnamese market. Approximately 1,000 metric tons of rice in study area is exported to Vietnam in 2010. Rice mills should strengthen the current horizontal integration, such as organising a common marketing action in order to deal with the international market. Farmers in study area should have a collective action in order to facilitate the purchase of rice by traders, whilst giving them “a bargaining power”. The link between farmers and traders can be leveraged to increase the flow of information if the information transfer between farmers and traders is better organized and linked, farmers can orient their production to the market demand rather than produce for home-consumption as rice still plays an important role in the economic activities of household because the incomes from rice production are an important contribution of household incomes.

### ***Large Ruminant and Pig Marketing Chains***

The large ruminant marketing chain was similar than the pig marketing chain. The animals were usually sold to local butcher and/or broker in the district level, while carcasses and other meat products are sold to consumers. In the urban area, the urban butchers play an important role in fresh meat supply. The actors involved in the marketing chain were producer (smallholder/farm), broker, local/urban butcher, slaughterhouse, and meat retailer. Similar than rice marketing chain, the formal horizontal integration did not exist in the production level. Producers sold their animals separately to their trust buyers and their own connections. However, the horizontal integration between the meat retailers was

quite well structured and functioned as a collectively marketing was in place with the systems of rotation to assure the market demand.

Farmers sold the animals to two principal buyers: (i) local butcher who either slaughter for fresh meat sales in local markets in their own district or resell them to Vietnamese traders for the exportation. This was the most important channel which accounted for 70 to 80 % of animals sold, and (ii) broker who buy the animals for resale either immediately or after some minor fattening operations (case of pigs) to butcher in town. This channel represented only 20 to 30%. In 2010, approximately 3,450 head of large ruminants and 4,125 pigs were commercialised. These quantities represented only 3% of large ruminants and 11% of pigs' production in the studied area.

The livestock was regarded by farmers as a form cash-flow and a form of saving or capital accumulation for their family rather than the commercial product. They raise the animals without taking in consideration the market demand. The traditional production technology with poor feed and high mortality were difficult for farmers to streamline with the market demand. However, the opportunity to increase the income of livestock producers exists as the study area had an advantage of geographical position for the expansion of exports to inter-province and Vietnam. However, the main constraint of livestock marketing chain is related to supply sources as different actors affirm that it is increasing the difficulty to source the local variety animals. In addition, the vertical integration between producers and traders should be improved by establish the core of supply zone to facilitate the collect of animals and better adjust to the market demand, whilst built the trust relationship between producers and farmers. Farmers should have a collective action in order to obtain a regularity of supply in quantity and quality and have a bargaining power when they sell their animals.

### **Banana and Yangbong Cropping Systems and Marketing Chains**

Household survey data in 2010 had shown more than 56% of producers in the upland agro-ecosystem in Savannakhet planted bananas and 26% planted yangbong as cash crops. For those who harvested these crops, they contributed around 75% of their cash income. Farmers grow banana and yangbong in the former upland rice plots and the fallow land. Products are mainly exported to Vietnam. However, there were very few studies on these two emerging products and markets on how farmers produce them, what are their potential and constraint of production, and how the market functions in order to improve the production and market of these two products.

The study of cropping systems and marketing chain of banana and yangbong in Sepon and Nong Districts of Savannakhet Province was realized in December 2012. The objective of the study was to understand the crops production and collect a basic data thought out the marketing chain in order to identify main actors in the chain and understand their function, interaction and requirement. The data was collected using a concept of cropping systems and participatory approach consisting of semi-structured interviews. The information gathered from the first interview was then used to identify secondary respondents who were linked to the other actors in the marketing chain. In total, 209 people have been interviewed by researchers, lecturers, students from the Faculty of Agriculture of National University of Laos (NUOL) and the National Agriculture and Forestry Research Institute (NAFRI). The study was conducted in 5 villages in Sepon and Nong Districts.

The surface area of banana plantation per household ranged from 0.16 to 5 hectares. The average land area on banana per household is 2 hectares. Around 2-3 varieties found in the surveyed area but only one variety that export to Vietnam which called "*Kouynam*" or water banana, *Kouynam* variety was brought from Vietnam since 2001 by local Lao people and expanded very fast to the villages located close to Vietnam border. There were 3 banana cropping system: banana cropping systems without association with other crop, banana cropping system associated with rice and banana cropping system

associated with Yang bong. In average farmers could get around 12,000-16,000 kg of banana per hectare. Some farmers sold their plantation before harvest to Lao or Vietnamese traders while the major farmers sold after harvest. The price of banana in 2012 varied from 500-1200 Kips/kilogram. The cropping system associated with Yang bong brought the highest income to farmers 12,776,500 Kips/hectare and 147,800 Kip/man day. Farmers sold their banana mainly to Vietnamese collectors (50-55%), Vietnamese farmers (30-35%), Lao Export Company in Xepon (8-10%), Lao collectors for domestic market (3-4%) and Lao retailers in Xepon (1%). The major problems of banana production and marketing are the price fluctuation, disease, not enough labor and capital to investment.

The average land area of Yangbong (*Persea kurzii*) cultivated in the studied area was 2.4 hectares. Yangbong seedlings were brought from Vietnam by Vietnamese traders through Lao-Bao border and some of yangbong seedlings were distributed by DAFO. Today farmers can produce the seeds and seedlings by themselves and sell locally. There are two varieties of yangbong cultivated in the area – red and white. There are 3 cropping systems of yangbong: (i) yangbong cropping system without association with other crops; (ii) yangbong cropping system associated with rice; and (iii) yangbong cropping system associated with banana. The last cropping system produced the highest income per surface area to farmers as stated above. The major problems of yangbong production are related to the problem of insects, not enough capital for production, and not enough land and labour. About 30% of farmers sold their yangbong plantation one year before harvest, and the price was about 40% lower than the price at the harvest. About 90% harvested, transported, debarked and dried yangbong before selling to traders. There were 2 types of traders: Lao traders and Vietnamese collectors. The price of dry yangbong varied from 5000-7200 kips/kg while the price of wet yangbong is 5000-12,000 kips/tree. One tree of yangbong could give 4 kilograms of wet bark equivalent of 2 kilograms of dry product. About 40% of Farmers in Sepon sold dry Yang bong to Vietnamese collectors, 30% sold to Lao traders at Sepon, 30% sold to Vietnamese and Lao traders before harvest. Farmers in Nong sold their product 100% to Vietnamese collectors because the district is less accessible.

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### 7.3 Securing the wet season rice crop: Crops and soil improvement

More than 83 percent of the people of Laos live in rural areas, engaged in rice production. Of these, 88 percent labour in rainfed upland and lowland environments which are difficult systems in which to culture and produce rice. Rainfed areas frequently suffer from significant incidences of both drought and floods. Drought is a regular occurrence especially on upper terrace fields and the uplands. Loam, sandy loam and sandy soils which predominate in the rainfed lowlands of Laos intensify drought by their low moisture holding capacity. Soil improvement by addition of clay may increase water and nutrient holding capacity of soils. Both early and late wet season droughts occur and can severely affect rice production. Floods ravage significant areas on the banks of the Mekong River. Short-term flooding of low-lying fields and areas adjacent to streams and tributaries to the Mekong River submerge rice fields for varying periods which often extends beyond one week, resulting in total crop loss. Low soil fertility also limits rice grain yields. Fertilizer application may raise grain yields, but risk-averse farmers apply little or no fertilizer for their rice crop because drought or flooding may wipe out the crop. Volatile rice prices, unfavourable input/output price ratios, and weak market access also discourage farmers from spending on fertilizers and other agricultural inputs.

Significant improvement in rice production is possible with the deployment of high yielding rice varieties adapted to local conditions and the use of appropriate crop and field management practices. This includes the judicious use (quantity, number of splits and

timing of application) of inorganic fertilizers, organic matter, and soil amendments to create favourable conditions for crop growth and development. Water collected and stored in small on-farm reservoirs and water pumped from rivers and/or from the ground makes it possible for farmers to apply supplemental irrigation during drought events and engage in post-rice dry season vegetable, pulse, or forage crop production for livestock.

### **7.3.1 Evaluation of GxE interactions of Lao rice varieties in multiple environments**

The project addressed the question of whether the appropriate varieties were being grown in the right environment through on-farm and on-station trials to understand rice genotype by environment interactions and assess the suitability of existing popularly grown rice varieties to different rice growing environments in southern Laos, and to define rice production environments by the rice crop characteristics that “fit” into rainfed lowland and upland rice production ecosystems.

Thirteen modern improved Lao rice varieties were grown, side-by-side, in on-farm trials in Savannakhet and Champasak during the 2011 and 2012 wet seasons. Rice grain yield was higher in 2012 than in 2011, but there were consistent trends in both years. Lao varieties differed significantly in their performance across all sites. Grain yield of TDK1 and TDK11 was stable across the two years of the trials. In contrast, TDK8, TSN8, PNG1 and VT450-2 showed plastic yield response, varying between the two growing seasons. Productivity of rice in Savannakhet province was stable between the years of the trials, however, grain yield in Champasack sites varied. Soukhouma District produced the highest rice grain yield among the districts in 2012, and significantly contributed to the higher Champasack mean rice yield. The data from these trials would make it possible to evaluate the best performing varieties for specific sites and to define application domains for each variety in the trials.

### **7.3.2 Validation and dissemination of more productive upland rice varieties**

In common with the lowland rice environments, multi-environment trials using three traditional cultivars (Nok, Non, Laboun, Makhinsoung) from northern Laos and an aerobic rice line (B6144F-MR-6) were conducted on farmer’s fields in Xepon and Nong Districts in Savannakhet. These entries perform well in sloping upland rice fields of northern Laos. During the first year of the trials, these entries produced more than twice the grain yield of local check cultivars. Grain yields in 2012 were about half those in 2011. This is the reverse of the trend observed in rainfed lowlands where 2012 production levels were much higher than in 2011. However, the entries in the trials consistently produced higher rice grain yield than local check variety in both years. The decline in grain yield from the first to the second year of cultivation is consistent with observations and reports from upland rice fields in northern Laos.

### **7.3.3 Mechanised crop establishment – dry direct seeding**

Economic growth is increasing wage rates in Lao PDR as people find opportunities outside of agriculture in particular. To remain viable, rice production techniques must find a way to produce similar yields, but with much less labour input. Analysis suggests that a labour saving of 30 days per hectare must be achieved, whilst maintaining similar yields, in order to justify a labour value of 50,000 kip/day with current rice prices and other input costs.

Dry direct seeding can save the required 30 days per hectare of labour. However, given basic varietal suitability, the ability to maintain yields with this technique revolves around

weed control. There are many methods of achieving weed control. Water management, mulch, selective herbicides and/or thorough seedbed preparation before seeding, which may use a stale seedbed, can reduce yield losses from weeds. Other opportunities include improved crop competitiveness through manipulation of seeding rate, germplasm selection, fertilizer placement or water management.

Water management offers one option for weed control; direct seeding offers the ability to dry the soil surface more than when rice seed is broadcast on the soil surface, as the seed is placed in the soil where soil moisture is greater. Dry-season experiments at Pakse, Champassak and in Champhone district, Savannakhet withheld irrigation for up to 20 days after seeding with no effect on the rice growth. Using direct seeding offers an opportunity to seed early in the wet season, when rainfall events are generally smaller, and the soil dries in between rainfall events.

Fertiliser management can be manipulated with direct seeding to improve weed competitiveness and yield. In a 2012/13 dry season experiment at Ban Wattana, Champhone District, Savannakhet Province, placing 120 kg/ha of 15-15-15 with the seed had no effect on plant height at 20 days after seeding, but increased plant height by 13 cm at 85 days after seeding, compared to broadcasting the basal fertilizer at 47 days after seeding. Waterlogging after drill-seeding can cause much of the fertilizer nitrogen to be lost through denitrification into nitrous oxide and nitrogen gas, so it is only worthwhile placing nitrogen with the seed with if fields are not water-logged after seeding.

Non-waterlogged conditions at crop establishment make P availability very low. Three experiments over two seasons (dry and wet seasons 2014) used a direct seeder to place compound fertilizer with the seed to assess the effect on weed competitiveness and grain yield. In the dry season, drilling 70% of basal NPK with the seed increased ground cover at 45 days after seeding (DAS) by 73-155%, and increased grain yield by 38-73% (1.18-1.84 t/ha) compared with broadcasting basal NPK. Drilling 93% of basal P, but none of the basal K, added an additional 1.4 t/ha of grain yield. Reducing basal N, P and K rate by 30% and drilling all of it still almost doubled ground cover and increased grain yield by 38%, compared with broadcasting basal NPK. In the following wet season, drilling 70% of basal NPK more than doubled ground cover at 35 DAS. Adding basal fertilizer with the rice seed greatly increased weed competitiveness and grain yield, and also allowed less basal fertilizer to be used whilst maintaining a higher yield than broadcasting basal fertilizer.

Direct seeding offers an opportunity for significant labour savings, and this method can capture benefits in terms of returns to labour if yields can be maintained or increased relative to other establishment methods. However, weed management is essential if labour savings are to be realised. The management approaches trialled here offer some options to capture the labour savings from drill-seeding to reduce weed impacts, increase yields and reduce fertilizer costs. Given the ability of weeds to adapt to any single weed control technique, long-term weed management will only be achieved by using a variety of methods, both in the one season and between seasons. This implies that rice establishment methods must vary over time.

#### **7.3.4 Validation and dissemination of flood-tolerant TDK1sub1**

Validating the effectiveness of TDK1sub1, an improved Lao glutinous rice variety in which the *sub1* gene had been introduced was carried out to address low productivity and crop loss in low lying, flood-prone areas. The *sub1* gene enables rice to resume growth and development after about 14 days of submergence. TDK1sub1 was grown in flood-prone sites in Savannakhet and Champasak provinces during the 2011 wet season. Flooding occurred in all sites, but flood duration, turbidity and flow characteristics differed among sites. These variations in the nature of flooding had different consequences on the observed grain yield of TDK1sub1, even as other varieties were wiped out. The data



indicates strong genotype by environment interactions between TDK1sub1 and its growing environment.

The project disseminated seed kits (5 kg of TDK1sub1 and recommendations (in Phaasa Lao) on how to grow the variety, including tips on promoting growth recovery and grain yield after inundation) to 400 farmers in Savannakhet, Salavanh and Champassak provinces during the 2012 wet season. A follow-up survey to poll farmers' experiences with the variety and track farmer-to-farmer seed dissemination was conducted in the 2013 wet season. Of the farmers surveyed, 60% had planted TDK1sub1 in two consecutive years; these farmers had almost twice the incidence of flooding (in the previous 5 years) compared to farmers who did not plant again. From 100 farmers surveyed, seed had been shared with a further 70 households, mostly by farmers who were planting seed again in 2013 (93%). TDK1sub1 appears to be relatively well accepted by farmers who have a high risk of flooding, making it a suitable option for improving wet season rice production in selected areas.

### **7.3.5 Evaluation of aerobic rice varieties for drought prone areas**

Improvement of productivity in the upper toposequence positions of rainfed lowlands, prone to drought and, therefore, alternating anaerobic and aerobic soil states was addressed with on-farm testing of aerobic rice varieties. Three entries (B6144-MR-6, IR 55423, TDK11), which can be grown in both upland and lowland conditions, were grown on farmer's fields in Phine, Xepon, Outhomphone and Soukhouma Districts. The grain yields of the entries were not significantly different from those of the local check. However, grain yields of entries across replicates were statistically significant, indicating the widely diverse nature of these environments. More aerobic rice entries will be tested to find suitable rice germplasm material for these environments.

### **7.3.6 Evaluation of performance and longevity of “perennial” rice lines**

Rice with the “perennial” trait is meant to be sown on the ground once and left on the field to grow and develop over several seasons. This trait is thought to be an enhanced version of the (ratooning) ability of rice to grow new tillers after it has been cut during harvest or physically damaged. During its cycles of growth, grain and or aboveground biomass may be harvested. These rice varieties are targeted towards sloping uplands where they may provide crop cover to the soil for erosion control, produce grain (at least in the first year) and forage for livestock with the added convenience of less labor needed for crop establishment.

Thirteen promising lines from a cross of wild rice (*Oryza longistaminata*) and an established rice variety (RD23) were in replicated trials in Xepon and Pakxe, Savannakhet and Champasack Provinces, respectively, during the 2011 wet season. Grain yield differences among the entries in 2011 were statistically significant. Line 2011HN\_FS\_213 and RD23 performed best among the entries in both years. The Xepon site had significantly higher mean grain yield than the Phonengam site. Grain yield s were much lower in 2012 than in 2011 among all entries.

### **7.3.7 Manipulation of Risk through Nutrient-Water-Variety Interactions**

With soils of low fertility, low water-holding capacity and variable rainfall, Lao farmers are reluctant to apply fertiliser due to unreliable crop yield responses. This study sought to explore opportunities to use combinations of nutrient application (at rates likely to be economically viable), supplementary water application and choice of rice varieties to vary risk of crop loss. Two nutrient treatments (60-30-30 NPK, Nil), two water treatments

(supplementary, Nil) and three varieties were tested on-farm, using a randomised blocks design with three replicates in five villages each in Savannakhet and Champassak provinces in 2009 and 2010. Overall, locations accounted for 62% and nutrient/water treatments and their interactions accounted for 38% of the variation in grain yield. Rice responded to supplementary water only when nutrients were adequate. At the Savannakhet sites only, there was greater response to NPK and water with variety TDK1 when soil fertility was low. The results indicate that farmers have a choice of management options to increase rice productivity and farmer livelihood. Further details of the economic strategy are discussed in Summary 10.3.

### **7.3.8 Modelling and field testing of “site specific nutrient management”-like system**

Site-specific nutrient management aims to apply the correct amount of nutrients in the soil to achieve uniform crop stands and achieve targeted crop yields. The study aimed to estimate the amount of fertilizer (N-P-K), based on soil properties in each of the study sites, needed to achieve a target rice grain yield of 5 t/ha. The study employed a model that used soil properties to predict the rate of fertilizer needed to achieve 5 t/ha of grain yield in a range of sites, and field tested these rates to validate the model recommendations. Five fertilizer rates and 4 rice varieties were evaluated in 18 farmer's fields. The recommended fertilizer rate for rice (60-30-30) gave the best economic returns among the treatments. Model-recommended rates achieved the target yield target in some sites, but were uneconomical. Rice varieties TSN8 and 9 gave the best grain yield in almost all sites. TDK 8 and 11 achieved 4-5 t/ha in some sites in Champasack province.

### **7.3.9 Evaluation of bentonite clay for soil improvement**

Soils in the rainfed lowlands of Laos are chronically poor because they have low clay contents and contain mainly low quality clays. Soil improvement with organic matter is possible but not durable. The project tested the effect and economics of soil improvement with bentonite clay amendments in on-station trials at two typical rice growing sites, Thasano and Pakxe, in Savannakhet and Champasack provinces, respectively. Soil physical properties were slightly better at Pakxe (finer soil texture, higher total pore volume and plant available pore volume) than in Thasano. In contrast, soil chemistry seemed better at Thasano (higher pH, SOC, TSN, available/exchangeable nutrients (except Mg), and CEC) than at Pakxe.

Grain yield was consistently higher in plots treated with 1 and 2 t/ha of bentonite in the three-year experiment in Thasano. In contrast, bentonite application, at any rate, had little or no effect on rice grain yield in Pakxe, Champasack. These results, in light of the physical and chemical properties of soils at both sites, may indicate that the positive effect of bentonite on grain yield at Thasano was due to improved soil water holding capacity rather than enhanced nutrient supply or holding capacity.

### **7.3.10 Plant protection**

The project began work on crop protection in 2012, focusing rice gall midge (RGM), a serious pest of lowland rice, which was particularly severe in one of the project's target villages. The crop protection work had four major lines of investigation, in part conducted under a separate small research activity funded by the Lao Agricultural Research Fund (varietal resistance and ecological engineering):



**Assessment** - Determining relationship between visual manifestations of RGM infestation (presence of onion stem) and rice grain yield at harvest is important for the early evaluation of options that farmers may employ.

**Varietal resistance/plasticity** - This line of investigation centred on the screening of cultivars and lines for resistance to gall midge, and testing of agronomic practices to stimulate recovery from RGM damage (e.g. fertilizer application).

The primary objective of this study was to evaluate the relative susceptibility to RGM of a selection of improved varieties, breeding lines, and local varieties, when grown in areas with known high levels of RGM infection in Savannakhet province. The study was carried out during the 2013 wet-season (May to October) in the districts of Atsaphone and Phalanxay. The experiment involved the assessment of 10 varieties and breeding lines, comprising two traditional varieties (*Thakhet* and *Somvang*); six improved varieties (TDK 8, TDK 11, TDK 1-Sub 1, VTE 450-1, VTE 450-2, and TSN9); and two promising breeding lines (TDK 25 and TDK 42).

The results of this study in the two districts of Phalanxay and Atsaphone confirmed the relative resistance of the traditional variety *Takhet* to RGM damage (1.04% and 7.21% of onion shoots respectively, in the test locations), while among the breeding lines the lowest levels of RGM infection were for TDK 25 (9.20% and 3.64%) and TDK 42 (11.88% and 3.52% for Phalanxay and Atsaphone, respectively). In contrast, the highest levels of infection in the two districts were in the varieties TDK 11 (20.66 % and 10.02%), *Somvang* (17.09 % and 11.68%) and VTE 450-1 (17.14% and 9.67 %). Despite the higher level of RGM resistance of the traditional variety *Takhet*, it was among the lowest yielding varieties (1.05 t/ha and 2.93 t/ha for Phalanxay and Atsaphone, respectively). The highest grain yields in each of the two districts were from the two promising breeding lines, TDK 25 (3.10 t/ha and 7.06 t/ha) and TDK 42 (2.80 t/ha and 7.02 t/ha for Phalanxay and Atsaphone, respectively). The results of the 2013 wet season study showed that the use of improved rice varieties with RGM resistance can significantly reduce RGM infestation and yield loss due to RGM. However, the resistance mechanism depends on several factors including, the quality of seed, planting location, time of planting, severity of infection, and potential integrated control techniques based on the use resistant varieties and ecological control strategies.

**Ecological Engineering** - Modifying the rice environment to favour predators and parasitoids of RGM, potentially leading to control of RGM populations. In two villages in Phalanxay and Atsaphone, this approach was tested by planting sesame on rice bunds, with the intention of the sesame plants flowering (and thus creating a favourable environment for predators of RGM) at the most critical time of damage from RGM. However, there were problems with establishing sesame on the bunds, and the timing of flowering, and hence follow up work is required. This is a collaboration with Dr. Geoff Gurr, Charles Sturt University, Australia.

**Control** - Population control in large areas the end goal of this work. Initial studies revolved on testing the effectiveness of synthesized pheromones to attract male RGM. This work is collaborative research with Dr. David Hall and Dr. George Rothschild, University of Greenwich, UK.

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## 7.4 Options for diversification

### 7.4.1 Understanding water availability and local hydrology

Water is a major constraining factor affecting food production by southern Laotian farmers. The climate of the region exhibits distinct annual wet and dry cycles, and during

the wet-season, rainfall may exceed 2000 mm per season. Due to the preponderance of saturated soils at this time in the lowlands, rice is the only viable food crop that can be produced and even its production can be unpredictable due to early wet season drought or flooding. Conversely, except where irrigation infrastructure exists, the lack of water during the rain-free dry-season over the region constrains options for agricultural production during this period of the year, despite otherwise ideal crop growing conditions. Water is one of the major determinants in a household's ability to diversify their on-farm system. As a consequence, Laotian farmers have a diet consisting mainly of rice based products with supplementation by locally grown vegetables and some animal protein.

This component had several areas of emphasis:

- Quantification of an inventory of water sources existing in the rural areas of southern Lao and including the evaluation of a model to aid in predicting conditions of elevated risk of drought or flood.
- Investigation of the suitability of methods for saving water in dry-season irrigated rice production.
- An evaluation of lines of flood/submergence tolerant varieties of rice.
- Dry season cropping options.
- Evaluation of the attitudes and awareness of Lao farmers to water and water productivity.

This component saw its role mainly in the production of knowledge for use by government agencies in the formulation of policy, and for informing farmers about potential sources of water and superior germplasm to improve food security and increase farm profitability. As currently exists, government funded infrastructure to aid southern province farmers in accessing water is restricted to narrow strips of land adjacent to the Mekong river, and information gaps exist regarding the availability and sustainable supply of groundwater as well as the viability of privately constructed farm ponds. This work contributed underpinning information to the government in its determining water policy across this region to assist farmers in gaining access to water resources to increase agricultural productivity and farm profitability.

## **Quantification of Water Sources**

### **Groundwater**

The alluvium landscape of southern Laos contains vast quantities of groundwater, and groundwater usage at present in Champasak province is largely confined to domestic usage. Due to the size and complexity of Champasak province, the component made a decision to centre the majority of its investment and activities in central Champasak, focusing around the Sukumar district. Few observational wells exist in a southern Laos, and this component initially focused groundwater studies behavior on a network of domestic wells through the district. Using this and other data, initial rates of groundwater recharge across the region estimate that around 14 – 20% of annual rainfall is estimated to recharge the surface groundwater system annually, substantially via vertical leakage from the surface regolith associated with residual water from wet season rainfall. The dependence on height of groundwater in the surface aquifer was confirmed over 2012 as the wet season was drier than normal, and consistently less groundwater recharge was observed to occur. In 2012 the component authorized the construction of five pairs of groundwater observation wells (80-120 m; 25-35m, respectively) in a transect across the Mekong alluvium from Ban Boun Keo in the east and adjacent to the Mekong river, to Ban Hiang in the west on the lower slopes of the foothills associated with the Thailand border. These bores identified that:

- the majority of groundwater is contained within fractured sandstone aquifer beneath the Mekong floodplain.
- initial observations indicated that the aquifer beneath Sukumar district had relatively high transmissivity rates and reasonable yields, indicating that some potential for use as a source of water for supplementary irrigation of dry-season non-rice crops may exist.
- There is a strong relationship between rainfall and recharge of the aquifer after the onset of the wet season, and depth to groundwater is highly seasonal.
- recharge of the deeper system comes from the east associated with the Mekong river and from the uplands to the west of the Mekong floodplain.
- despite indications of appreciable groundwater system recharge, poor recovery rates after pumping in the observational well at Ban Hiang indicated little potential for groundwater usage in the foothills to the west of the Mekong floodplain.

A survey conducted in three villages Champassak province (N=60) was undertaken to explore the nature and extent of groundwater use at the household level, and to gauge farmer perceptions of opportunities and constraints to increased groundwater use. Groundwater extracted using electric pumps was accessed by all households, providing the main freshwater source for both domestic needs and agricultural production. Use of groundwater for production of non-rice crops ranged from 5% - 100% of village households within a village, depending on location and market access. Non-rice crops included maize, vegetables, eggplant, watermelon and chilli. Groundwater was seen as the preferred water source for further agricultural expansion, although there was already awareness that groundwater resources were often inadequate for crop production towards the end of the dry season. Farmers were interested in additional information regarding the potential impacts of overuse of groundwater, although this was driven largely by the desire to reduce pumping costs.

### Surface water

Farm and community ponds are a potentially valuable resource to small landholders in the rainfed lowlands. Excepting through investment by NGOs, these resources are commonly not paid for by the Lao government and in many instances, arise as pits in the landscape from which road-base has been derived by road construction companies. These resources are therefore excavation pits located near roads, and are neither properly designed, battered nor compacted. While the size of ponds varies, they often range from 2 – 2.5 m deep and are less than 2 ML in volume (52% of those surveyed). Research here indicated that the majority of ponds fill during the wet season with many dry by the end of the dry season. This is partly ascribed to excessive levels of vertical leakage from these ponds commonly estimated to range from 4 – 6 mm per day, due to the coarse texture of regolith and the lack of compaction of the base of these pits during construction. Due to these complications, the component recognized that poor pond construction reduces the efficiency of operation of these resources. The use of artificial aids to reduce leakage losses was tested on-farm. These ponds are an important resource to farmers as they are used for aquaculture and in some instances supplementary irrigation for small scale vegetable production as well as to supplement wet season rice during an early, wet-season drought; any water savings captured through a reduction in leakage are likely to have a positive effect on productivity.

Farms surveyed as to their use and access to water illustrated some critical facts about access to water and its potentially beneficial effect on the economy of small landholders:

- The total income of farms with ponds exceeded that of farm without ponds by 1.7 million LAK.

- The “land-water ratio” has a significant negative effect on crop income but not significantly on total income, and implies that some level of pond area needs to be identified in order to have a maximum effect on crop revenue.
- Irrigation from ponds affects crop income and livestock income. On average, increasing irrigated area by one hectare compared to previously non-irrigated land increases net crop income by 18.4 million LAK.
- In general, pond farmers can also generate income from fish culture. Irrigation by pond water has an impact on livestock income, increasing by 5.9 million LAK. It may be due to conversion of land to pond.
- Investment in human capital pays dividends; higher education results in higher income from cropping and off-farm activities.
- At the village level, distance from the major centre decreases significantly the crop and livestock income, due to difficult access to markets.

### ***Residual soil water***

A soil water balance model was originally developed to assess flood and drought risk, and only required a small number of parameters. The model has been spatially applied in Savannakhet and Champasak provinces to show the typical length of growing season. In Savannakhet, in general the model showed that districts in the south western part of the province experienced longer growing seasons and had higher coefficients of stored soil water than districts in the east, particularly Nong district. In Champasak province, similar studies indicated that the western regions have shorter growing seasons than eastern areas. Studies of soil water content indicate less soil water in the profile in the western regions in the early wet season indicating greater vulnerability to drought than in eastern districts.

However, as rainfall in Champasak and Savannakhet province over the wet season exceeds the water requirement for wet season rice in most years, residual soil water remaining in the soil profile at the end of the wet season in most years could contribute in part to the water requirements for short-duration dry-season non-rice crops.

### ***Alternate wetting and drying of rice***

Rice culture using alternate wetting and drying (AWD) is the practice of scheduling the irrigation of rice when the soil water table recedes to 15 cm beneath the soil surface. This alternative method to flood irrigation has been practiced in numerous countries of Southeast Asia. In the past several years, the practice of AWD has been investigated for southern Laos and demonstrated to farmers in Savannakhet and Champasak provinces. The following conclusions have been reached:

- Under flood irrigation, farmers apply more water during each irrigation compared to when using AWD and under AWD, fields had a shallower field water depths (about 5 compared to 10 cm after each irrigation) than in flood irrigated systems.
- Average irrigation water input (from transplanting to harvest) ranged from 11.4 to 13.5 ML/ha in flooded rice, and was significantly more than in alternate wetting and drying (between 8.8 to 10.2 ML/ha)
- Between 19 – 25% of water was saved in AWD systems compared to flooded rice.
- Largely no significant difference in rice yields were observed in crops flood irrigated compared to alternate wetting and drying rice crops. Exceptions were observed in 2012 when the yields of crops growing with AWD, exceeded those of rice when flood irrigated.
- 85% of AWD demonstration farmers recognized that AWD saved water without compromising yield and 10% indicated it saved money/input/labour costs.

- Farmers reported weeds as being a problem in AWD crops if not carefully controlled after crop establishment.

### ***Dry season alternative crops***

Outside of the irrigation areas, the lack of substantial quantities of water available for crop production precludes rice as a dry season crop. Due to the probable, regular carryover of small quantities of water and to the availability of small quantities of supplementary irrigation water, there is a niche for short-duration grain and forage crops. The assessment of short-duration mungbean for use in southern Lao commenced in 2012 and illustrated that short duration mungbean can develop rapidly in these environments (sowing to mid flowering) within five weeks. Further work followed to investigate sowing method, patterns of water use, the requirement for irrigation, and biomass and yield potential (see subsequent section).

### ***Summary***

This component produced valuable information regarding availability and access to both surface and ground water resources, water management approaches, and farmer perceptions regarding these resources. In particular, the work undertaken in understanding and quantifying groundwater use in Champassak province offers policy makers an opportunity to develop robust, evidence-based policies for sustainable groundwater management, within an environment of increasing demand for this valuable resource.

## **7.4.2 Post-rice crops**

### ***The effect of different rice-based crop rotation systems on productivity of rainfed lowland systems***

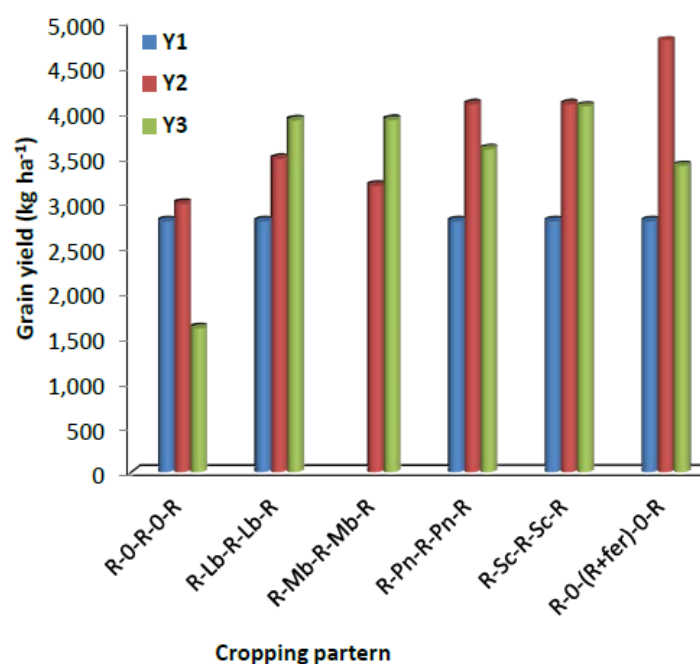
Dry seasons in the rainfed lowlands usually mean that rice fields are fallowed and become grazing land for livestock because little or no water is available for crop production. Water availability has been described in 7.4.1. The project engaged in advocating, encouraging and providing both technical and material assistance to farmers who had on-farm ponds and tube wells, and were interested in engaging in dry season production of vegetables (long bean, cucumber, chilli) and field crops (peanut, mungbean and sweet corn). The project provided technical support, seeds, fencing and in some cases low-cost pumps to enable key farmers to carry out dry season crop production to improve understanding of the effects of post-rice crop production on the farming system.

In marked contrast to wet season rice production, farmers willingly invest in fertilizers for dry season crop production (Sengxua et al., 2014). This is possibly because crops are targeted for markets, the land area and corresponding amount of fertilizer needed is small and there are fewer risks involved in the enterprise due to the ability to manage water application. The project sought to monitor and gather data on the performance of the different crops that farmers chose to cultivate towards the definition of best wet season rice – dry season crop production options. Part of this work was to evaluate the effects of dry season crop production, including fertilizer applied to dry season crops, to subsequent wet season rice productivity. This evaluation was conducted in more than 30 farmers' fields in Savannakhet and Champasack provinces.

Farmers preferred sweet corn, long-bean, mungbean and peanut, based on crop performance, consumer demand, prices and income. Sweet corn and long beans provided



farmers with higher cash income than other crops. Crop prices, however, varied and differed significantly among the locations. Savannakhet prices for the dry season crops were generally higher than in Champasack. Significant amounts of residual fertilizer were found in some farmers' fields following post-rice crop production, mainly on sandy soils in Champasack province. This resulted in improved yield for the following wet season rice crop, as shown in Figure 4.



**Figure 4 Comparison of rice grain yield under rice and rice-post rice cropping systems in Soukhouma district. R Rice; O Non-rice; Lb Longbean; Mb Mungbean; Pn Peanut; Sc Sweetcorn; R+fer Rice with inorganic fertiliser.**

### Mung beans

The inclusion of a short duration pulse or a leguminous forage/fodder crop offers many potential advantages to farmers in the rainfed lowlands, including as a cash crop, for household consumption, as a source of animal feed and for soil improvement. Modelling exercises indicate that in many years in southern Laos, sufficient residual water may remain in the soil at the end of the wet season to supplement a short duration, non-rice crop such as a pulse. Eight varieties of short duration mungbean were sourced from The World Vegetable Centre (AVRDC), and their performance was trialled both on-farm and on-station in Savannakhet and Champassak. Seed, biomass yield performance, and water use was measured under two irrigation regimes (irrigation as needed or irrigation every 15 days).

Results showed that seed yield was significantly different between sites only. Water regime and mungbean varieties/lines did not differ in seed yield. The trial in Champhone District, Savannakhet had more than twice (1.3 t/ha) the productivity of the Phonengam, Champassak trial (0.5 t/ha). Mean seed yield from the watering regimes was about 0.9 t/ha. Among mungbean varieties/lines, VC7118A performed best (0.98 t/ha) among all the entries. In contrast, MN97 had the poorest yield (0.80 t/ha) in both sites and all water regimes. On average, mungbean varieties/lines flowered, about 42 days from sowing. The range of flowering dates reported was 39 – 47 days in Savannakhet and 37 – 46 days in Champassak.

The mungbean varieties/entries tested here have been pre-selected from among a range of mungbean germplasm materials for high productivity and early flowering. Hence, it makes sense that the varieties and lines in the field trials did not exhibit statistically significant differences in seed yield. Similarly, all entries achieved reproductive stage at about the same time regardless of the suitability of the sites. Data indicated that the Savannakhet site was more suitable to growing the mungbean entries than the Champasak site. The site differences may, perhaps, be due to better soil nutrient content or water holding or drainage in the Savannakhet site compared to the Champasak site, but management of the trials is also likely to have had some effect.

Had sufficient time been available, the next logical step would have been to determine the performance of the mungbean entries as a post-wet season rice crop using only residual soil moisture. Establishment techniques to sow mungbean into standing rice crop also need to be investigated. The timing of mungbean establishment to enable the mungbean crop to germinate, develop and produce seeds using only residual soil moisture or at most one irrigation is another area of urgent enquiry.

### ***The effect of organic and inorganic fertilizer application rate on Chilli production***

Chilli is a commonly produced non-rice crop in home gardens and sometimes larger areas if water is available, for consumption and income generation. It is able to be consumed in both fresh and dried states, and market demand is relatively stable. However, current management regimes result in low productivity. Trials were undertaken to determine the appropriate rate of chemical and organic fertiliser application for increased yield, and to assess economic benefits of these regimes. Trials were conducted in one village in Savannakhet province, and comprised of seven treatments (different rates of manure, fertiliser and time of application). The results revealed that the fresh yield of chilli in experiments were in the range 69,167 - 91,333 kg/ha. The lowest yield was from T6 (Manure + 15-15-15 at a rate of 25 kg/rai/time, applied at 1, 2 and 3 months after planting). The highest yield was from T4 (Manure + 15-15-15 at a rate of 16 kg/rai/time, applied at 1, 2 and 3 months after planting). However statistical analysis found that the fresh yield of all treatments was not significantly different at a probability of 95%. When economic analysis is taken into account, the results show that the appropriate rate of fertilizer should be T4 (Manure + 15-15-15 at a rate of 16 kg/rai/time applied at 1, 2, and 3 months after planting) because it trends to higher yields and lower costs compare with other treatments.

## **7.4.3 Livestock Integration**

### ***Starting point***

Livestock production has been recognized as an important activity for Laotian farmers. It currently provides income and serves as a cash reserve, supports ceremonial activities, and provides a certain level of food security, especially where small livestock are concerned. Through integration and improved management it has the potential to multiply its contributions to household income, improve economic resilience, support crop production, household and national food security, and the stabilization of farm and community eco-systems.

In southern Laos, only a few projects so far have focused on the improvement of production and management of livestock systems. Most farmers use minimal input approaches, and practice free grazing during the six-month dry season while cattle are semi- confined, tethered or simply “looked after” during the cropping season. Feed availability and quality is in most cases insufficient to keep body conditions constant throughout the dry season. As the control of free roaming animals is difficult, damage to



crops and even complete crop loss is common. Spreading of disease in such freely wandering populations is easy and often leads to significant reductions in livestock numbers. Additionally, potential added values from livestock, such as using manure as fertilizer, are not exploited.

### **Intervention strategy**

The considerations taken when choosing the livestock to focus on were that smaller livestock (pigs, goats, poultry) required more complex management interventions with higher risk of loss by disease if not implemented properly, while cattle and buffalo were easier to manage, but turning them into constantly producing commodities required a farming systems change. Due to the linkage of large livestock to cultural values and overall farm management strategies, improving such systems requires farmers to restructure their financial and farm management strategies, which is a sensitive issue.

At the initial phase of the project, markets and farming environment were assessed and a focus on cattle was decided. The decision was based on the observations that:

- cattle are abundant in the target areas but management systems are very traditional
- farming systems are strongly crop focused; getting farmers to invest in livestock would be challenging, and easier interventions are more likely to be successful
- the demand for cattle is outstripping the supply, and prices are expected to rise or at least remain stable
- cattle permit a stronger integration into other farming activities than smaller livestock.

However, at the request of NAFRI, which had focused on research on chickens, it was decided to include work on these small livestock in our activities as an option to also involve poorer farmers. The focus was on improved management, leading to faster growth and lower mortality rates. The decision was made to involve a large number of farmers from the beginning of the project to follow NAFRI policies, which demanded the involvement of as many districts and farmers as possible. This led to 121 farmers in 22 villages throughout 7 districts who showed interest in trying forages for their cattle. Due to constraints in human resources in the districts, the strategy had to be adjusted, with a stronger focus on fewer farmers, and supporting district staff with students from local agricultural colleges.

### **Process and achievements**

Despite the research idea of a component-overarching integration, the initial selection of sites was done quite independently by each component. The livestock component focused on first finding suitable germplasm for the difficult environmental conditions, which include water logging, prolonged drought, nutrient-poor soils, low organic matter content, and eventually torrential rainfall. This combination of factors made the development of a suitable year-round system challenging. We chose a combination of regionally available and not yet available, already tested and new germplasm, to be trialed in various environments (upland, lowland, different soils etc). We found that many of the regionally available varieties would only be partly suitable. *Paspalum atratum* and also *Panicum maximum* 'Mombasa' gave good results on better soils in flood prone or waterlogged conditions. Mulato 2 established well in areas of moderate soil acidity and nutrient availability, and persisted well in the dry season. Cayman, as one of the newer varieties, showed promising results under waterlogging on very poor soils. Some new *Brachiaria brizantha* and *B. humidicola* varieties were tested and showed some interesting traits, such as silkiness and weed suppression potential, but could not compete in terms of yields with the released materials.

Post-rice forage options to be grown on residual moisture in the soil were considered and tested. Given the short establishment period, fast growing annual legumes were anticipated to be the best-bet candidates. However, growth on post-rice paddy fields was stunted, and although the plants went through a full life cycle, including seed production, total yields were small. This improved on upland fields, although the short period of water availability limited the options. *Lablab purpureus* with its fast life cycle was among the best materials, especially when small amounts of supplementary irrigation were available. However, several limitations reduce the feasibility of such approaches: seed is not available, supplementary irrigation is rarely feasible in upland areas, and large areas needed to supplement animals throughout a 6-months dry season would require high labor inputs. The establishment of post-rice pastures from planting material was also considered, and seems promising if low levels of water supplementation can be provided. But labour and availability might also be constraints here.

On-farm a participatory approach was taken, providing a variety of materials to farmers to be tested under local conditions. The establishment turned out to be extremely cumbersome and was marked by several drawbacks. Reasons were combinations of heavy weather events and farmer attitude towards the requirements for the system. Lack of fencing, weeding during the establishment phase and subsequently regular cutting were the most common problems leading to plot degradation or destruction.

Based on these experiences and acknowledging the constraints in human resources at district levels, it was decided to involve students as agents of knowledge transfer and monitoring support. Students were first trained and then grouped in pairs to work as a team with one or a few selected farmers in the target villages on improving forage and livestock systems. In early 2012 the decision was taken to concentrate on focal villages with the most promising systems, in which more emphasis would also be laid on the integration of different farm components. Both approaches proved to be suitable in attracting farmer interest, providing the needed support, and collecting basic data and information for our core team.

From the 121 initially interested farmers in 2010, only 37 had established plots by 2011, and none of these plots were used, which was mainly attributed to insufficient follow-up and support by district staff. After plans were made to improve this situation in early 2012, DAFO reported a total area of planted forages of 45.2 ha by 65 farmers in the intervention areas of which 15.9 ha were plots smaller than 800m<sup>2</sup>. Still, the actual usage of such plots seemed to be low, and farmers often said that they did not know how to use the plants with their unconfined animals. In some cases farmers tried to use the established cut and carry plots for grazing, which led to rapid degradation and destruction of the plot due to trampling and overstocking. The focus on a few champion farmers was combined with a stronger focus on district staff capacity building. By early 2013, nine farmers in 6 villages in 4 districts had initiated a true systems change, keeping at least some of their animals penned, and fattening them with forages and higher quality crop by-products such as maize stover. The student on-farm work showed that their animals gained at least 15 kg per month during the dry season, while control animals, kept in the traditional way, lost weight. In the case of two farmers who intended to sell their animals, this increased weight led to a 40-45% increase in farm gate price. These pioneer farmers are seen as crucial players on the way to adoption as they form centres of innovation around which new farmers adopt new methods and technologies.

District and provincial staff were sent to training and cross-site visits in northern Laos and Thailand. Our main partner on the provincial level received 2 months training in livestock and forage management at Khon Kaen University, Thailand.

## Summary

The livestock component focused on exploring options for improved cattle production, in particular in identifying alternative feed sources for changing management systems. Importantly, suitable forage germplasm for the challenging biophysical environments in southern Laos has been identified and tested on-station and on-farm. Additionally they tested options for supporting farmers with systems change, to promote innovation in livestock management. Pioneer farmers continue to improve their livestock production systems in a step by step manner, working towards continuous animal production and sale, and developing the most suitable business strategy for their circumstances (e.g. cow calf systems, fattening of adult thin cattle, full raising cycle etc.). Importantly, the project has contributed to the capacity development of provincial and district staff, leaving a lasting legacy of support for farmers in their region.

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## 7.5 Knowledge sharing and capacity development

At the commencement of the project, the Knowledge Sharing component concentrated its efforts on developing WS rice management guidelines using the *Cropcheck* extension methodology. Following the collection of the farmer information, a comparison was made with the IRRI-developed principals where a lot of similarities between the crop practices and IRRI recommendations were highlighted. Additional Lao-based staff were recruited after the first two years of the project, which made expansion of the component's activities possible. Consequently, in 2012 the focus of the Knowledge Sharing component shifted to concentrate on some key areas within the project, including:

1. Building capacity within PAFO/DAFO staff and farmers by providing training opportunities in key areas identified by the project and by staff and farmers themselves.
2. Identifying priorities for the production and dissemination of information on new technologies.

### 7.5.1 CropCheck extension methodology

Investigations into the suitability of the Cropcheck extension methodology for wet season rice production were conducted during the 2010 and 2011 wet seasons. A total of 84 farmers were surveyed over the two seasons in 4 districts of Savannakhet province. This sample size was not big enough to clearly identify reasons behind crop yield variability in the two seasons in which it was trialled. However, the investigations highlighted that the useful sample size in which crop management practices can be benchmarked for grain yield and profitability needs to be much bigger than that used in this project. The requirement for a larger sample size is related to the inability of the farmer to control factors such as water, pest and disease, and large variability in fertiliser management practices. Based on the sample size used, the surveys were able to indicate a degree of consistency with IRRI's 7 step production guide, further validating the use of these steps for Lao smallholders. Aspects of the *Cropcheck* methodology such as farmer discussion groups were favoured by farmers and district staff, because they allow discussion between farmers and between the staff and farmers.

### 7.5.2 Staff training

A skills needs assessment was undertaken to determine training requirements for farmers and DAFO staff, to ensure that sessions developed were relevant and useful for all

parties. Feedback was sought from farmers, DAFO and project staff (component leaders). Priorities for DAFO staff were based more on data analysis and reporting, project management and computer skills, with some technical requirements also. For farmers, skills needed were technically based, and were mostly incorporated into cross-site visits to relevant areas for learning and knowledge exchange. In total, the project has provided over 250 training places (targeting a consistent group of PAFO and DAFO staff and farmers). These sessions have also included participants from other projects (e.g. ADB-IFAD project staff), staff from a private company in Savannakhet, and students from Savannakhet University and Na-Keh Agricultural College.

The training sessions were designed to build on each other, and to make use of previously acquired knowledge. They reflect the needs of the project, starting with a focus on technical topics, and more recently trying to build skills in integrating and reporting on project activities.

1. Improved livestock systems, including forages, cattle, pigs, goats and poultry management.
2. Crop management, including fertilizer application and plant based measurements
3. Water management, including modeling for whole farm planning
4. Socio-economics, including market chain analysis
5. Establishing and maintaining a demonstration site
6. Integration and farm management
7. Fundamental professional skills, including topics such as research design and methodologies, data analysis, documentation and presentation skills, and computer skills, including how and where to find reliable information on the internet. A significant amount of time was devoted to case study writing, as well as developing District Action Plans (DAP) for district extension.

### 7.5.3 Cross-site visits

In total, more than 450 people have participated in cross-site visits for knowledge exchange. These cross-site visits covered a broad range of topics, which reflected interest from farmers and PAFO/DAFO staff, as well as successful project trials and demonstrations. Topics have included:

1. Upland rice varieties
2. Improved lowland rice production, including varieties and Best Management Practices
3. Crop establishment, focusing on direct seeding
4. Water management, including AWD
5. Improved livestock production systems, including forage evaluation and marketing
6. Crop marketing techniques for vegetable producers
7. Commercial sweetcorn production
8. Integrated farming systems at the smallholder level

### 7.5.4 External links

External links are important for outscaling and in terms of building capacity at provincial levels. It is important to be flexible in terms of who we link with and how we link with them, given that there are different agencies working in each province, and they will have different needs and capacities. Broadly, these links fit into the following categories:

→ **Projects:** The project has links with the *ACIAR Climate Change project (LWR/2008/019)*, due to common staff in Savannakhet province; some of their trials have also been used for cross-site visit sites. Contact with the *ADB-IFAD Sustainable Natural Resource Management and Productivity Enhancement Project (SNRMPEP)* has also been established, through joint training sessions, cross-site visits and

exchange of seed materials. The project has also linked with the *ADB Smallholder Development Project* in Champassak for cross-site visit arrangements, bringing farmers and DAFO staff from Savannakhet to learn sustainable commercial farming techniques.

- **Private companies:** Through the Forage-Livestock component, links have been made with Birla Lao and the Theun Hinboun Power Company. These groups are interested in improved forage systems to support livestock production. Additionally, the project has tried to link farmers to the Happy Farmers seed company, for potential seed production activities.
- **NGOs:** A working group has been established in Savannakhet to link organizations working in the agricultural sector. Outcomes to date include the development of a database of NGOs and projects to look for synergies among projects, and identification of common issues. The project has also worked separately with GAA to provide training in improved livestock production.
- **Educational providers:** Students from Savannakhet University (8) and Na-Keh Agricultural College (7) in Savannakhet have worked with project farmers in target villages during their practical work experience terms to demonstrate improved livestock systems and integrated farming systems.
- **Volunteers:** The Australian Volunteers for International Development (AVID) program is an Australian Government, DFAT initiative. In late November 2012 the project welcomed Jessica Armstrong, an AVID Volunteer who joined with the project for 15 months, working with the Knowledge Sharing component based in Pakse. Additionally, Ms Emilie Kirk, a MSc student from the University of California, Davis, worked with the project for four months in 2013. Emilie contributed to a survey on capacity building outcomes and staff and farmers' experiences with the on-farm research process.

### 7.5.5 Extension materials developed

A range of extension materials have been produced throughout the life of the project, including the following:

- Posters, pamphlets and/or handbooks, including the following: lowland rice Best Management Practice; submergence tolerant rice (TDK1-sub1); dry direct seeding; forage information (aim to improve understanding of forage varieties: characteristics and adaptation in the local area; techniques for forage establishment, management and utilization); improved cattle and buffalo production systems (feed production and locally available feed utilization; animal management (housing, feed trough, hygiene and animal health care and manure management); cattle fattening technique (animal selection, feeding, animal health care); post-rice corn; rice varieties (lowland and upland); nutrient management for rice, linked with direct seeding (government priority for targeted production increases).
- Video promotion: promoting forage-based livestock management (made in conjunction with Savannakhet TV and screened in Savannakhet for 6 months); dry direct seeding establishment and management.
- T-shirts featuring lowland rice Best Management Practice

### 7.5.6 Summary

Significant effort has been devoted to capacity building activities for provincial and district staff, and to providing opportunities for farmers to experience and discuss technologies

they are interested in exploring further. Additionally, the project team has made links with institutions in the provinces for capacity building and outscaling purposes.

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## 7.6 Approaches to synthesis and delivery

### 7.6.1 Establishing Focal Villages for project operation and delivery

One of the key aims of the South Laos Project (SLP) was to understand the farming and marketing systems using an integrated approach. A fundamental requirement is to understand the key priorities and needs at a range of levels, from farmers to policy makers and donors; this then prioritises the need for underpinning research activities which can be carried out by the components. The results from these research activities, in conjunction with the identified constraints, inform the application and knowledge sharing approach, being undertaken through Focal Village (FV) sites. The FV sites represent the major typologies identified previously by the Socio-Economic component. The typologies defined have been identified as integration points, as a basis for site selection and integration of possible technologies within FV sites. Taking a typology approach to planning and implementing activities/technologies means that there is an identified method for outscaling results, with a clear definition of the application domain for the knowledge generated and integrated farming systems that may be possible within each typology. They provide local relevance and practical application to enhance understanding and adoption of technologies introduced.

Two levels of integration required for successful project operation and delivery have been identified, including planning and project management, and integration of technologies at the farm or village level.

**Integration of planning and project management among the components.** This level of integration is intended to enhance the effectiveness of project activities. This will benefit both the project team, through increased synergies between project components, and ultimately the end users of the technologies, through more appropriate solutions developed in a systems context. The elements to be integrated are the individual components (disciplines), in terms of planning and delivery of research activities, and the outputs from these activities. Additionally, the Knowledge Sharing component works with the other components for capacity building and outscaling of mature technologies. Evidence of this is seen in the production of rice BMP and TDK sub-1 extension material; through the planning and conduct of cross-site training visits; through the planning and conduct of training workshops; and through the development of the FV sites.

To achieve this, there is a need to understand each component's research activities, and identify ways in which these activities can be modified for application within the different typologies. Significant effort has been devoted to planning integrated activities (where appropriate) for the 2013 dry season, with emphasis on key activities rather than only by component. Integrated activities have been discussed at several project meetings and project field trips, and opportunities for each component to contribute identified. This reflects an important change to previous planning processes. Importantly, the FV sites have value in terms of being a physical presence around which activities can be planned; this helps to apply the concept of integration.

**Integration through technologies at the farm and village level.** This level of integration is intended to benefit farm households and communities. It focuses on physical integration of project knowledge at the farm and village level, to be applied in a way that fits the Lao smallholder farming systems context. The aim is to introduce improved options for different parts of the existing farming system in a way that fits with the local conditions, and explore the effects of systems changes. In this context the FV sites are being used for learning sites for project participants to see the effects of integrated activities while



offering pathways for outscaling promising technologies. At the FV sites the project has targeted proactive farmers in progressive villages as a way of promoting uptake of agricultural activities with high potential.

FV sites have value as an integrating factor for project activities, offering targeted sites for practical on-ground implementation of activities. They provide a common location to work together, enhancing institutional integration. By selecting these common sites, opportunities for dialogue and cooperation among project components have been enhanced. For researchers, the use of FV also allow a space to see the whole picture, giving insights into how events are interconnected, which can lead to targeted interventions for change. They allow the identification of the wider effects of individual activities within the farming system, and will increase understanding of the interplay between constraints and solutions, and the prioritization of these.

→ *Wet season 2012*

Initial meetings were held in selected FV. These were held with DAFO staff, the village head and interested farmers. The project had been operational in each of the villages previously, and in general there was a good level of co-operation, with around 35 farmers participating in discussions. The purpose of the integration was presented, and current activities in each village discussed, including the successes from previous project activities. A list of potential demonstration activities was presented. For the first wet season, there was a limit to the activities that could be undertaken due to time constraints, but many farmers were willing to demonstrate BMP and forage systems. Throughout the season, several additional activities were identified in each village where the project could 'value add' onto previous component activities.

→ *Dry season 2013*

The dry season 2013 post-rice crops are an example resulting from the integrated planning and implementation process. In suitable locations, the post-rice sweetcorn crop was included as an integration point, with input from all components. Management recommendations for sweetcorn were adjusted (staggered planting times, irrigation rates) to allow this activity to provide a livestock feed source over a longer period; this may also have implications for marketing options. The need to develop protocols in conjunction with each other was agreed, to ensure synergy for what is delivered to our DAFO and farmer collaborators. These systems have been successfully implemented, with positive feedback from farmer cooperators.

→ *Supporting farmers and district staff*

It is recognised that in applying this physical integration at the farm level, there is a need to provide support for farmers to ensure that these activities are adjusted for maximum benefit, and to ensure that we can identify the benefits that result from integration through comprehensive data collection. To support this process, the project has engaged with students from provincial Universities and Colleges, as well as 'volunteer' DAFO staff, who have worked in the FV sites to support farmers in undertaking these integrated activities and demonstrating the outcomes.

It is also acknowledged that PAFO and DAFO staff are an important support for farmers; however, the concept of different disciplines from these organisations working together at a common site or on an integrated activity is new, and will require an adjustment in the way of thinking. Support from the project will be needed for this to happen, including training, mentoring, planning and budget allocations.

Focal Village sites have value as an integrating factor for the project activities of the SLP. They offer targeted sites for practical, on-ground implementation of integrated activities. Importantly, they provide a common location to work together, enhancing institutional integration. By selecting these common sites, opportunities for dialogue and cooperation among project components have been enhanced.



## 7.6.2 Techniques for improving systems understanding – Variance 5

The activities reported in previous sections were delivered within the main phase of the project, up to February 2014. The South Laos Project was given a final no-cost extension to October 31<sup>st</sup> 2015 (Variance 5), for synthesis and delivery of Objective 2, ‘Optimisation, testing and adaptation of crop and livestock technologies and marketing/extension approaches’, with particular reference to crop and livestock technologies and extension approaches tested during 2010 – 2014. Variance 5 centred on drawing together the various technical crop-livestock outputs, and analysing these links within the farming system. This extension thus continued to build capacity for project staff at DAFO, PAFO and NAFRI levels, in terms of synthesizing techniques, and in analyzing crop-livestock technologies within the on-farm and wider farming system. Engagement with relevant stakeholders was also a key focus, particularly as a way of transitioning to the CSE/2014/086 project ‘Crop-livestock systems platforms for capacity building, testing practices, community learning and commercialisation (CLSP)’. The CLSP project was designed to follow the SLP, and will use an Innovation Systems approach to explore options for initiating Innovation Networks. Innovation Networks (or platforms, as they are often called) are a way of bringing together different stakeholders to identify solutions to common problems or achieve common goals (Homman-Kee Tui et al, 2013). They can be used to identify challenges and opportunities, share information, undertake joint activities related to a shared interest, and trigger innovation. Work done within Variance 5 has been an excellent basis for the following project in terms of testing approaches, building capacity in systems thinking, and identifying potential stakeholders and their roles.

Variance 5 incorporated a series of systems workshops for synthesis of technology materials, and introduced tools for exploring and understanding farming systems and linking with stakeholders. Workshop 1 focused on identification of crop and livestock technologies that were tested within the project, and that project staff felt were sufficiently ready for outscaling. Extension materials were prepared that incorporated project experiences and data, for materials that are contextually relevant for farming systems in southern Laos. Focus group discussions were held with farmers to consider their perspectives on crop and livestock integration, to look at their existing experiences and constraints, and to identify opportunities to strengthen these links, helping to incorporate the ‘demand side’ perspective of farmers in relation to crop-livestock links. Workshop 2 convened local and international experts to present aspects of farming systems research, and let the project team explore project technologies in the context of existing farming systems, using integrative enquiry approaches to identify constraints and opportunities based on prior experience, project results, and wider scientific inputs. Throughout Variance 5, and in conjunction with CSE/2014/084, project staff have had an opportunity to consider the potential benefits of engaging with a range of stakeholders to address farming systems constraints using an innovation network approach. Workshop 3 allowed communication of project outputs to a range of provincial stakeholders, and exploration of options for working together to address system constraints for mutual benefit.

### ***Project technology synthesis***

An initial workshop was held to identify and document crop-livestock technologies and extension approaches tested during the main delivery of SLP (2010 – 2014), and to select those considered suitable for outscaling to external stakeholders (namely farmers, other DAFO and PAFO staff, and technical staff of NGO development projects). From the complete list of 28 technologies tested during the project, 19 were considered to be suitable for outscaling, and the development of technical manuals, pamphlets and posters was highlighted as the preferred formats, although other avenues were also discussed (radio, television, online, sms). Participants developed the technical content for each technology using data and experience gained during the project. Following this, group discussion allowed the topics to be reviewed and refined, ensuring that the technology was focused and incorporated lessons learned from within the project. During the group reviews, participants were keenly engaged in the discussion, sharing observations and giving their opinions. This process allowed participants to start thinking and commenting about the technologies in terms of their 'system fit' and indeed there was already good discussion about how some of the technologies are linked.

1. Training and cross-site visits
2. Capacity building for trainers
3. Forage information (aim to improve understanding of forage varieties: characteristics and adaptation in the local area; Techniques for forage establishment, management and utilization)
4. Improved cattle and buffalo production systems (feed production and locally available feed utilization; Animal management (housing, feed trough, hygiene and animal health care and manure management); Bull/Steer and heifer raising technique; Cattle fattening technique (animal selection, feeding, animal health care)
5. Integrated systems (the role, importance and benefit of crop-livestock integration systems; post-rice corn; duck and fish raising in lowland rice paddies; rice straw quality improvement and utilization)
6. Post-rice crops (peanut, mungbean)
7. Rice varieties (lowland and upland)
8. Nutrient management for rice, linked with direct seeding (government priority for targeted production increases)

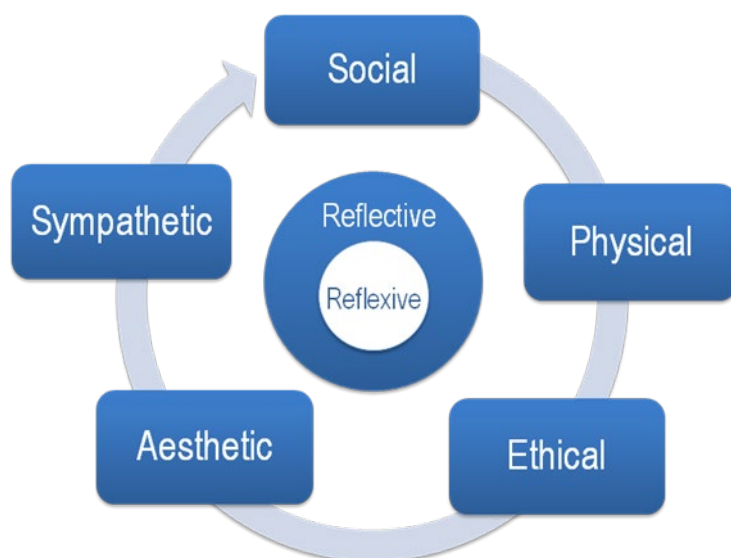
### ***Exploring technology integration within the farming system: drawing together a range of perspectives***

One of the key aims of Variance 5 was to document linkages across technologies, within a farming systems context. This was achieved by drawing together perspectives from a range of sources, including scientists (research outputs, the literature and previous experience), provincial and district agriculture staff (practical experience) and farmers (practical experience and observations from farm management). Researchers and agriculture staff contributed to exploration and working documents during Workshop 2, while farmer perceptions were explored in focus group discussions in six villages. The resulting outputs are a greater understanding of farming systems, strategic integrated approaches for planning and management, and methods for documentation.

- ***Setting the scene for integrated crop-livestock systems: lessons from research, experience and the literature***

### **Integration and transdisciplinary research**

Transdisciplinary research and practice is needed to address “wicked” problems, that have no one clear answer, and that require multiple stakeholders to collaborate to generate unique solutions. Drawing together multiple stakeholders with a range of knowledge of any given system and its parts can help to solve issues that surround the depth and scale of understanding that is required when searching for solutions to complex problems. However, approaches are needed to analyse and describe existing systems and their problems, and to create a basis for shared understanding. The social learning/integrative enquiry framework is one such approach, which encourages the incorporation of different ‘ways of thinking’ into social learning and collective decision making (physical, social, ethical, aesthetic and sympathetic); for example, see Brown (2011). These ways of thinking are further supported by reflective and reflexive thinking, as shown in Figure 5. The ‘five ways of thinking’ can help to provide a framework for analysing existing systems and their problems, and to create a basis for shared dialogue and understanding.



**Figure 5 Perspectives or domains of human thinking (adapted from Brown & Harris, 2014, as presented by Liz Clarke).**

This framework was used within the workshop to guide small group discussions on elements of the farming system and their links, and to create a shared understanding for different participants. It was well received, and with several iterations the depth of reporting improved significantly. Researchers working with small groups noted that participants were enthusiastic about moving beyond the agronomic/biophysical aspect of technologies to include other elements.

### **Systems research: crop and livestock experiences and integrating factors**

Integrating factors for crop-livestock systems were presented by researchers, based on their prior experience, including biophysical, social and economic aspects. Farming systems and the level of integration at the farm level were based on using the resources available to produce crop and livestock products; such resources include land, water, labour, finance, markets and knowledge. Some of the influences on integration, for example access to a fixed land area, mean that there is competition between different

activities, so integration is also an exercise in considering options to maximise use of resources.

Integrated crop-livestock systems are influenced by economic factors, including cost of inputs, returns to labour and access to finance and markets. In terms of decision making, wet season rice production is still the basic activity upon which the system relies, and is a platform that can be used for improving rural livelihoods (see Section 7.1). Increasing labour costs are the main factor responsible for driving farming system adaptations in the southern Lao lowlands, and in the future it is likely that the adoption of low input, labour efficient and relatively stable rice production systems will be adapted and adopted for most households. Building on this rice production platform, post-rice crop diversification and improved livestock management are activities that can generate returns to family-owned and -accessed resources.

It is necessary to identify both internal and external factors that affect integration. This in turn highlights the importance of defining a system boundary, and in looking at the integration between different systems levels. The common themes emerging from this session on prior experience in systems research, and the factors affecting integration and farming systems research included;

- Understanding access to resources as a determinant of the farming systems implemented and possible in a given location;
- The importance of understanding the boundaries of a given system, and the interactions within and between farming systems and their external influences;
- The need to draw together different stakeholders in order to elicit their goals and priorities to create a shared understanding. This is particularly relevant in terms of working with farmers and the wider value chain, recognising different priorities, goals and decision making approaches. Farmers already use systems thinking to achieve their goals, and these goals, in combination with access to resources, are the drivers for existing systems and any future adoption of new technologies.

A range of existing integrated crop-livestock systems in Laos were presented; such systems can range from basic rice – livestock systems through to diversified integrated systems that incorporate processing and marketing options. It is important to keep this range in mind, so we know that systems can range from simple to complex, with different systems boundaries erected. In terms of integration, it is impossible to outscale a general model, because there are so many different factors that influence it, but we can introduce different technologies to strengthen parts of the system. This aligns with the results of the focus group discussions, in terms of farmer perceptions on integration (Section 7.6.2).

### ***Exploring technology links within the farming system: refining integration and systems fit***

#### **Farming systems in southern Laos**

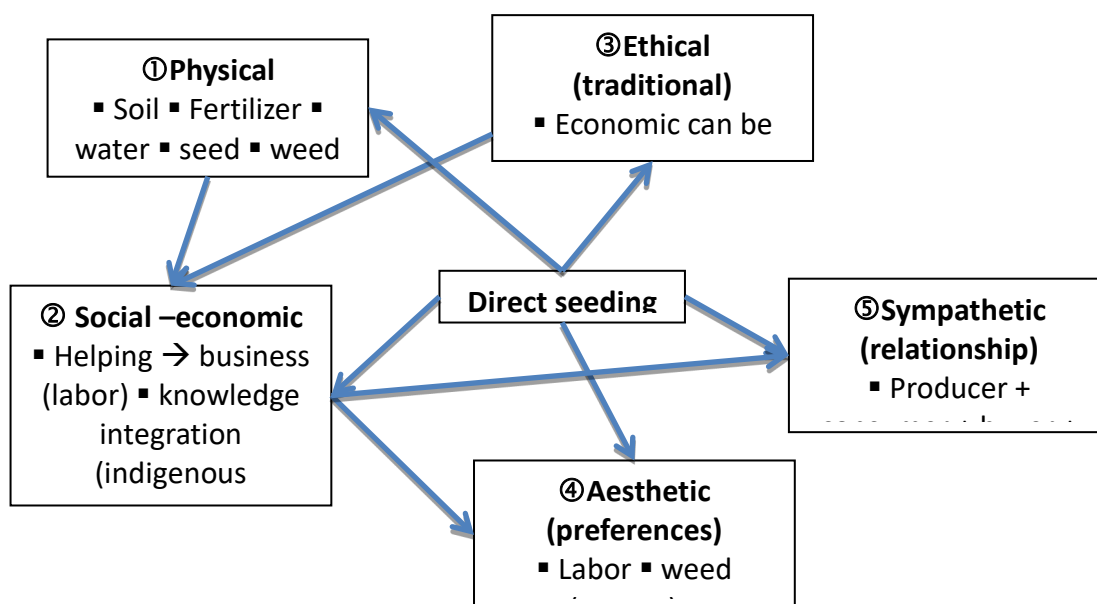
Following the presentations given on Day 1 (Workshop 2), different systems levels were defined with respect to the farming systems in southern Laos; these are shown and described as nested systems in Figure 2, Section 7.1. In this example, the systems centre on rainfed rice production as the ‘platform’, which is part of a wider household livelihood system; both of these fit within a wider system that extends beyond the farm, and includes local communities and markets. This diagram allows system boundaries to be defined, and then interactions between the system levels to be identified. Using this nested system approach allows the integrative enquiry framework to be applied at a range of levels to identify the related aspects of the ‘five ways of thinking’, while being aware of the relevant boundaries, and the interactions that occur within and across them. At the centre of the

system is the wet season rainfed rice production (often meeting a subsistence goal), with a range of other preferences and options for complementary or replacement activities existing in addition to this, for adaptation to the rapid changes being experienced by Lao farmers. While there are various levels of engagement in commercial and semi-commercial enterprise and diversification of farming activities, others have moved more towards a labour or off-farm income-oriented trajectory, often involving migration (Manivong et al., 2014). In addition to wet season rice production, the SLP has focused on exploring viable techniques for on-farm adaptation options, including enhancing livestock production through animal management and forage production, a suite of alternative dry season crops, water management and labor saving strategies (in particular direct seeding of rice), and integration of these technologies within the system.

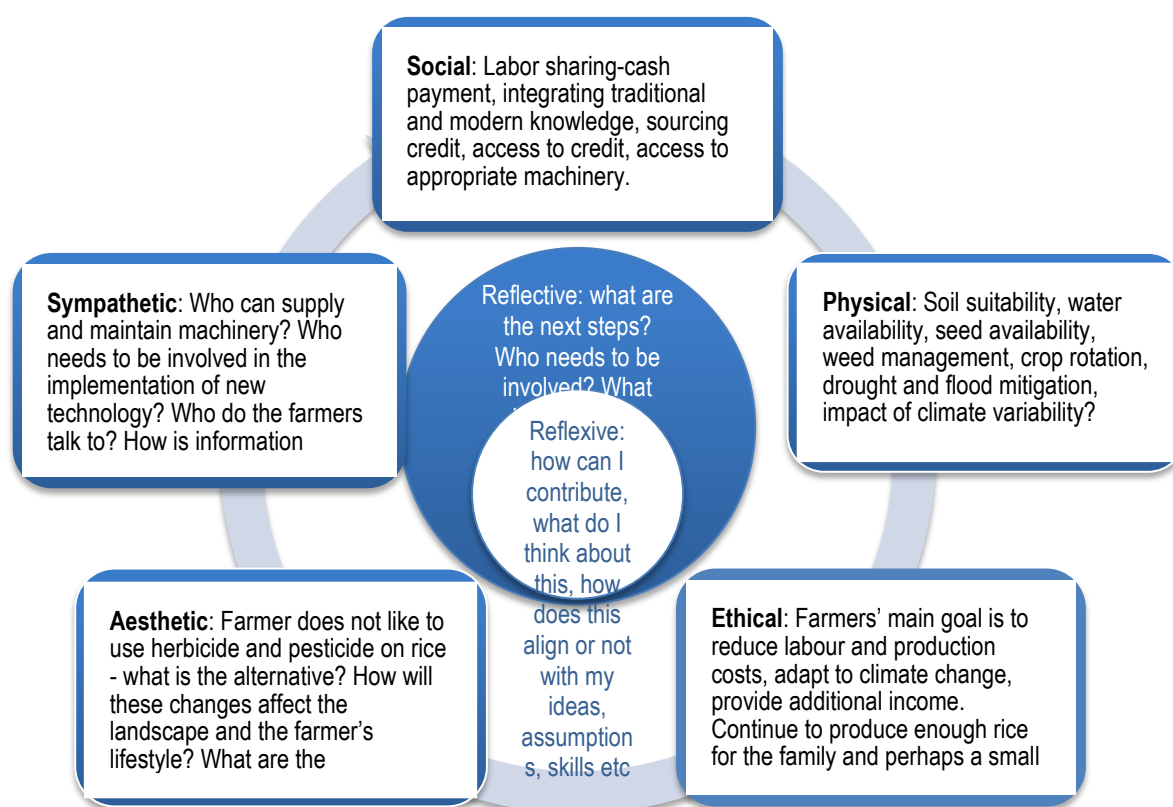
### **Exploring and capturing systems links from technology areas**

In order to explore the situation for different parts of the crop-livestock dimension, an iterative process based on the integrative enquiry framework (described above) was undertaken. Participants split into groups to discuss and document aspects of crop-livestock integration associated with technologies tested within the SLP in the context of on-farm application. The outputs were documented links within the farming system, and targeted areas for further work. Initial work focused more on physical constraints of farming systems. When the final diagrams were presented by the different groups (see translated diagrams in Figure 6, Figure 7 and Table 3), it was clear that there had been a move towards a deeper and more comprehensive understanding of the different systems in question. As an example, by the end of the workshop, the group focused on direct seeding identified issues around specific soil types and how their waterholding capacity influenced interaction with the direct seeding technique; in partnerships – i.e. it is the trader who identifies the rice price, not the farmer; and in adoption, in terms of changing techniques in a step by step fashion. Other technology areas had moved towards a similarly deeper systems understanding. Translation of key diagrams and subsequent analysis identified a range of themes arising within each subject area. Other outputs from this workshop can be found in the report on Variance 5.

Dr Leigh Vial worked with one of the small groups to draw out outcomes from the SLP and frame future direction in the context of crop-livestock integration, particularly with respect to dry direct seeding in lowland Laos. Despite initial challenges in applying the integrative enquiry approach, by the end of the second session a coherent picture had emerged of the entirety of the issues on drill-seeding in an integrated system - moving away from just the agronomic angle. It was noted that the group enjoyed building on the agronomic aspect of dry direct seeding, which despite its importance, is not new. Figure 6 shows the relationship between different aspects of drill seeding technology within the farming system, which is then summarised in Figure 7. There was a progression in thinking during the workshop and poster formation. Two examples are particularly salient; the first was discussion about business models (about drill-seeding in this case), in terms of how the drill-seeding *service* will be accessed? The second was discussion about the sustainability (of the drill-seeding system in this case). There was awareness that (a) drill-seeding done obsessively will likely quickly fail, (b) rotations of establishment method and weed management method, and (c) new twists in weed control await.



**Figure 6 Translated version of the final diagram for constraints to using the dry direct seeding technology in current rice production systems, produced during small group work in Workshop Two.**



**Figure 7 Aspects of dry direct seeding technology (constraints, opportunities) analysed according to the integrative enquiry approach during small group work in Workshop Two.**



**Table 3 Key themes and additional questions that emerged from the discussion and diagrams produced for use of the dry direct seeding technology during Workshop Two.**

Key themes	Additional questions
1. Culture shift in farming households from cash-less labor exchange to a money-based on-farm culture with subsistence rice production (for household needs still at the centre) i.e. direct seeding reduces labor costs and potentially frees up labor for other activities.	<p>How to manage risks around rapid uptake and implementation?</p> <p>What other practices need to change for direct seeding to be successful?</p> <p>How will this shift the household dynamics – in terms of labor allocation and decision making between different household members, in particular gender dynamics?</p> <p>How can the weed burden be managed in direct seeding? (e.g. cutting and ploughing the crop after standing water achieved, manual, fertilizer management, bio-control, etc)</p>
2. Combination of traditional knowledge and new techniques and problem solving is a critical focus. (implementation of direct seeding requires a problem solving approach)	<p>How to source adapted, appropriate, affordable machinery?</p> <p>How to provide adequate training, service and maintenance for new machinery?</p>
3. Focus on yield stability of rice as the household system foundation, rather than intensification, will be the focus and measure of success for dry seeding.	

### **Summary of workshop achievements**

Against a background of technology development, systems experiences and integration factors, a framework was introduced to allow a deeper and more strategic understanding of farming systems. Based on practical experience, key considerations for farming systems research lay in defining system boundaries, understanding access to resources and drawing together diverse stakeholders. The integrative enquiry framework introduced uses five core 'ways of thinking' as a basis for thinking about different systems. This framework uses physical, social, aesthetic, ethical and sympathetic aspects to describe and understand systems at different levels, recognising that individuals often tend to focus more on single aspects of a system, and that in bringing together transdisciplinary teams there is a better chance of developing a rich understanding of a system. With this rich understanding comes the likelihood of developing more appropriate and sustainable solutions to system constraints. The project team used this framework to explore the major technology areas tested and refined within the SLP (rainfed rice, direct seeding, post-rice cropping and livestock production systems). Using the 'five ways of thinking' in conjunction with participatory analysis tools (concept mapping, construction of problem/cause-effect trees and stakeholder analysis), the project team worked to understand how the different technologies fitted within the system levels, and the links between crop and livestock systems.



The workshop provided the time, space and support to allow researchers and agriculture staff to explore relevant areas of farming systems in more detail, and provided a framework that allowed a comprehensive understanding of farming systems. Participants recognised that such a process gave practical tools for strategic planning and priority setting at different levels, including identifying appropriate technology options to address constraints, where relevant. During the workshop, the level of understanding increased in terms of breadth and depth with respect to the five ways of thinking. The final materials presented in relation to the core subject areas were much more comprehensive and detailed, and in some cases groups were able to tie systems characteristics to stakeholder engagement and specific roles. In terms of future work, these processes informed the innovation network approach, providing a strategic and rigorous basis for generating a shared understanding, and undertaking group reflection in a systematic way. This approach (materials, tools) will be further refined based on group feedback, in order to ensure that it can be used practically in CSE/2014/086 to draw together the views of multiple stakeholders for strategic planning and priority setting.

- ***Exploring crop-livestock links with farmers***

To complete our systems understanding, it was also necessary to explore how farmers perceive the links within their systems, and how these could be strengthened in the future. The literature reports a wealth of benefits associated with integrated crop-livestock production systems. Combining crop and livestock production diversifies risk, provides a form of insurance and access to capital, and can result in a more even cash flow (Erenstein et al., 2007; Moll, 2005). Improving the integrated farming system, in particular through improvements to the livestock component, can provide a pathway out of poverty and promote gender equity (Thomas et al., 2002). Additional benefits may include enhanced environmental resilience through increased biodiversity, more effective and efficient nutrient cycling, improved soil health, provision of ecosystem services, enhanced forest preservation, and a contribution to adaptation and mitigation of climate change (FAO, 2010). As has been identified and discussed previously, lowland farming systems in Laos are usually mixed and are linked at different levels, meaning that farmers may experience some or all of the benefits identified in the literature. This activity sought to identify what farmers perceive to be the links within their systems, how these links might be strengthened in the future, and what the constraints are to achieving this. Identifying farmers' perceptions of the links and constraints gives a 'demand side' perspective of integrated farming systems, and can identify future pathways for strengthening crop-livestock links to achieve increased benefits for smallholders.

A focus group discussion approach was used to gauge farmers' perceptions regarding crop-livestock integration within their farming systems. Focus group discussions were held with 51 farmers (13 women) in six villages in Savannakhet and Champassak.

### ***Farming systems: What kinds of links do farmers see?***

A 'successful farming system' envisaged by the participants focused on self-sufficiency in rice in addition to livestock and non-rice production. This is already the most common central strategy for farming households in lowland areas of southern Laos today, as described earlier and by Manivong et al. (2014), and achievable by relatively wealthier farm households. However despite the common strategy, most households do not currently achieve the levels of production associated with the 'successful' systems, and changes are required to the system to improve productivity. Farmers' perceptions of an 'ideal farm' have previously been found to be consistent with the relatively better-off farm types within a given region, and 'average' farms could move towards this ideal situation in alternative ways, including intensification through input related approaches and/or by structural and qualitative change (Tittonell et al., 2009).

Farmers were able to identify a range of links within their farming system (Table 1). The level of those links depends on the current farming system and level of diversification; access to resources (including land, water and market access) influences the type of farming systems possible (van Keulen and Schiere, 2004). In locations where resources are favorable, farmers diversify their farming system, which allows for stronger and more numerous links between parts of the farming system. To contrast two villages, Village 1 (which was close to the road and had access to water) had lowland rice, livestock and vegetable production; Village 2 (far from the road, with access to a water source) had traditional lowland rice varieties and livestock. In Village 1, there were many links identified, with both crop and livestock by-products being used intensively and in a strategic manner. In contrast, the links in Village 2 were minimal, with the only identified link being that animals grazed on standing rice straw (as well as forest areas) during the dry season. As the level of diversification increases, so too do the opportunities to strengthen links within the farming system (Rufino et al., 2009).

**Table 4 Crop-livestock links in farming systems in southern Laos**

Link	Example
<b>Livestock – rice</b>	<p>Rice straw forms the key staple diet of cattle, buffalo and goats in the dry season, generally through grazing on this resource. Sometimes rice straw is collected and stored for animal feed in both wet and dry seasons. In the wet season rice straw is required because grazing area is limited; in the dry season, all feed resources are limited.</p> <p>Apply manure to rice fields, either by collecting it from livestock pens and applying it manually, or directly by tethering animals in rice fields.</p> <p>Rice husks used as a form of bedding for goats.</p>
<b>Livestock – post rice crop</b>	<p>Manure for vegetable production</p> <p>Crop residue for animal feed</p>
<b>Livestock - Home garden</b>	<p>Use manure for home garden production</p> <p>Use low quality fruit and vegetables to feed poultry, and then apply poultry manure to vegetable gardens</p>
<b>Crop – crop</b>	<p>Rice straw for preparation of beds for vegetable production</p> <p>Observe an increase in soil fertility after post-rice gardening (impact on the yield of the following rice crop)</p>

There are definite and strategic links and management practices used to optimize mutual benefits between crop and livestock systems. For example, farmers in two of the villages demonstrated the importance of rice straw in their systems, by declining to sell straw outside the village, and one village also declined to sell manure. This gives a clear message that farmers understand the value of these resources as fundamental to their production systems.

It was highlighted that links are not regular and are often opportunistic; farmers (notably female farmers) in Village 1 said that they would like to change to more continuously linked systems, and had several clear ideas for pathways to achieving this, for example by expanding the area and timing of vegetable production and/or by improving goat production system to increase the quantity of manure available. In the villages where women participated in the discussions (3/6), it was noted that they seemed to have a

better understanding of the links within their farming system, and also ideas on how to strengthen those links in the future.

The limits to integration are the same as for other management constraints and resource availability issues, rather than lying with the process of integration itself. Resource limitations like water, land and labour were highlighted by participants, although labour was only seen as a limitation in two villages, despite being frequently reported as a limitation in the literature (Suh, 2014; van Keulen and Schiere, 2004). Water availability determines the scale of post-rice crops that can be produced, and grazing land influences the level at which farmers rely on alternative feed sources for livestock. Pest and disease management for both crop and livestock was also mentioned in all villages. In fact, the most common limitation raised was access to information and technical assistance for implementation of improved techniques.

### ***Conclusions and implications for further work***

Any changes to farming systems should be able to be introduced gradually (step-wise) and sustainably for lasting impact. 'Successful' farming systems are currently seen as an improved version of the current crop-livestock system, with emphasis on rice self-sufficiency and robust livestock production systems. Current farming systems can therefore be seen as a stable platform from which to pursue farm-level and livelihood diversification (Manivong et al., 2014) to shift farmers along the pathway to their perceived 'successful' systems. Farmers identified several links between crop (rice and non-rice) and livestock systems, and demonstrated the importance of those basic links (rice straw as a feed source, manure as fertiliser) within their farming system. This highlights the importance of focusing on these parts of the system as entry points to improving resource use efficiency.

What is practised in terms of diversification and intensification changes the links between crop and livestock, both by creating opportunities for new links and by changing the strength of existing links, for example the quantity and quality of flows between systems. Pathways for strengthening links to improve resource use efficiency could include changes at range of scales, including increased input use intensity through to structural changes that require intensification of labour, management and investments (Tittonell et al., 2009). These could incorporate simple changes to existing systems to improve productivity at minimal financial and labour costs, for example treated rice straw, better storage of manure and residue to increase feed and nutrient quality, through to major changes to farming systems such as introducing new elements like post-rice crops or different livestock management techniques.

Knowledge and access to information came up as a limitation to testing and applying new technologies in every village, so any technical options to strengthen links for improved resource use efficiency must also give due consideration to extension approaches, support structures and patterns of adoption. Research should also consider how the alignment between intensification pathways and household types is played out in southern Laos. Farmers have identified a range of links within their farming systems; the challenge is to align farmers' aims with practical measures to move them along the pathway towards strengthened integration.

### ***Summary of farming systems understandings***

Drawing together the perspectives of farmers, agriculture staff and researchers generates a deeper understanding of farming systems, and the links within those. Drawing on the literature, applied research and practical experience, technology links within lowland rice based systems are evident. Farmers showed practical examples of these links, and the ways in which access to resources (in particular water, markets and information)

influences the level of integration within farming systems and the wider community. By further exploring the farming systems from different 'ways of thinking', options for identifying and addressing constraints can be identified. To be implemented in a sustainable way requires input from different stakeholders. The approaches described here can be used within multi-stakeholder groups to create shared understanding, and for strategic planning and priority setting.

### ***Engaging with stakeholders for outscaling and exploring the value of networks***

Complex problems require multiple stakeholders to collaborate to generate unique solutions. The activities within SLP Variance 5 focused on understanding farming systems from different perspectives, in order to identify system links and constraints and challenges. Addressing these constraints needs inputs from multiple sources. A final workshop was held to communicate technical and synthesis materials, and explore the idea of creating networks to facilitate system change, with provincial stakeholders. A deliberate attempt was made to bring together a wide cross-section of agricultural stakeholders to identify knowledge and action gaps, to get different perspectives, explore roles and responsibilities, and come to a common understanding about some of the actions that could be taken to solve systems constraints. In addition to presenting the project outputs, this workshop also linked technology and systems integration with the innovation network process at the provincial level. Concepts of innovation networks were presented and related to practical systems understandings in southern Laos. In small groups, participants worked on documents (systems diagrams, stakeholder logs) from a previous workshop. The aim was to get feedback on these concepts and processes through small group work and wider discussion, with regard to gaps in current understanding, how such networks could work in practice, and what different stakeholders see as the benefits of such an approach.

It was clear to see the different and diverse inputs from members of the private sector, banks, agricultural colleges, and Department of Industry and Commerce, often with vigorous debate and different opinions between the different participants with regard to the most appropriate measures to be taken. For example, when the low price of rice was identified as a constraint, there was much debate around using subsidies as a solution, or other incentives. This is a good example of the value of having diverse stakeholders engaged, and being able to manage opposing viewpoints within a group. Discussions and comments moved beyond just physical/technical aspects and incorporated more of the 'ways of thinking', for example two of the groups first mentioned conflict between farmer tradition and new technology (social/aesthetic); the commercial angle talked more about management of relationships (sympathetic); and there was also discussion related to the lack of awareness and adherence to rules and regulations (social). These understandings were captured through documented changes to systems diagrams and an issues log identifying stakeholders, roles and responsibilities.

When looking for ways to manage multi-stakeholder networks, participants highlighted some of the key lessons for working with stakeholders, based on their prior experiences:

- Forming groups and identifying the right stakeholders
- Managing rules and regulations; enforcing arrangements
- Managing relationships
- Aligning stakeholder responsibilities with role and capacity
- Understanding priorities

These discussions demonstrate the value of bringing together diverse stakeholders to address system constraints; despite a small number of participants from commerce, the private sector and others, their different views were valuable in expanding the understanding of the group, and in some cases allowing debate to occur. Based on prior experiences, there were also some key lessons learned that could indicate aspects to be managed in a multi-stakeholder group. This feedback and lessons learned will inform the establishment and management of innovation networks within CSE/2014/086.

### **Summary and way forward**

Variance 5 has resulted in the synthesis of crop and livestock project outputs for practical uses, refocusing attention on these technologies and their application in southern Laos. Technical materials are being shared with relevant stakeholders, and are available for use in subsequent projects. Importantly, Variance 5 has allowed the exploration of their position in the wider farming system, improving understanding through synthesizing aspects of research outputs, the literature and participant experiences. This has included discussing and documenting farmers' perceptions, reviewing socio-economic outputs with regard to analysis of household livelihood analysis and market chains, and using integrative enquiry to enhance understanding of systems constraints. Practical tools will be further developed in the subsequent project that are able to be used by DAFO and PAFO staff for greater understanding of farming systems, and for identification of actions for addressing constraints with multi-stakeholder groups.

Initial work with external stakeholders has demonstrated the value of diversity within a group to develop broader options to address constraints. Based on experiences, key aspects of managing groups in southern Laos might include ways of forming groups and identifying stakeholders, building awareness of and managing rules and regulations, managing relationships, aligning stakeholder responsibilities with capacity and work role, and understanding different priorities. The Crop-livestock systems platform for testing practices, capacity building community learning and commercialization project (CSE/2014/086) has been designed to follow on from this project, and the extension period has allowed a strong base from which to proceed, including through reviewed familiarity with technical content, methods for enhancing systems understanding, and a recognition of the value of working within diverse networks.

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## **7.7 Conclusion and future opportunities**

As its overall goal, the South Laos Project strove to improve food security and rural livelihoods in southern Laos. In working towards this goal, the project team explored and enhanced understanding of farming and marketing systems, appropriate crop and livestock technologies, and water availability and management. Operationally, the project team worked in a range of on-farm and on-station locations to generate locally tested, contextually relevant options for smallholders in the south. These activities resulted in an impressive array of outputs, including;

- A better understanding of farming systems, market chains and their interaction.
- Better matched rice varieties to different project locations and systems constraints, including lowland, upland, flood-prone, drought-prone, and pest-resistant (RGM). Many of these varieties have been adopted by smallholders, and continue to be used in project locations and beyond.
- A suite of appropriate forage Germplasm suitable for use in southern Laos, and importantly, lessons learned for researchers and extension staff in terms of extension approaches that are suitable for the south, where experience was

previously lacking. While these forage options have not been adopted on a wide scale, existing farmers have larger plots and a clearer idea for how these fit within their system. There is also evidence of other forage types being outscaled in Savannakhet province (e.g. Napier), and it is possible that staff experience at the DAFO and PAFO level in working with the SLP has contributed to this success.

- A more thorough understanding of the local hydrology of Champassak province (Soukhouma district), with real potential for evidence-based policy development of groundwater regulations in this region, at a critical time in the groundwater development timeline.
- A broad contribution to capacity development at a range of levels, from farmers and extension officers at district and provincial levels, through to researchers and policy makers at the national level. This capacity has been developed across technical as well as 'soft' skills, and importantly, project participants (e.g. at the district level) report increased confidence, ability and motivation to deliver in their roles. The project has also given an opportunity to enhance systems thinking, including through tools for strategic planning and priority setting.

The results from the SLP provide a sound understanding of farming and marketing systems in southern Laos, and importantly, have created capacity at all levels for taking these results and experiences to another level. While there is evidence that some farmers are using technologies tested and developed by the project, there is room to improve for lasting impact. Options for outscaling these results lie in creating conditions that are favourable for innovation, in terms of linking research with the wider system, and providing support through different mechanisms. The SLP has supported research and extension, and this has formed a sound base from which to proceed with the subsequent, complementary project (CSE/2014/086) 'Crop-livestock systems platform for capacity building, testing practices, commercialisation and community learning (CLSP)'. Consequently, CLSP has a continued focus on integrated crop-livestock systems and will initiate approaches for bringing together multiple stakeholders to generate and support innovation in the farming system, building on the results produced within the SLP.



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## 7.8 Training Activities

### *Socio-Economics*

#### **1. Pre-survey training (household surveys)**

Initial training - **26<sup>th</sup> April 2011**, NAFRI, Vientiane

Conducted by Mr Vongphaphane Manivong, Mr Khamphou and Dr Jonathan Newby

Participants included 2 NUOL staff, 2 NUOL students and 8 NAFRI staff.

Second training – **6<sup>th</sup> May 2011**, Xepon district, Savannakhet

Conducted by Mr Khamphou and Mr Sian

Participants (entire team):

2 NUOL staff (enumerators)

2 NUOL students (enumerators)

3 PAFO junior staff (enumerators)

3 NAFRI staff (enumerators)

Mr Khamoun - PAFO head of crop division

Mr Khamphou - NAFRI

Dr Jonathan Newby – UQ

The training involved going through each question and the possible responses, while members of the team raised queries with the survey coordinators.

#### **2. Training on value chain survey**

Date – **11-15 July 2011**, NUOL, Vientiane. Totally 5 days

Conducted by Mrs. Phengkhouane Manivong, Thansamay Dethphakhoun

Participants included 5 NUOL staff and 5 NAFRI staff.

#### **3. Economic analysis of agronomic trial and survey data for farmer recommendations and policy advice**

Date: **March 13 – 15<sup>th</sup>, 2012**

Location: Policy Research Centre, NAFRI Vientiane

Training conducted by: Dr Jonathan Newby and Vongphaphane Manivong

Objective:

- To provide training in basic techniques for evaluating the economic performance of various agricultural activities
- To discover various indicators of economic performance
- To understand the importance of risk and uncertainty
- Translate agronomic and survey data into farmer recommendations and policy advice

Topics covered

- Designing on-farm experiments that enable economic analysis
- The role of economic analysis in on-farm research analysis
- Farmer goals
- Enterprise budgeting
- Partial budgeting

- Opportunity cost
- Net present value analysis
- Marginal analysis
- Sensitivity analysis
- Threshold analysis
- Risk analysis

Trainees: Total 18 (16M, 2F)

- Policy Research Centre (NAFRI) - 9 (8 M, 1 F)
- Division of Planning and Cooperation (NAFRI) - 1 (M)
- Department of Agriculture, NUoL - 3 (M)
- Agricultural land research and planning centre (MAF) - 1 (M)
- Phonengam Research Centre, (Champasak) - 2 (M)
- Agricultural Section, PAFO Savannakhet - 2 (1 F, 1 M)

#### **4. Training on Rapid Market Survey**

Date - **1 to 5 October 2012**, Savannakhet.

Conducted by Mrs. Phengkhouane Manivong, Silinthone Sacklokham

Participants included 12 district and provincial staff from Savannakhet and Champasack

#### **5. Training on data analysis methods in value chain study**

Date- **18<sup>th</sup>- 22<sup>nd</sup> March 2013**, Vientiane

Conducted by Mrs. Phengkhouane Manivong, Thansamay Dethphakhoun

Participants included 6 NUoL staff and 4 NAFRI staff

### **Forage/Livestock**

#### **6. Technical training on forages, silage, farming systems and research approaches**

**October 01, 2012 to December 21, 2012:** CIAT HQ, Cali, Colombia. Intensive training for Mr. Souksamlane Khamphoume

Funded by *On-the-Job Research Capacity Building for Sustainable Agriculture in Developing Countries* and CIAT

Purposes

1. Enhancing the trainees' capacity to develop research questions and approaches to address practical challenges that smallholder livestock farmers in their country are facing in a scientific manner and document them properly. The expected outcome is an increased capacity to develop consistent and reality-oriented research proposals independently, and improved technical knowledge, to carry out their research in a sound scientific manner. To achieve this, the candidates will be presented with an actual case from which they will have to identify an underlying problem. They will develop a research approach to address the constraint and will test, in a guided approach, different methodologies for finding a solution to the problem. The results shall be documented in a scientific article, improving their documentation skills.
2. Contributing to the current ensiling research program at CIAT by testing the technology in their home countries and provide new input to locally implemented livestock projects. Back in their home countries, a conjoined developed action plan will enable the trainees to conduct further experiments on the topic and test the viability of the approach

and its extension. Importantly, distance supervision and follow-ups will be given to help overcoming local challenges.

**7. PAFO livestock contact staff intensive training, Khon Kaen University Thailand, March 18 to April 28, 2013.**

Mr. Kongsackda received training in animal nutrition and feed technologies (in which KKU has a recognized regional expertise). The work group of Dr. Kritapon is specialized in this field and offered to integrate Mr. Kongsackda for the given time in their workgroup. The training included three main parts, a 15 hour lecture, observation and practice at the KKU research farm with students and the farm manager, and a 3-day study tour to farmer groups in Sakornnakorn province.

**Water/Hydrology**

**8. Farmers' training on AWD and Best Management Practices in rice production**

Four batches of training on AWD and associated best management practices in rice production were conducted to provide farmer-co-operators and other farmers in study sites in Savannakhet and Champassak provinces with practical knowledge on AWD and other water management practices; give hands-on experience in the installation of field water tubes as a tool for AWD implementation, and explain the implementation protocol of AWD technology demonstration trials.

31 Jan 2012, Boungkeo, Soukhuma, Champassak, total of 15 participants, 13 males and 2 females.

2 Feb 2012, Veun, Mounlapamouk, Champassak, total of 16 participants, 10 males and 6 females.

3 Feb 2012, Phaeleng, Champone, Savannakhet, total of 16 participants, 10 males and 6 females.

4 Feb 2012, Sakehun, Champone, Savannakhet, total of 10 participants, 9 males and 1 female.

**9. AWD Farmers field day (March 14-17, 2012)**

The objectives of the field days were to showcase the AWD demonstration trials to other farmers, on-site briefings and experimental sharing among farmers.

The field days were conducted in demonstration sites in Sakeun and Phaleng villages in Champone, Savannakhet (total of 25 participants), and Thaseng and Thakor villages in Soukhuma, Champassak (total of 37 participants).

**10. Training the students in irrigation measurements, Savannakhet (27-29 November 2012)**

The objectives of the training were to: a) teach students how to estimate irrigation input from pumps (including how to calibrate pump flow rates), b) provide overview on the principles and practices of alternate wetting and drying, c) explain the protocol for implementing AWD for farmers in Savannakhet.

**Knowledge Sharing**

**11. Establishing & Maintaining a Demonstration Site**

During the 2011 wet season the project identified the need for training of DAFO staff in the establishment of demonstration site and the collection of suitable data from the sites. This together with the identification of the desire of staff in the Outhomphone district to be trained in this are also (see needs analysis training table) KS proposed a series of training workshops for the DAFO staff. The first workshop was the establishment and maintenance of field demonstration site and was held in Outhomphone and Phin districts.

There were a number of organisations involved in the provision of the training:

- SLP project staff; Thongchanh and John Lacy
- PAFO staff Khammone and Ly
- DAFO staff Somkiat
- Konada Rao (a manager from pulp and plantation company Birla Lao).

#### Methodology:

Each training session was held over two days. The first day allowed for training on the selection of demonstration sites using an IRRI fact sheet. Those attending the training were then split into small groups, based on their interest and experience, to discuss the application of the factsheet within their area of interest.

The facilitated small groups were asked 1) to discuss how to plan, conduct and measure the results of a successful field demonstration and 2) how would the results be communicated to farmers in the village or district. Each small group then reported back to the group as a whole generating discussion on the requirements for demonstration within each circumstance.

The second day allowed field inspections of two existing demonstration and/or research sites at each training location. This enabled discussion about the advantages and disadvantages of the sites with practical application of what had been learnt during day 1 of the training.

#### Results:

A total of 41 participants were trained in the two workshops. In Outhomphone there were a mix of DAFO, PAFO, farmers from both Outhomphone and Champassak and Birla Lao staff. The training at Phin was a mix of DAFO, ADB/IFAD project members and farmers representing Nong, Sepon, Phin and Phalanxai districts.

Participant numbers and organisation:

Location	PAFO	DAFO	Farmers	Other	Total
Outhomphone	4	8	1	6	19
Phin	4	2	10	10	22

## 12. Integration and technical skills for dry season activities

The training took place in Outhomphone on 27<sup>th</sup> – 29<sup>th</sup> November 2012. The total number of participants was 50 (including 10 women). This included DAFO staff, volunteer DAFO staff from Champassak (3) and students from Na-Keh Agricultural College. PAFO officers from Champassak and Savannakhet also attended, as well as project members from Knowledge Sharing, Crop, Livestock and Water components.

Participants in the integration training:

Participants	PAFO	DAFO	Farmers	Other	Total
Savannakhet	6	15			21
Champassak		9			9
Champassak DAFO volunteers				3	3
Na Keh Agricultural Collage				7	7
NAFRI				7	7
Knowledge Sharing				3	3

<i>Total</i>	<i>6</i>	<i>24</i>	<i>0</i>	<i>20</i>	<i>50</i>
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The training covered various topics. Integration and farm management (presented by Mr Thongchanh) described the definition of both integration and management, and also contained details of integration types and its effectiveness, including raising awareness in farm management. In addition to this, we discussed the SWOT analysis approach, with staff from each district spending time thinking about their own district using this approach. This was followed by district group presentations on results, which will be used for further activity planning. The second topic was Data Management (presented by Tamara and Soulyphone), covering data collection methodology, and giving principle and methodology of data collection, avoiding data bias, and how data is effectively used for analysis. Technical topics included: the relationship between crop, soil and water (presented by Dr Thavone), calculation of amount of water applied and the AWD technique (presented by Somsamay), BMP in rice (presented by Mr Sipaseuth), crop sampling and experiment design (presented by Saisathit), and cattle fattening and poultry raising (presented by Viengsavanh). Two practical sessions were included: in groups working on SWOT to present the context of their district for further development of an action plan for the coming fundamental skill training, and experimental design for volunteers assisting farmer at the focal villages.

### 13. Fundamental Professional Skills

In total, 35 staff attended this training, including PAFO staff who participated and helped with the delivery of presentations and with assisting in practical activities.

<b>Participants</b>	<b>PAFO</b>	<b>DAFO</b>	<b>Other</b>	<b>Total</b>
Savannakhet	5	10		15
Champassak	6	8	1	15
NAFRI			2	2
Knowledge Sharing	1		2	3
<i>Total</i>	<i>12</i>	<i>18</i>	<i>5</i>	<i>35</i>

Topics covered by this training session included the following:

1. Microsoft Office – Word, Excel, PowerPoint (for presentations and poster design)
2. Data management
3. Statistics – basic experimental design and data analysis
4. The internet – how to find reliable information, using social media
5. Case study writing
6. Developing District Action Plans

Sessions were structured to incorporate hands-on activities, and participants were given time to develop case studies and action plans for their districts, using the skills learnt in previous sessions. A computer was available for groups of 2-3 staff members to work together during the training session.

A significant amount of time was devoted to the District Action Plan activity, which followed on from work during the previous training session in November. Staff then assessed their districts using the SWOT approach (Strengths, Weaknesses, Opportunities and Threats). To build on this, each district was asked to identify one (or more) activity that had been trialed by the project in their district, and develop an extension plan for their district, including a budget and workplan.

Each district produced a presentation and report containing a workplan and budget for their District Action Plan. These will be incorporated into the KS workplan for 2013. In general, the standard of these was high, with participants spending a significant amount of time discussing and planning these activities. Feedback from participants was positive,

with several mentioning that more time could be spent on this activity in the future, including thinking about where the technologies fit and with which types of farmers.

## 7.9 Cross-Site Visits

### Socio-Economics

#### 1. Vegetable Marketing, Ban Nongbua, Phontong district

This cross-site visit was conducted in Bane Nongbua, Phonethong, Champasak on 13<sup>th</sup> December 2012. A farmer group with 4 households headed by Ms Pouna, Mr Thongsai, Mr Pheng and Mr Kham was visited.

Objectives:

- To provide an opportunity for Savannakhet DAFO and farmers to learn greenhouse techniques and vegetable contract farming from farmers in Champassak.
- For farmers to be able to apply this model for income generation in Savannakhet

Implementation:

- KS members linked with Smallholder Project in Pakse to select a pilot group of vegetable growers, also linked with DAFO in Phonthong concerning the agenda and content for discussion.

In total, there were 23 participants, including two women.

Location	PAFO	DAFO	Farmers	Total
Nong		1	2	3
Sepone		1	1	2
Pine		1	3	4
Phalanesai		1	3	4
Outhoumphone		1	2	3
Savannakhet	1			1
Champassak	1			1
Smallholder Project	2			2
Knowledge Sharing component	3			3
<b>Total</b>	<b>7</b>	<b>5</b>	<b>11</b>	<b>23</b>

Outcomes:

- The farmer's gardens were inspected:
  - Ms Pouna's garden is 0.44 ha with lettuce, parsley and onion. She has an income of 10 million LAK in the first 3 months. On average, she has 7 crops per year with income not less than 3 million LAK per crop.
  - Mr Thongsai's garden has 3 greenhouses (8m x 30m) where he produces water spinach, which has a 21 day cycle with an income of 3-5 million LAK.
- Other management techniques include using more locally available resources such as rice straw and manure for compost to make the soil friable and rich in nutrients with a little chemical fertilizer, and also the use of herbal pesticides.
- From the beginning of the project 5 years ago, the Smallholder Project has trained farmers about marketing and facilitated contracting with traders. Now farmers can find markets by themselves by observing the amount of vegetable in the nearest market. The lowest prices are during January – April, so growing in greenhouses in the wet season is very profitable.



- Farmers were satisfied with the lessons learned, but need to visit other sites such as corn growers, effective broadcasting and direct seeding for rice. Also need to visit group where contract farming is very effective.

## Crops

### 2. Improved rice production: Lowland rice varieties and BMP

- a) *Ban Phanomxai, Phalanxai district.* This cross-site visit was held on 13<sup>th</sup> October, 2012.

In total, 25 people attended (including 4 women).

#### Objectives:

- To visit a rice variety trial where farmers could participate in the variety selection of the 14 varieties in the trial
- The sharing of ideas between farmers with technical staff and between farmers themselves, and to provide farmers with information about new rice varieties and Best Management Practices.

#### Results:

- Farmers learned and shared knowledge about techniques and the use of new rice varieties, especially with the farmers who have tried and practiced with the new varieties.
- Farmers can visit, to know and touch the characteristics and outputs of variety in the trial rice field and can consider varieties that are suitable to the situation of their land.
- Farmers discussed and have more understanding about good outputs if they follow and use the best management practice (BMP) on rice.
- The costs of fertilizer and yields required to pay this back were discussed, using data provided by the Socio-Economic team
- After visiting the trial, farmers voted for varieties they liked and disliked.

- b) *Ban Vongsikeo, Phin district.* This cross-site visit was held on the 17<sup>th</sup> October, 2012.

In total, 28 people attended (including 3 women)

#### Objectives:

- To visit a rice variety trial where farmers could participate in the variety selection of the 14 varieties in the trial in Vongsikeo village, Phin district.
- To enable the sharing of ideas between farmers with technical staff and between farmers themselves, and to provide farmers with information about new rice varieties and Best Management Practices.

#### Results:

- Farmers have more knowledge and are interested in the results of rice production for each of the varieties that was planted in the last year.
- Farmers learned and shared knowledge about techniques and the use of new rice varieties, especially with the farmers who have tried and practiced with the new varieties.
- Farmers know and have more understanding about good outputs if they follow and use the best management practice (BMP) in rice.
- Farmers have the new good knowledge about the use of suitable varieties for each area, especially the submergence tolerant rice (TDK1 sub 1).

- Farmers can visit, to know and touch the characteristics and outputs of varieties in the trial rice field and can consider varieties that are suitable to the situation of their land.
- After visiting the trial, farmers can decide and select good and bad rice varieties for them. The results from the PVS are shown in Table 20.

c) *Ban Bounkeo & Ban Khoknongbua, Soukhuma district*. This cross-site visit was held on 10<sup>th</sup> October, 2012.

In total, 25 people participated in the activity, including three women

Objectives:

- To expose more farmers to BMP techniques for them to learn and apply on their own farms
- To promote close discussion between farmers, extension workers and DAFO directors
- To conduct Participatory Varietal Selection for lowland rice varieties

The KS component had linked with Soukhuma DAFO and extension officers concerning the sites in Ban Bounkeo and Ban Khoknongbua, to clarify the objectives for technology transfer and close discussion for better rice growing. Then a date for the visit was appointed, and target farmers invited to join the activity at the learning sites.

The visit started with a meeting at Soukhuma DAFO, where KS staff discussed the objectives of the visit, expectations and further action plans for the district to improve the production system. After that the deputy head of DAFO emphasized the ownership of staff and farmers to learn better lessons from pilot sites and deeper discussion for further implementation. Then we moved to the rice field in Ban Bounkeo and Ban Khoknongbua. Farmers from both sites explained the process of implementation for BMP and PVS technology. Then all participants moved to observe the field sites, followed by discussions and questions among farmers and technical staff. The main points of discussion were about fertilizer rate linking with different soil types, land preparation and soil improvement.

Outcomes:

Farmers exchanged their experiences and learned techniques in the field, many key people explained deeply the technology that made them enthusiastic in rice growing. Close discussion was held among farmers about BMP and variety selection for alternative resource effective use. Finally, farmers were able to build relationships with the other farmers for future reference

The participants reached the following conclusions:

- the quality of soil plays an important role in rice production, especially available microorganisms which make the soil living and effective use of inputs
- different varieties are adapted to different soil conditions and different field toposequences; in the case of Khoknongbua which has fertile soil along the Mekong, we observed that nearly all varieties of rice grew better than at other sites.

Farmers need to visit more sites of different conditions, different farming sizes and levels of mechanization to learn about BMP and select varieties that fit different conditions. We should provide and discuss photos explaining different steps or videos showing the implementation so that farmers can learn in more detail.

There was some difficulty in getting to Soukhuma (difficult road access) that took more time travelling, resulting in a short time for learning.

### **3. Upland rice, Ban Meuangsén, Sepon district and Ban Tangalay, Nong district**

These cross-site visits were held on 17<sup>th</sup> – 18<sup>th</sup> September, 2012.

In total, 55 people attended from PAFO, DAFO and farmers (including four women).

Location	PAFO	DAFO	Farmers	Total
Sepon	4	2	16	22
Nong		4	24	28
Phin		1	4	5
<i>Total</i>	<i>4</i>	<i>7</i>	<i>44</i>	<i>55</i>

Objectives:

- To make a cross site visit for upland rice varieties in Sepon and Nong districts.
- To exchange and share information about upland rice varieties between participants (farmers, DAFO and PAFO staff).

Activities:

- Introduction by PAFO to DAFO and the head of village, after that went to the farmer field.
- Let farmer who grew upland rice introduce this activity.
- Discussion and exchange and sharing of ideas between participants.
- Participants did PVS.

Results:

- Participants exchanged knowledge about growing new upland rice varieties and using those varieties trialed by the southern Laos project.
- Participants saw and touched these varieties at the field at Meaungsan, Seponkao and Tang Alai villages.
- They shared experiences between farmers who have used those varieties before and who would like to use these varieties in the future.
- Participants did PVS about those varieties to see which are preferred and why.

#### 4. Direct Seeding, Ban Phinneaua, Outomphone district

This cross-site visit was held on the 26<sup>th</sup> – 27<sup>th</sup> September, 2012.

PAFO staff participating include:

- Mr Khammone Thiravong, Deputy Head of Crop Section
- Dr Leigh Vial, Expert for direct seeding
- Mr Sysavanh Saiyavong, Technical staff
- Mr Phetsamone Symaly, Technical staff
- Mr Sysavanh Vorlasan, Technical staff

Location	PAFO	DAFO	Farmers	Total
Outomphone	5	2	21	28
Champhone			3	3
Phin			5	5
<i>Total</i>	<i>5</i>	<i>2</i>	<i>29</i>	<i>36</i>

Outcomes:

- Farmers learned and shared knowledge about techniques and the use of the drum seeder (wet direct seeding) and dry direct seeding, especially with the farmers who have tried and practiced this method.

- Farmers can visit, to know and touch the results of direct seeding in trial demonstration in Phinnuea village, Outoumphone district, Savannakhet province.
- For the farmers who have not been successful, they can see the results and they also need to expand out of the trial area.
- Other farmers who have not participated in direct seeding activities are also interested in and need to use this technique.
- The coordination with DAFO and authorities was good
- PAFO and DAFO have participated in the organization of activities with successful results.
- The participants were attentive and interested in the technique of dry direct seeding and how to use the drum seeder in wet conditions.
- The participants from other districts (Phin and Champhone district) also want to have a drum seeder to practice the technology in their village.

## 5. Commercial Sweet Corn Producers, Ban Keune, Vientiane province

This cross-site visit was held on the 20<sup>th</sup> December, 2012.

Objectives:

- To provide knowledge to farmers and DAFO staff, after wet season harvest, to practice sweet corn production effectively as a fallow crop for supplemental income generation in the dry season.
- To introduce the concept for DAFO staff and farmers to be proactive to practice agricultural production in a large farm size to supply the commercial factory.

Implementation and participants:

After the results of cross-site needs assessment from farmers was conducted in both provinces, we set the agenda and objectives of the visit. Farmers visited a group of sweet corn producers and company factory of milk corn. Participants were selected from both provinces, with 34 participants attending the learning visit, including five women.

Location	PAFO	DAFO	Farmers	Total
Nong		1	3	4
Sepone		1	2	3
Pine		1	1	2
Phalanesai		1	2	3
Outhoumphone		1	4	5
Phonethong			5	5
Soukhuma		1	1	2
Mounlapamok		1	2	3
Phone Ngam	1			1
Crop component	3			3
Knowledge Sharing component	2			2
<i>Total</i>	<i>6</i>	<i>7</i>	<i>20</i>	<i>33</i>

Outcomes:

- There are 7 farmer groups with an area of 3.4ha. But the total number of producers in Ban Keune is 42 households with a total area in the wet season of 530 ha, and in the dry season 200 ha. All the production is to feed the corn milk factory.
- Farmers access two types of credit:
  - Credit from the bank

- Advance investment from the company - in land preparation, seed and fertilizer. The company also contributes irrigation water and transportation for all producers.
- The production is valued in 3 quality categories: Grade A - 1300kip/kg; Grade B - 800kip/kg; Grade C - 500kip/kg.
- As well as the operational aspects of production, participants learned the basic techniques of commercial sweet corn production using irrigation water, including hand tractor for land preparation, planting techniques and water management.
- Participants commented on the following advantages for Bane Keune farmers:
  - They have a corn factory, good soil along Nan Ngum river, and good infrastructure.
  - They have bigger market access, higher mechanization compared to southern provinces.
- All participants were satisfied with the visit that opened their view for the future commercial production in the provinces. For the next visit, we should organize for another industry crop to learn more technology in agriculture that fits the current trends of socio-economic development.

## 6. Crop Establishment Methods, Water Management & Dry Season Cropping

In total, 35 participants attended the field day in Ban Alan Watana. This included Dr Leigh Vial from IRRI, who had previously established a direct seeding trial in the village.

Location	PAFO	DAFO	Farmers	Total
Savannakhet	7	3	23	33
Knowledge Sharing component	2			2
<i>Total</i>	9	3	23	35

This cross-site visit was held on the 30<sup>th</sup> March in Ban Alan Watana, Champhone District. In this village, there are a number of demonstration sites, including:

- Direct seeding using a drill seeder
- Direct seeding using a drum seeder
- Machine transplanting
- Laser levelling
- Water management using Alternate Wetting and Drying (AWD)
- Legume establishment in the dry season (eight new varieties of short duration mungbean)

Additionally, farmers can compare the alternative crop establishment methods with farmers' practices of hand transplanting and broadcasting.

Objectives:

- To expose farmers to different crop establishment and water management methods, with opportunities for farmer-to-farmer discussion.
- To show farmers new varieties of legumes (short duration mungbean).
- To get feedback from farmers regarding crop establishment methods, water management methods and mungbean varieties, and to determine research questions for the 2013 wet season.

The field day was conducted as follows:

- Introduction to the objectives and agenda of the day, with time for farmers to look at and discuss three kinds of direct seeders: a drum seeder, drill seeder (with tyne assembly), and a direct disc seeder.
- Move to look at the laser leveled fields, and those established using a machine transplanter. These were compared to farmers' practices of transplanting and broadcasting.

- Discussion of the direct seeding trial using the tyne assembly. This included a fertilizer trial, and the effects of sowing with and without fertilizer were very prominent. Dr Leigh Vial and Mr Khammone conducted this session.
- Discussion of the drum seeder and AWD technique.
- Discussion and observation of the new varieties of short duration mungbean, including Participatory Varietal Selection (PVS) to determine preferred varieties by farmers.
- A final discussion followed lunch, with presentation of the steps of Best Management Practice, and discussion of the PVS results.

### **Forage/Livestock**

#### **7. Farmer field visit to Xieng Khuang, 21-26 November, 2012**

16 farmers were invited to join a field visit to former project sites in Xieng Khuang province where they visited improved smallholder production systems on cattle fattening, poultry breeding and pig production. Also, established farmer groups were visited and their advantages compared to individual farmers were discussed.

Participants:

- Mr Viengsavanh Phimpachanvongsod, Livestock Component, NAFRI.
- Mr Daosadeth vongsin, Technical Assistant, LRC, NAFRI.
- Mr Bounna, district staff, Xepone DAFO, Savannakhet province.
- Mr Bounmy, farmer from Nong district, Savannakhet province.
- Mr. Khamsay, farmer from Nong district, Savannakhet province.
- Mr. Laga, farmer from Xepone district, Savannakhet province.
- Mrs. Vone, farmer from Xepone district, Savannakhet province.
- Mr. Bounlay, farmer from Phine district, Savannakhet province.
- Mr. Xaythong, farmer from Phine district, Savannakhet province.
- Mr. Thone, farmer from Phine district, Savannakhet province.
- Mr. Cheuy Thepsombad, farmer from Phine district, Savannakhet province.
- Mr. Khamtanh, farmer from Outhoumphone district, Savannakhet province.
- Mr. Bounxou, farmer from Outoumphone district, Savannakhet province.
- Mr. Pha, farmer from Outoumphone district, Savannakhet province.
- Mr. Khong, farmer from Phonethong district, Champasak province.
- Mr. Souk, farmer from Soukouma district, Champasak province.
- Mr. Some, farmer from Soukouma district, Champasak province.
- Mr. Vieng, farmer from Soukouma district, Champasak province.

#### **8. Farmer training and cross visit: forage maintenance Naphokham**

**October 2, 2012:** Farmer (and DAFO) training at the biological station at Naphokham, Savannakhet province

The Governor of Phin was invited to get to know the project.

The learning activity comprised theoretical information, training on yield measurements and quality assessment, and farmer-to-farmer exchange to discuss forage plot and animal management.

Participants:

- 19 farmers from 5 villages (Naphokham, Nathom, Naseeng, KhamsaEe and Oudomxay) of Phine district.
- 2 development workers from Naphokham development focusing zone.
- 1 technician from Phine DAFO.
- 1 manager and 1 policy marker from Phine district authority.



- 2 farmers from 2 villages (Ladhor, Kengluang) Xepone district.
- 2 development workers from Ladhor development focusing zone.
- 2 technicians from Xepone DAFO.
- 4 technicians and extension from Savannakhet PAFO.
- 4 students from Savannakhet University.
- 3 from LRC, NAFRI.

## 9. DAFO staff training tour to Thailand, 20 Feb-3 March 2013

10 day training tour to livestock production and research facilities in Thailand.

Financed by the Rice-based Systems Research (RSR) program, ACIAR and CIAT project funds

Date	Activities
20/02	Travel to Paksong, Nakhonerasasima
21/02	Visit Paksong animal nutrition research centre ( <b>on station research activities</b> )
22/02	Visiting <b>on farm research and development activities</b> ; Nakhonerasasima and neighbouring provinces.
23/02	Visiting <b>on farm research and development activities</b> ; Nakhonerasasima and neighbouring provinces; and travel to Khonekane.
24/02	Visit Khonekene animal nutrition research centre ( <b>on station research activities</b> )
25/02	Visiting <b>on farm research and development activities</b> ; Khonekene and neighbouring provinces.
26/02	Visit Khonekene University.
27/02	Travel to Sakonnakorn; Visit Sakonnakorn animal nutrition research station ( <b>on station research activities</b> ).
28/02	Visiting <b>on farm research and development activities</b> and in Sakonnakorn province (included Phonngangkham cattle fattening cooperative).
01/03	Visiting <b>on farm research and development activities</b> and in Sakonnakorn and neighbouring provinces; and travel to Moukdahan.
02/03	Visit Moukdahan animal nutrition research station, Visiting <b>on farm research and development activities</b> in Moukdahane province.
03/03	Travel back to Lao.

Participants:

- Mr Viengsavanh Phimpachanvongsod, Livestock Component, NAFRI
- Mr Souksamlane Khampoumee, Technical Assistant, LRC, NAFRI
- Mr Toun Keowpaseut, Technical Assistant, LRC, NAFRI
- Mr Kongsackda Inthaphouthone, Technical Officer, Livestock Section, Provincial Agriculture and Forestry Office, Savannakhet
- Ms Bangon, District Agriculture and Forestry Office, Phin District, Savannakhet
- Ms Phetsakone, District Agriculture and Forestry Office, Outomphone District, Savannakhet
- Mr Phetpoumy, District Agriculture and Forestry Office, Nong District, Savannakhet
- Ms Oudom, District Agriculture and Forestry Office, Soukhouma District, Champassak

## **Knowledge Sharing**

### **10. Integrated Farming Systems, Ban Don Jod, Phontong District**

Following the project's activity of selecting Focal Villages for activity implementation, Mr Kong's farm in Ban Don Jod (Phontong district) has emerged as a good example of an integrated farming system. During the dry season 2013, several activities are being undertaken, including:

- Confined cattle system, based on irrigated forage, corn stover and urea treated rice straw
- Staggered planting of dry season sweetcorn
- Intercropping of peanuts and mungbean

During the third training activity in Pakse in March, the opportunity was taken to arrange two cross-site visits to Ban Don Jod, one for farmers from Ban Nahsomvang and Ban Don Jod (5<sup>th</sup> March), and one for the training participants (PAFO and DAFO staff) (6<sup>th</sup> March). In total, 53 farmers and staff participated in these cross-site visits

	<b>Farmers</b>	<b>PAFO/DAFO Staff</b>	<b>Total</b>
Male	12	26	38
Female	7	8	15
Total	19	34	53

Participants discussed the individual activities being undertaken, and also had a chance to ask questions of Mr Kong and technical specialists from NAFRI.

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## 8 Impacts

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### 8.1 Scientific impacts – now and in 5 years

This project has contributed broadly to the understanding of farming systems in southern Laos, from several aspects, including socio-economics, marketing, local hydrology, rice and non-rice production, livestock management options, and extension approaches. Additionally, there is much to be gained from the systems approaches used, including for integration of technical and project activities, and in the tools used to improve systems understanding.

Individual activities that have shown promise and have the potential to continue to make impact include;

- A practical typology for classification of farm households, to understand farming systems and farmers decision making.
- Better understanding of crop performance in southern Laos, including rice (lowland, upland, pest-resistance, flood-tolerant, drought resistant, direct seeded, perennial), non-rice (maize, chilli, mungbeans, peanuts, longbean) and forage (suitable Germplasm for lowland systems).
- Better understanding of nutrient management, both for rice and post-rice crops, and the associated economic interactions.
- Better understanding of dry direct seeded rice, including drill seeding, weed and fertiliser management options.
- Quantification of water resources availability (surface – ponds - and groundwater), and groundwater behaviour in Champassak province (in particular in Soukhouma district). This information could help to inform policy development for groundwater management at a critical time in the development timeline.

A complete set of technical reports were developed, with many of them published as papers in the Lao Journal of Agriculture and Forestry (Volume 30, 2014), in the Lao language, ensuring that scientific results are available for the wider Lao agricultural community. Finally, higher-level reporting included contribution of five papers to the RSR workshop in Phnom Penh in April 2014, and manuscripts for international conferences and scientific journals.

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### 8.2 Capacity impacts – now and in 5 years

There has been a major investment in capacity building, via training to NAFRI, provincial and district staff, which enhanced the ability for scientific and community impacts both during the project and in the following period. This capacity building was essential, as this project included topics that were relatively new in the south, and where there was initially low or no capacity, especially forage/livestock and water resources quantification and management. In addition, there has been training in protocol development, data handling and analysis, and financial acquittals (Section 7.8).

To achieve a greater integrative focus required changes to project staff, training, and collaboration across components and within government departments. The greater systems focus required institutions to work across traditional boundaries of discipline, to co-operate with others, and to be willing to contribute beyond research to delivery as well.

In particular, there was a need to strengthen activities in the provinces, and this was achieved by co-location of experienced national and international staff with their counterparts there. These include the Research Fellow in Knowledge Sharing in Savannakhet, and the Postdoctoral Fellow in Hydrology/Water in Champassak, supported

by a NAFRI Research Officer and an AVID volunteer in Knowledge Sharing in Champassak, and an MSc student in Savannakhet..

This process has demonstrated a demand for relevant training in support of this process, and this project has been instrumental in delivery of significant capacity building at all levels in the project, from technical and scientific, to collaborative and social, to managerial, budget and reporting. Even apart from technology delivery, this is a lasting social legacy of this project.

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## **8.3 Community impacts – now and in 5 years**

### **8.3.1 Economic impacts**

For farming households, improved cropping and livestock, water and nutrient management techniques can increase net household income through increased yields and/or a reduction in production costs in either absolute or per unit terms. As the wet season rice production is the foundation of the farming system, helping farmers to achieve self-sufficiency here allows them to consider other options for diversification. For example, providing improved Lao lowland rice varieties that are adapted to local conditions, including flood tolerance and pest resistance. The identification of varieties with submergence tolerance may generate early economic impact in flood-prone areas such as near the Mekong and other rivers in the lowlands. Additionally, upland rice varieties from northern Laos, which proved higher yielding than local checks in southern upland districts; two of these varieties continue to be used, and have been outscaled by other NGOs (including to more than 200 households in Nong district in 2015).

Improved technologies for post-rice production have generated cash income for many families, and provided an opportunity to increase returns to household labour.

Technologies for livestock intensification, such as use of forage and treated rice straw, can lead to animals being in better condition at peak times, and gives farmers an option to keep animals if prices offered are not appropriate; in several cases, farmers have kept animals for extra time, which has resulted in increased returns.

Dry direct seeded rice has reduced production inputs in terms of labour, increasing the productivity of wet season rice.

### **8.3.2 Social impacts**

A thorough understanding of household livelihood strategies undertaken by the project highlights the importance of diversification of the household portfolio. This includes migration for work opportunities, and so reflects that a significant goal of the household might lie outside the farming system. Return to labour, which is increasingly limited, thus becomes a key consideration for technology adoption – and therefore for research activities. This is highlighted by the rapid spread of the dry direct-seeding technology in Savannakhet province in recent times, which is likely to have wide-ranging social impacts as crop establishment becomes a much shorter activity, and which potentially frees up female labour during this time. Social impacts will also be felt within households whose primary source of income is as farm labourers.

Nonetheless, this research also shows the importance of the lowland rice crop, as the central platform on which the farming system revolves. Improvements here can secure this key goal, freeing up labour, time and capital to be directed to other pursuits, such as livestock, non-rice crops or off-farm work.

### 8.3.3 Environmental impacts

Improvements in rice performance in fragile submergence-prone lowland and drought-prone uplands via improved varieties helps to stabilise soil surface and ground cover. Refining fertiliser management recommendations, and dissemination of this information, allowed farmers to better match fertiliser use with crop demand, and reduce negative impacts associated with use of inorganic fertilisers. Intensification of lowland rice systems may take pressure off shifting cultivation in uplands, as will improved integration of forage and improved livestock management. Use of residues and fodder crops as an alternative to burning through integration of livestock production may also reduce emissions. A better understanding of groundwater hydrology can contribute to policies for management, with the aim of preventing degradation of this resource.

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## 8.4 Communication and dissemination activities

The major contribution to communication and dissemination has been through training activities and cross-site visits (see Sections 4 and 10.11). These have often been held in conjunction with relevant local counterparts (NGOs, government agencies, colleges and universities). Press releases were also circulated about the project in local newspapers and on radio in Vientiane and the provinces.

A project brochure and summary were developed for translation into Lao and distribution to participants and interested parties.

A full set of experimental protocols has been produced by NAFRI, in English and Lao.

A range of posters, pamphlets and handbooks have been developed and disseminated to relevant partners (topics in more detail in Section 10.2.5).

T-shirts were distributed to project staff and farmers, which featured '7 steps to improved rice production' on the back.

Videos were made for promotion of forage-based livestock management and dry direct seeding. The forage promotion video was made in conjunction with Savannakhet Television, and screened for six months in 2014. A shorter version of this video was also part of a session at the International Grasslands Congress in October 2013.

A full inventory of experiments, data return, analysis and reports was compiled by CSU, prior to the Final Review in August 2013, which are available from the Project Leader at CSU, or from ACIAR.

An agrinetwork was established in Savannakhet, which allowed sharing of information; members were particularly interested in market chain reports produced by the project.

Finally, higher-level reporting includes a Special Issue of the NAFRI journal (April 2014), chapters for the RSR workshop in Phnom Penh in (May 2014), and manuscripts for international conferences and scientific journals.

## 9 Conclusions and recommendations

### 9.1 Conclusions

The Southern Laos Project has delivered its research and key findings, both in the scientific literature and via delivery in focal villages and associated knowledge sharing and capacity building. This is supported by substantial technical reporting, translated into conference and journal papers, including the special issue of the Lao Agricultural and Forestry Journal in November 2013, and the book chapters for the ACIAR Rice-based Systems Research Workshop in Phnom Penh in April 2014. The focal villages are hubs for integration and delivery, including demonstration and training of technologies, knowledge sharing via extension materials in Lao, and emerging linkages for outscaling. Adoption of promising new technologies has commenced, with farmers adopting Sub1 rice with submergence tolerance, new upland rice cultivars with higher yields, and forage grasses previously unknown in southern Laos. Farmers are also trying mechanised direct seeding, supplementary-irrigated post-rice crops, livestock-feeding strategies and other more complex systems to diversify and intensify their livelihood. Market awareness and use are emerging as improved skills for farmers as a result of social sciences. While the first signs of technology adoption are visible, sustained success in the longer term will require effort beyond the life of this project. Perhaps the greatest strength of this project is its robust framework in the provinces, with international and Lao staff collocated, and a pathway for delivery established across the typology via focal villages. These integrative efforts have generated enhanced capacity and technology awareness in the districts, and although adoption has started, the risk is that, without further support, emerging gains could be lost. Fortunately, ACIAR has invested in the Crop Livestock Systems Platform project for continued capacity building and delivery at provincial and district levels.

### 9.2 Recommendations

Following the completion of the Southern Laos Project in October 2015, an opportunity exists to build upon its established structure, location and expertise in a following systems project with enhanced design features for improved communication and synthesis. This opportunity is being realised in CSE/2014/086, the 'Crop-livestock systems platform for capacity building, testing practices, commercialisation and community learning' project. This project is making full use of the technical outputs, capacity built and relationships formed during the South Laos Project, to explore new approaches for refining systems understandings and translating research into impact for smallholder farmers. This project was designed to follow the SLP, and will use an Innovation Systems approach to explore options for initiating Innovation Networks. Innovation Networks (or platforms, as they are often called) are a way of bringing together different stakeholders to identify solutions to common problems or achieve common goals (Homman-Kee Tui et al, 2013). They can be used to identify challenges and opportunities, share information, undertake joint activities related to a shared interest, and trigger innovation. Work done within the South Laos Project has been an excellent basis for the following project in terms of testing approaches, building capacity in systems thinking, and identifying potential stakeholders and their roles.



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## 10 References

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## 10.2 List of publications produced by project

### 10.2.1 Journal Papers

Vote, C., Newby, J. C., Phouyyavong, K., Inthavong, T., & Eberbach, P. (2015). Trends and perceptions of rural household groundwater use and the implications for smallholder agriculture in rain-fed Southern Laos. *International Journal of Water Resources Development*, 31(4), 558 - 574.

Hongsathilath, M., Boulaphanh, C., Inthavong, P., Thiravong, K., & Schiller, J. M. (2014). Resistance of improved rice varieties and breeding lines to Rice Gall Midge. *The Lao Journal of Agriculture and Forestry*, 31, 154 - 164.

Jackson, T. M., Kirk, E. R., Pathoummalangsy, K., Sensourivong, T., Smith, J., Samadmanivong, S., et al. (2014). "Het tua jing": experiences with on-farm research for local stakeholders in southern Laos. *The Lao Journal of Agriculture and Forestry*, 30, 131 - 154.

Lampayan, R. M., Inthavong, T., Vongthilath, S., Quicho, E., & Eberbach, P. (2014). Farmer participatory evaluation of the wetting and drying (AWD) watersaving technology in southern Laos. *The Lao Journal of Agriculture and Forestry*, 30, 179 - 202.

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Samson, B. K., Boulaphanh, C., Sihathep, V., Sengxua, P., Douangboupouha, K., Vongkhamsoo, B., et al. (2014). Multi-environment testing of selected released modern Lao PDR rice varieties. Field trials in Savannakhet and Champassak provinces, 2011 and 2012 wet season. *The Lao Journal of Agriculture and Forestry*, 30, 62 - 76.

Samson, B. K., Sengxua, P., Thiravong, K., Jackson, T. M., Phimsamone, S., Bountheang, et al. (2014). On-Farm Screening of Upland Rice Cultivars in Xepon and Nong Districts of Savannakhet Province. *The Lao Journal of Agriculture and Forestry*, 30, 77 - 86.

Sengxua, P., & Wade, L.J. (2014). Developing improved farming and marketing systems in rainfed regions of southern Lao PDR: Introduction to the Southern Laos Project. *The Lao Journal of Agriculture and Forestry*, 30, 1 - 18.

Wade L.J. & Sengxua, P. (2014). Synthesis of 'Developing improved farming and marketing systems in rainfed regions of southern Lao PDR'. *The Lao Journal of Agriculture and Forestry*, 30, 203 - 210.

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Tiemann, T. T., Khamphoumee, S., & Phimpachanhvongsod, V. (2014). Lessons from forage based livestock interventions requiring a farm systems change. *The Lao Journal of Agriculture and Forestry*, 30, 110 - 118.

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### 10.2.2 Conference Papers

Bouahom, B., Wade, L.J., Sengxua, P., & Jackson, T. M. (2015). *Drawing together information and practice through integrated on-farm research*. Paper presented and published by the Australian Society of Agronomy Conference, available at [www.agronomy.org.au](http://www.agronomy.org.au).

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Sacklokham, S., & Chealue, L. (2013). *Banana Cropping Systems and Marketing Chain in Savannakhet*: National University of Laos.

Sacklokham, S., & Fueyang. (2013). *Yanbong production and marketing in Nong District and Xepon District, Savannakhet Province*: National University of Laos.

Sacklokham, S., & Manivong, P. (2011). *Analysing the marketing chains – with special focus on rice, large ruminants and pigs in Savannakhet Province*: National University of Laos.

#### 10.2.5 Extension Materials

- Lowland rice production - Best Management Practice (poster)
- Submergence tolerant rice management (TDK1-sub1) (poster)
- Sweetcorn best management (poster)
- Project t-shirt for staff and farmers, featuring 7 steps for Best Management Practices
- Forage promotion video produced with Savannakhet Television
- Training and cross-site visits (key elements) (pamphlet and handbook)
- Forages (improve understanding of forage varieties: characteristics and adaptation in the local area; Techniques for forage establishment, management and utilization) (poster, pamphlet and handbook)
- Improved cattle and buffalo production systems (feed production and locally available feed utilization; Animal management (housing, feed trough, hygiene and animal health care and manure management); Bull/Steer and heifer raising technique; Cattle fattening technique (animal selection, feeding, animal health care) (poster, pamphlet and handbook)
- Integrated systems (the role, importance and benefit of crop-livestock integration systems; post-rice corn; duck and fish raising in lowland rice paddies; rice straw quality improvement and utilization) (poster, pamphlet and handbook)
- Post-rice crops (peanut, mungbean) (poster, pamphlet and handbook)
- Rice varieties (lowland and upland) (poster, pamphlet and handbook)
- Dry direct seeding management (promotional video, poster, pamphlet and handbook)
- Nutrient management for rice, linked with direct seeding (government priority for targeted production increases) (poster, pamphlet and handbook)