Agriculture and Environment: Managing Rice Landscapes: Experiences and Lessons from Northern Laos

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Good afternoon. My name is Ben Samson. I work with the International Rice Research Institute (IRRI). The work I am going to talk about is a collaboration between several institutions. We receive funding from the Swiss Agency for International Development and Cooperation (SDC); the Challenge Program for Water and Food (CPWF), which is a project within the Consultative Group on International Agricultural Research (CGIAR); and the International Fund for Agricultural Development (IFAD). We work with the National Agriculture and Forestry Research Institute (NAFRI) and the University of California at Davis.

Before I continue, I want to thank all the other speakers who came before me, because they have made my job easier by giving a good background and macro-perspective on the situation in Laos and the Greater Mekong Subregion. They talked about some of the major issues, particularly the upsurge of forest and rubber plantations and the drive toward the cultivation of cash crops in Laos, especially in the northern uplands. What I want to do now is focus and talk about the northern uplands of Laos.

I will talk about the conditions of this area, including the geographical and socioeconomic state of this region. I will talk about the crops grown and common agricultural activities/practices in Northern Laos. I will briefly go over the conceptual framework that guides the rice landscape management project that IRRI is implementing in collaboration with NAFRI. Embedded within this project are efforts to screen and select rice germplasm, the sustainable management of crops and fields, and natural resources management. Toward the end of my talk, I will address interactions between uplands and lowlands via the flow of water through these ecosystems.

You may have seen this map before. It emphasizes the geographic positions of our sites of concern. Laos is a landlocked country. It is surrounded by China to the north, Vietnam to the east, Thailand to the south, and Myanmar to the west.

The work I will describe is concentrated mainly in Northern Laos, which has similar physical characteristics to Southern China (Yunnan Province) and Northern Vietnam. As Dr. Kanok said, the main physical feature that characterizes these areas is that they are hilly and mountainous.

This is a closer view of Northern Laos. The project covers the provinces of Luang Prabang, Oudomxay, Louang Namtha, and Sayaburi.

These are views of the rice landscapes of Northern Laos. Rice can be grown in purely upland areas or a mixture of sloping uplands, terraces, and lowland areas such as valley bottoms and riverbeds.

This slide describes the economic situation in Northern Laos. Industry accounts for 10% of the economy of the North; this is just a third of the national average of 37%. Agriculture is the major economic activity, employing about 70% of the total population. The service sector accounts for 20% of the economy of Northern Laos, compared to 26% in the rest of the country. High levels of poverty persist in Northern Laos, as in the uplands of other countries in the GMS and elsewhere.

Land elevation in Northern Laos ranges from 250 to 1,500 meters. Total rainfall ordinarily ranges from 1,200 to 2,000 millimeters per year. Soil is poor because the soil parent material is uplifted sediment that has undergone extensive erosion by rainfall. Soil in sloping areas is also unstable and prone to erosion and landslides. Soil on valley bottoms and riverbeds is composed of sediments deposited by runoff water from the slopes.

Access to sites is difficult. Road systems have just recently been established. Most of the population in Northern Laos is made up of ethnic minorities. Population density is low, but population is growing rapidly, at about 2.5% per year.

About 80% of farmers in the North are engaged in subsistence farming. The major trading partners of Northern Laos are China, Thailand, and Vietnam. The commodities traded include maize, rice, sugarcane, and rubber.

Investment in rubber plantations is being pushed by investors from China, Thailand, and Vietnam. Traders and trading companies get incentives from the government to encourage long-term investments, including land concessions on highly favorable terms. These investments have had a negative impact on traditional land-tenure arrangements and food security for small farmers whose land has been turned over to investors. Household supplies of rice, which used to be grown on designated rubber plantations, have to be purchased, or grown farther away from communities, leading to increased local demand for rice and higher prices. These external investments have had a major impact on the trajectory of agricultural and economic development of the North.

One of the four Lao policies governing the uplands involves putting a stop to slash-and-burn cultivation and stabilizing shifting agriculture. This is similar to measures taken by the governments of China and Vietnam in their uplands. Laos aims to have 70% forest cover by the year 2020. The rice landscape management project is actively testing alternatives to shifting agriculture.

The Lao government has implemented several strategies to stop slash-and-burn agriculture. The relocation of far-off communities to areas near road systems aims to reduce pressure on forests in the uplands. It benefits members of the community by facilitating the delivery of social services such as education and health services. Greater accessibility to markets and easy contact with investors increases economic opportunities for farm households, including raising cash crops and livestock for consumers elsewhere. Relocation, however, takes households away from their crop production sites. Part of the relocation program is the land allocation system, in which relocated households are allotted parcels of land to be used for sedentary agriculture. For example, a family of four or five may receive three parcels of land, equivalent to about three hectares. The household may cultivate one parcel a year and go through the three parcels in three years. In three years, the first plot will have lain fallow for two years. This short fallow period is not sufficient to renew soil fertility. Then, too, newly arrived households are allocated the poorest land around a village.

What crops are grown in our target sites? Rubber is extensively grown in the provinces of Luang Namtha and Sayaburi. The area planted is increasing in Luang Prabang. Job’s Tears, or *Coix lachryma-jobi*, is usually grown after rice. Maize is grown in place of Job’s Tears where there is market demand — mainly in Oudomxay Province, to provide raw materials for feed mills in Yunnan and Northern Vietnam. Maize production is contract-grown for investors who provide seed and agricultural chemicals and buy the produce at harvest. Maize is usually grown on sloping uplands. There is data showing that soil erosion is higher in maize cover than in upland rice.

Minor crops grown with rice and in rotation with rain-fed lowland rice are small grain legumes, spices, and fruits.

Rice is grown in both lowland/wetland and upland/dry land conditions. Farmers sow, transplant, and care for the rice crop and, finally, harvest it. The reward for all these efforts is good-quality rice for consumption by members of the household.

In Northern Laos, households say that they go through a hunger period when there is no rice to eat. Energy needs are met with cassava or other root crops as substitutes for rice. Not having rice to eat is perceived as hunger, even if calorie intake is sufficient. Households in some districts of Northern Laos still report 3–4 months of hunger.

Rice plays a central role in Lao culture and life. Rice is the major offering made to Buddhist monks to earn merit. Its centrality in the Lao psyche is reflected in the common greeting among friends, who ask each other whether they have eaten rice yet.

Let me shift gears and talk about how we were approached the issue of rice productivity in Laos. I will talk about the vicious and virtuous cycles of crop productivity, the use of natural resources, and management and household well-being in the uplands of Laos.

This is a conceptual framework for what we think is going on in the northern uplands. The intensive cultivation of fragile land, the sloping uplands, leads to land degradation and low food production. Households are not able to produce enough food and hence are food insecure. This prevents households from focusing on options for cash crop production. Limited cash crop production means that households have little income from their agricultural activities. This vicious cycle may be transformed into a virtuous one by increasing food productivity. We think that increasing food productivity will improve food security and encourage households to go into cash crop production and increase their incomes. Achievement of food security and higher incomes may move households toward more appropriate use of the different land forms and protect the environment.

In summary, factors that impinge on rice-based agricultural systems in Northern Laos include markets, local and national government regulations and policies, national institutions, and externalities such as changing economic trends in neighboring countries. The arrows represent the flows of information, materials, energy, and funds.

The objectives of the rice landscape management project are to improve the productivity of rotational upland systems, develop stable and permanent land use systems in both uplands and lowlands, and conduct policy analysis and dialogues for policy reform. The first two objectives cover the agronomic and biophysical aspects of our research. The third objective recognizes that all of our research does not amount to much if our results are not made known to policymakers and translated to appropriate policies or the reform of existing policies.

These are the organizations that participate in the rice landscape management program. We receive financial support from the Challenge Program on Water and Food (CPWF) and technical cooperation from the Yunnan Academy of Agricultural Sciences (YAAS) and the Consortium for Unfavorable Rice Environments (CURE). The International Fund for Agricultural Development (IFAD) provided financial support to the project for three years. IFAD support gave the project a platform to extend its findings through a requirement that the project have technical assistance linkages with IFAD loan projects. Lessons and technologies from the project were shared with IFAD for adaptation in loan projects. We work closely with the provincial and district agriculture and forestry offices (PAFO and DAFO). Our main partner is NAFRI, through the Northern Agriculture and Forestry Research Center (NAFReC).

The rice landscape management project is investigating component technologies to improve productivity as well as develop stable agricultural systems. Rice germplasm improvement in the upland project consists of a two-pronged approach: work on traditional cultivars and improved rice varieties. There is also ongoing work on field and crop management research and cropping systems. We are also investigating upland and lowland interactions through water flows. I will show a sampling of the work we have done in these areas.

This is picture of some of the researchers on the research project at NAFReC. It is composed of dedicated and talented young people.

Let me talk about the project's germplasm work. As I said before, we have a two-pronged approach to rice germplasm improvement in Northern Laos: a focus on traditional rice landraces and improved rice germplasm. The idea with traditional rice cultivars is to use cultivars that farmers are already growing and stream them into the screening and selection process to identify the best-performing cultivars for the range of environments in the uplands. We have also used growth duration as a germplasm selection criterion. We have been able to identify several traditional cultivars of short and medium growth duration. In addition, our work in this area identified cultivars suited for sites with short fallow periods or no fallow period between rice growing seasons.

The average yield for upland rice on sloping areas is about 1.5 tons per hectare. We have been able to double this yield with traditional cultivars. There is a wide variation in minimum and maximum grain yields. Coupled with screening for yields is the identification of application domains, the conditions/environments where rice cultivars have high yields.

The other prong of our germplasm work is the screening and selection of improved rice germplasm materials originating from outside of Laos. We have been successful in identifying lines and varieties from the International Network for Genetic Evaluation of Rice (INGER). INGER is a program within IRRI that collects best-performing rice and promising germplasm materials from its member countries and organizes these materials into nurseries, which are then disseminated to partners and institutions for testing and evaluation. INGER nurseries are organized to address specific abiotic and biotic stresses. Hence, there are INGER nurseries for poor soil, aerobic growing conditions, tungro, and planthopper. The project also tests materials from the Yunnan Academy of Agricultural Sciences (YAAS). One of our best-performing rice lines is B6144F-MR-6, which came from YAAS. It is a line that was originally developed in Indonesia. IR55432 is a line that was developed at IRRI. The average yield of these lines is about 0.5 tons better than the best-performing traditional cultivars in the North. Added fertilizer doubles their grain yield.

The acid test for our work is whether farmers are adopting the lines and cultivars we have identified through on-station and on-farm research. This is an illustration of farmer uptake of the traditional cultivar Khao Laboun, which was selected and purified at NAFReC. The cultivar was initially disseminated as one kilogram of seed to two farmers in one village in 2006. By 2008, there were 20 farmers using the cultivar, and the total seed planted had increased to 800 kilograms. B6144 dissemination began as 2.5 kilograms of seed distributed to five farmers in five villages. By 2007, farmers in 18 villages — 8 in the uplands and 10 in the lowlands — were using the line in their fields.

I will shift gears now and talk about our work to improve agricultural production in sloping uplands. Dr. Kanok touched on the regeneration process in the uplands; we have done work in this area, as well. The problem we addressed was shortening fallow periods, which adversely affected soil fertility regeneration. Our approach was to try to enrich the fallow to restore soil fertility at a faster pace. Fallow enrichment with legumes may raise soil nitrogen levels over a short period. Raising soil nitrogen levels is critical for crop production, as nitrogen is the essential macronutrient element deficient in upland soils. The scheme we devised involves establishing the legume even before the rice crop is harvested. This scheme uses residual soil moisture from the rice crop and ensures that the legume crop is in the ground for a longer period to improve soil fertility. Different species have been tried: stylo (*Stylosanthes guianensis*), pigeonpea (*Cajanus cajan*), paper mulberry, rice bean, leucaena (*Leucaena leucocephala)*, gliricidia (*Gliricidia sepium*), and crotolaria (*Crotolaria sp.)*. Each of these species has specific advantages, but we have found that stylo and pigeonpea are best suited for this scheme in sloping uplands.

This slide shows data comparing traditional and improved fallows, with stylo as the fallow enrichment species. Note that the stylo-enriched fallow yielded about 0.6 ton more grain per hectare than plain fallow. In a dry fallow season, stylo-enriched plots yielded 0.4 ton more grain per hectare than natural fallow. Rice productivity was similar in plots that had three years of paper mulberry fallow and natural fallow. The advantage of the paper mulberry fallow is that farmers can harvest its bark and sell it.

This is an illustration of one year's worth of data, in which we compared the stylo line-seeded to stylo broadcasted into the rice stand. The data shows that line-seeded stylo germinated and produced more biomass than broadcasted stylo, due to less competition for light with rice. Broadcast-seeded stylo were shaded out by the rice plants.

One of the major weed species in the uplands is *Imperata cylindrica*. *Imperata* is a noxious and persistent weed. It has underground rhizomes where carbohydrates are stored, hence the difficulty of ridding the land of this species. Cutting and burning does not kill this weed but actually encourages its growth. This weed takes land away from cultivation.

We wanted find a methodology to bring *Imperata*-infested land back into crop production. The method we developed involved a one-time application of glyphosate in combination with rapidly growing, highly competitive species that would shade out the *Imperata.* This figure shows the number of new *Imperata* shoots in control plots, glyphosate-treated plots, and plots that were sprayed with glyphosate and planted with pigeonpea as the shade species.

Glyphosate application at the beginning of the season kills the *Imperata* shoots and allows rice and pigeonpea to be established, resulting in a higher rice yield than treatment with glyphosate alone.

This is an illustration of a pigeonpea bush and the sticklac insect that lives on pigeonpea. This is sticklac, produced by the sticklac insect, a product that we think is going to serve as a profitable incentive to use pigeonpea as a means of enriching fallows and eradicating *Imperata cylindrica* from the uplands. Sticklac fetches a good price in the international market. Farmers growing pigeonpea to culture the sticklac insects and produce sticklac also improve soil fertility and rid the uplands of *Imperata cylindrica*.

Farmers spend a lot of their time weeding their upland fields, especially after the first year of cropping. Weeding accounts for more than 50% of the labor that goes into the cultivation of upland rice. We were interested in finding out what part of the rice yield is lost due to weeds. We set up an experiment in which we compared rice productivity in fields that were relatively weed-free and those that were managed according to usual farming practices. We found almost a 20% difference in yield, which means that farmers' fields were losing about 20% of their yields because of weeds.

Much of the program's work in rain-fed lowlands is concentrated on rice germplasm improvement and maintaining/improving the soil fertility in rice fields. Farmers in Laos apply little or no fertilizer to their fields. A key concern was how to maintain or increase soil fertility through the use of alternatives to inorganic fertilizers. The easy method of soil fertility maintenance/improvement would be to apply inorganic fertilizers; however, most Lao farmers do not have the capacity to buy them.

Our strategy was to investigate the use of locally available, abundant organic manures. We compared the effects of pig manure, chromolaena (C*hromolaena odorata*) green manure, and inorganic fertilizer on rice productivity in rain-fed montane lowlands. Rice grain yield in plots with 25 t/ha of *Chromolaena* green manure was not significantly different from plots treated with 60 kg/ha N, 30 kg/ha P, and 30 kg/ha K. Questions remain about chromolaena green manuring: where to source the biomass needed, labor requirements, soil fertility changes in the sites where the green manures are harvested, etc.

As I stated at the beginning of this talk, the upland project is investigating interactions between upland and lowland systems. Water flow through these systems is an obvious linkage, hence hydrology and flow of water across the systems is an active research area in the rice landscape program. A graduate student from UC Davis is doing his dissertation research in this area, using the programs research sites. The elucidation of the impacts on livelihoods and the characterization of water availability and rice production through the integrated assessment of land use options in terms of the biophysical resource bases of linked upland and lowland systems are the broad objectives of this work.

The analytical approach involves the use of GIS techniques and dynamic simulation modeling to look at watershed hydrology. The expectation is that the biophysical model can be linked to an economic model to enable the quantification of the consequences of land use changes in the uplands and the lowlands in terms of water availability and monetary flows to communities/farmers.

Some of the characteristics of the project's sites are shown here. The project has activities in one village in each of two districts: Banh Fay in Pak Ou and Banh Silalek in XiengNgeun.

Field methods involve the construction of weirs to facilitate the measurement of water flows through channels, meteorological stations, and automatic water flow measurement devices. Participatory assessments will be conducted on water, land, and resources; resources inventory; and peoples' perceptions of land and water use. These data are all linked to a GIS mapping exercise. We had thought that the mapping could be done using satellite photos, but we quickly found out that it was much better to go into the field and do manual measurements.

An initial result of this work is the definition of biophysical resource linkages, comprising the different land uses and the water flows, as well as the systems' crop and livestock components.

We now have a topographical map of the sites, rainfall and evaporation data, and land use and resource maps. We have crop production data from two years of work. The modeling work is ongoing.

Before I end, I would like to review the "take home" messages of this talk. There is high genetic diversity in the uplands of Northern Laos, which remains largely untapped. There is also high physical diversity, which is perceived as physical discontinuities and a wide range of microenvironments. The diversity of microenvironments raises opportunities for mixed strategies for increasing productivity and stabilizing production systems. The sticking point is how to achieve integration of component technologies suited for different rice landscapes. On top of these biological and physical complexities is the socioeconomic matrix of ethnic diversity, poverty, local and national policy directives, and external drivers such as highly focused investments and market demand for Lao products and resources. The rice landscape project focuses on alternative low-input, low-cost technologies that use locally abundant resources.

While there are incredible opportunities to develop ranges of technologies for the diversity of environments in the uplands, it is difficult to arrive at generic solutions. The physical and biological diversity of the uplands requires the development of typologies of environments and technology options for each typology and each situation in the typology. The work we are doing involves scientific research for understanding and development.

We, as researchers, develop options for farmers to choose from and decide which are more appropriate for their environments and economic circumstances. The end user — the farmer — ultimately decides which technologies to implement.

We found that it is not sufficient for technologies to be scientifically valid. They also have to make sense and fit easily into the way farmers do their work. Published or publishable technology research does not always translate into usable technologies by end users. Technologies need to be economically viable and socially acceptable to farmers.

Scientific research alone is not enough. Research results and technologies must be made known and explained to policymakers and end users. These are necessary steps for correct policies to be formulated and for change to occur.

Externalities play a big role in all these things. Changing economic and social demands mean that the context of the problems and their solutions changes as well, hence it is important not only to engage with present day issues, but also to look ahead and foresee future needs.

With that, I leave you. Thank you for your attention.

Questions and Answers

(Question) Thank you very much for the excellent presentation. I am wondering why farmers do not use herbicide to control weeds. You probably know that weeds are very aggressive plants. So farmers could use herbicide, or insecticide to protect rice plants from insect attacks.

(Benjamin Samson) The use of agricultural chemicals in lowland fields would, under certain conditions, be recommended. IRRI is a proponent of integrated pest management. Using insecticides on a schedule is not something that we do or recommend.

In the uplands of Laos, the economic status of farmers largely precludes the use of agricultural chemicals. What I showed here about the use of glyphosate, a systemic herbicide, is an effort on our part to introduce a technology that uses minimal amounts of chemicals in concert with a biological approach to control *Imperata* infestation in upland areas. Glyphosate is utilized as a one-time-use herbicide in our scheme. The effect of glyphosate wears out over time, but before it becomes ineffective and *Imperata* shoots start growing again, pigeonpea will have had time to be established and physically overtop *Imperata* and shade it out. We have similar a scheme for controlling weeds in lowland rice: manipulating the density and the planting times of rice, planting them closer or planting them wider apart, to manipulate timing of canopy closure and the amount of light that passes through the crop canopy.

(Question) I am concerned about the socioeconomic drivers. As you mentioned in your presentation, it is said in Japan that the green revolution introduced by IRRI in 1968 resulted from the wide economic gap between rich farmers and poor farmers, due to the lack of consciousness about the social condition of the farmers. What do you at IRRI think about that?

(Benjamin Samson) IRRI launched what we call the second green revolution. It is a greener green revolution, meaning that this green revolution is more environmentally friendly. Now, to address your question about the disparity of adoption between rich and poor farmers, and in terms of taking advantage of research and technological developments, I don’t think it is farfetched for us to think about it in terms of the risks that are involved when farmers adopt new things. For a rich farmer, changing the way he or she does cultivation, any kind of crop cultivation, presents little risk because they have something to fall back on. Poor farmers, especially subsistence farmers, find it much more difficult to adopt these changes. Crop failure impacts the food that a farmer’s family will consume for the rest of the year, the money that is needed to send the children to school, the money needed to buy clothes, etc. We think of this in relation to how much risk farmers are able to tolerate. Poor farmers tolerate smaller risks. Our project does not emphasize technology packaging, because packaging implies that users have to employ all the component technologies in an ordered manner. Our approach is to expose farmers to technologies that will increase crop productivity and let farmers choose those they are comfortable with. The thinking here is that farmers will take pieces of technology they are happy with. Eventually, they may try other technologies and adopt those, as well. So we think of this as an incremental process. It is slow, but hopefully the changes will be effective and long-lasting.

Managing Rice Landscapes: Experiences and Lessons from Northern Laos

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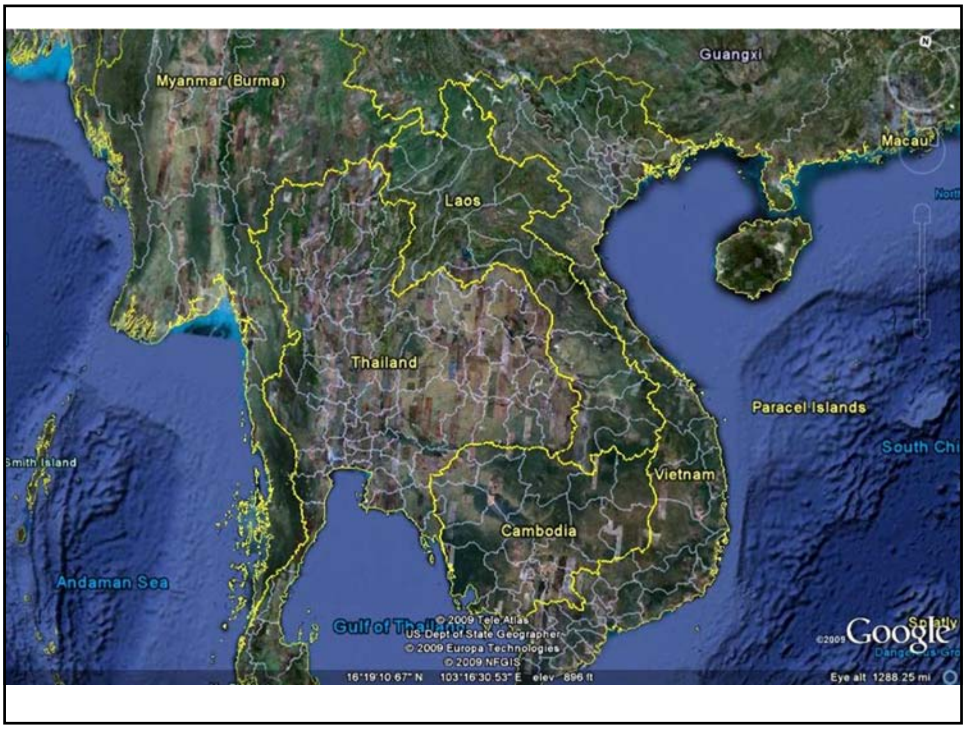
- Setting
- Crops
- Conceptual framework
- Rice Landscapes Management Program
- Approaches
  - Germplasm
  - Crop and field management
  - Natural resources manangement
- Upland – lowland interactions
  - Water flows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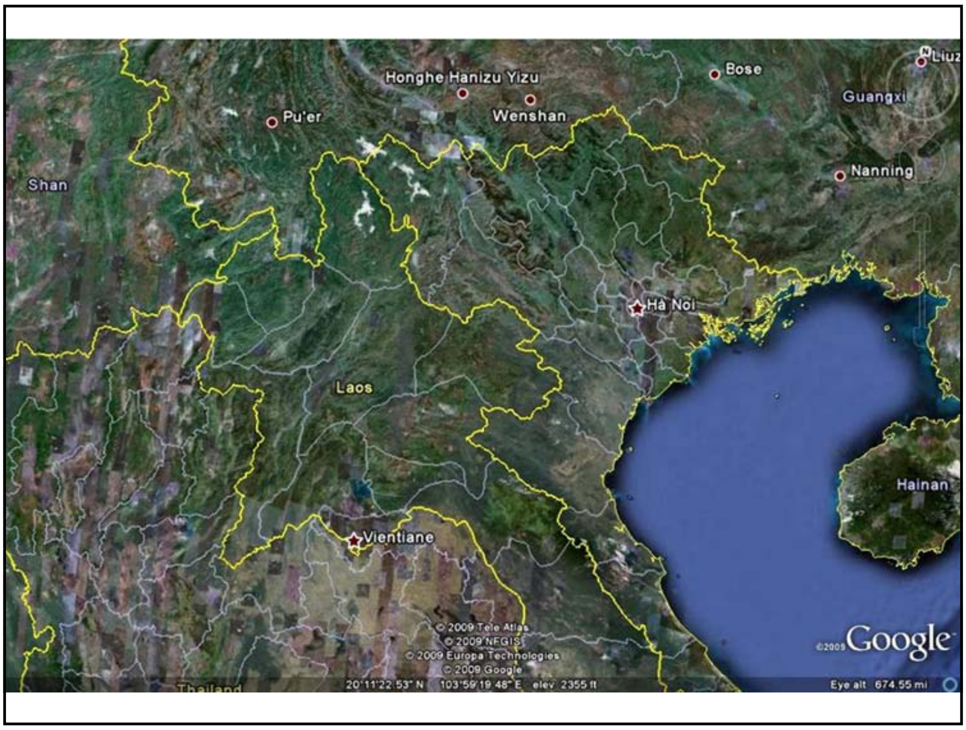
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Xiengngeun District, Luang Prabang, Lao PDR

Northern Laos

- **Economic setting**
  - Industry: 10% (National: 26.6%)
  - Agriculture: 70% (47.2 %)
  - Services: 20% (26.2 %)
  - High levels of persistent poverty
- **Physical setting**
  - Elevation: 250 to 1,500 m
  - Annual: 1,200 to 2,000 mm;
  - Soils: slopes, valleys, river beds
- **Access** is difficult
- **Ethnic minorities;** rapid growth (2.5%)
- **Subsistence farming (**80%)

Trade

Investments and trade
- China, Thailand, Vietnam

Commodities
- rice, sugarcane, rubber
- land concessions
  - land values
  - crop prices

Trajectories of agricultural development

Policy setting

– Stop slash and burn agriculture in uplands
  – stabilize shifting cultivation
  – 70% forest cover by the year 2020
  – alternatives to shifting agriculture

– Strategies
- Relocation near road systems
  – Access to markets / flow of investments
  – Delivery of social services/ education
- Land allocation system
  – Cultivation of parcels in rotation – **Shortened fallows**
  – Intensive agriculture for market oriented crops
  – Consequences on soil fertility, weed incidence, crop productivity

Crops

Rubber

Job's tears (*Coix lachryma-jobi*)

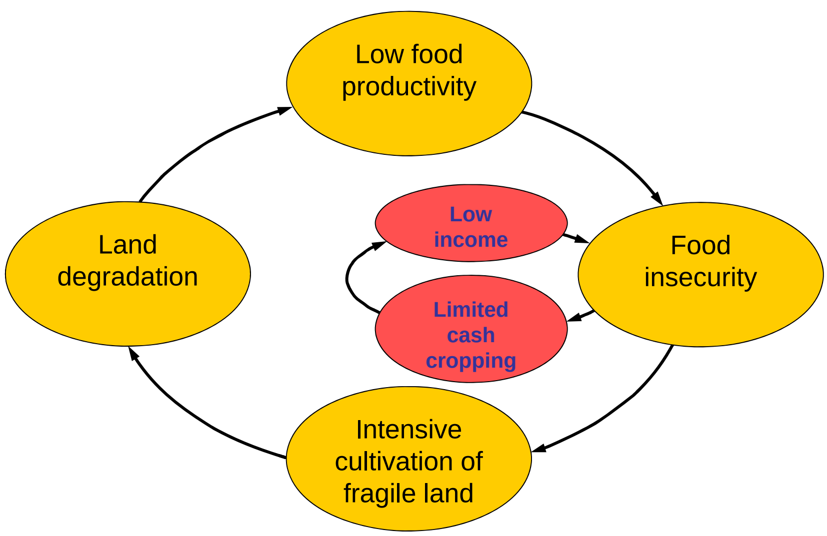
Maize (*Zea mays*)

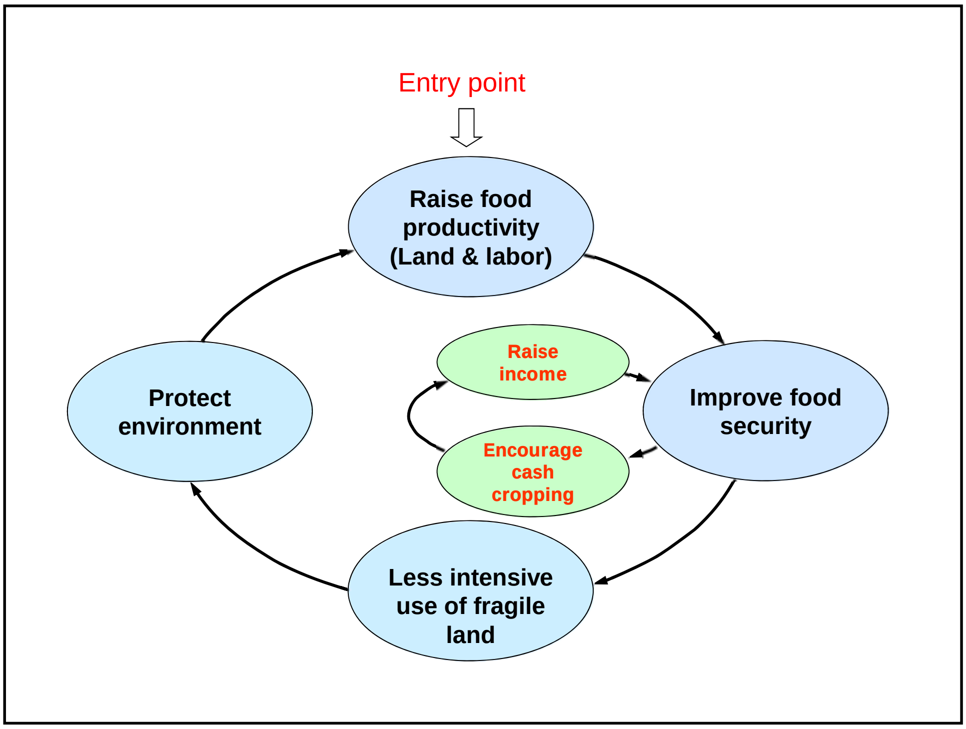
Small grain legumes (soybean, cowpea, mungbean), spices, fruit

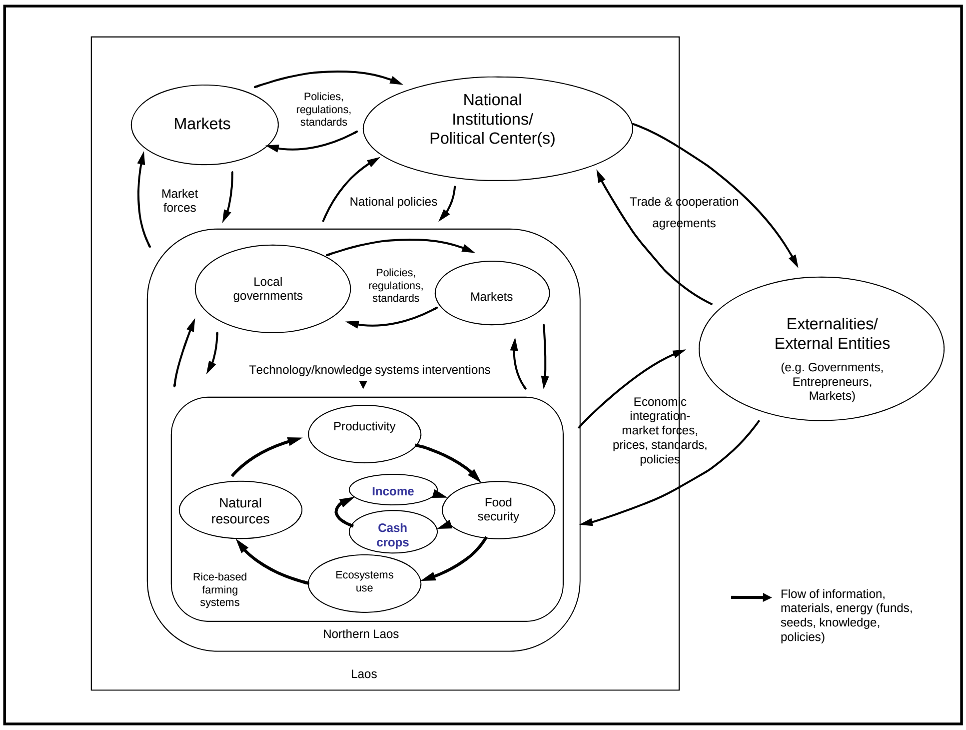
Rice is central to Lao life and culture

“Vicious” and “Virtuous” Cycles

In the Uplands

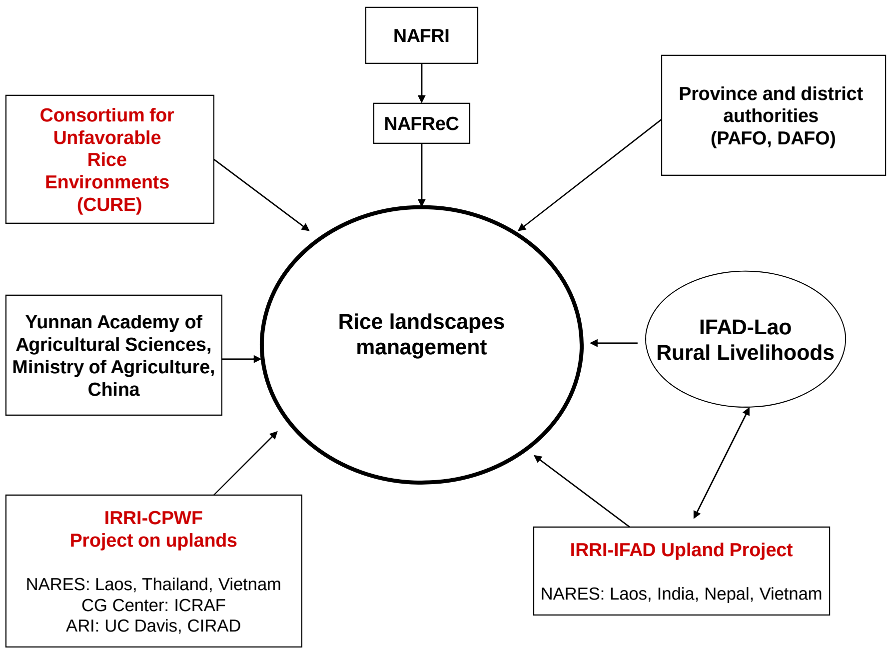



Entry point
Raise food productivity (Land & labor)
Improve food security
Raise income
Encourage cash cropping
Less intensive use of fragile land
Protect environment


Markets
Policies, regulations, standards
National Institutions/ Political Center(s)
Market forces
National policies
Trade & cooperation agreements
Local governments
Policies, regulations, standards
Markets
Technology/knowledge systems interventions
Externalities/ External Entities
(e.g. Governments, Entrepreneurs, Markets)
Economic integration- market forces, prices, standards, policies
Productivity
Natural resources
Income
Cash crops
Food security
Ecosystems use
Rice-based farming systems
Northern Laos
Laos
Flow of information, materials, energy (funds, seeds, knowledge, policies)

Objectives

- Improve the **productivity** of rotational upland systems
- Develop **stable permanent land use systems** in uplands and lowlands
- Conduct **policy analyses and dialogues** for policy reforms



Approaches

- Component technologies
  - Germplasm improvement
    - Traditional cultivars
    - Improved rice lines and cultivars
  - Field and crop management research
- Cropping systems
- Integration
  - Upland-lowland interactions

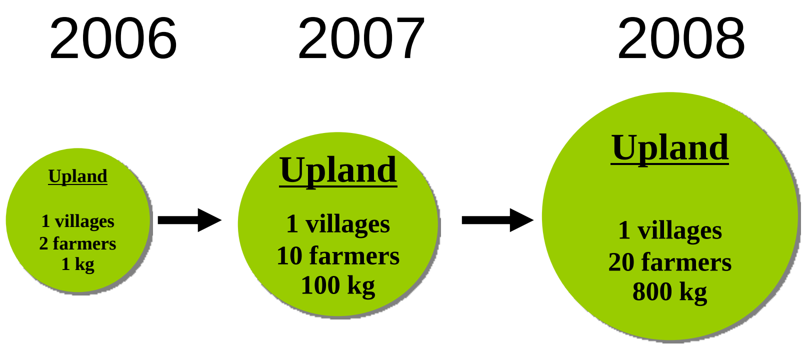
Grain yield (t/ha) of traditional and modern upland rice varieties.

Variety/Line	Min. Yield	Max. Yield	Ave. Yield
Short duration, Short fallow			
Chaodo	0.1	3.4	1.5
Nok	0.2	4.7	1.8
IR65261	0.8	3.5	1.6
Palawan	0.5	3.9	2.1
Medium duration , Short fallow			
Makhinsoung	0.2	4.7	1.8
Non	0.2	4.4	1.8
Phaenoi	0.9	3.5	2.0
Continuous Rice			
Chaomad	0.1	3.9	1.8
Laboun	0.2	4.0	1.9

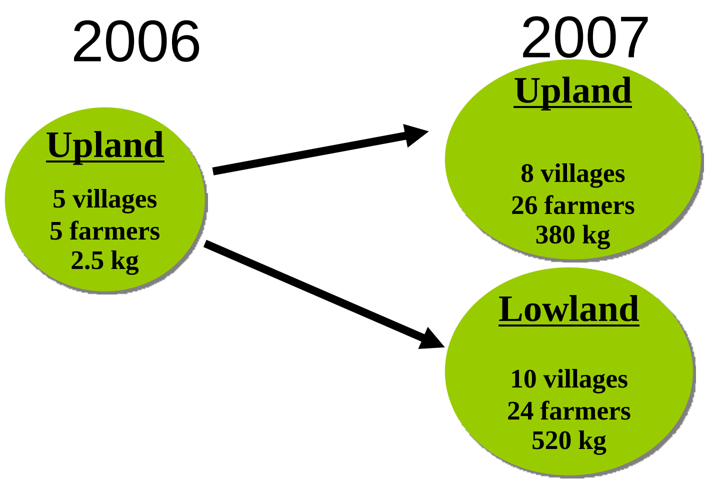
Grain yield (t/ha) of aerobic rice varieties.

Line	Number of sites	Ave. Yield
Low input		
IR55432-01	10	1.9
B6144-MR-6	10	2.0
Local check		1.3
Fertilized		
IR55432-01	6	3.0
B6144-MR-6	7	3.0
Local check		1.8

Adoption of Laboun through farmer to farmer exchange (Luang Prabang)



Adoption of B6144F-MR-6 through farmer to farmer exchange (Sayabouri)



Rice - Enhanced fallow systems

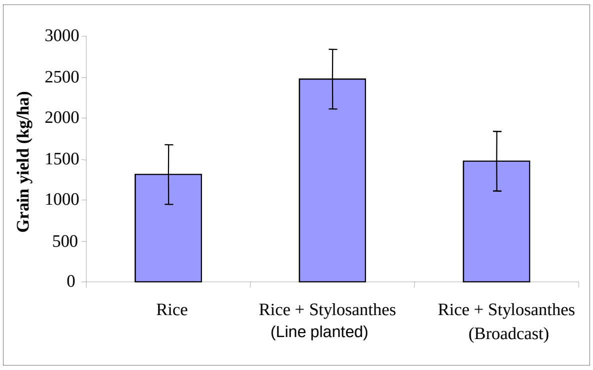
Traditional systems	**Rice**	**Fallow**	**Rice**
Improved fallow systems	**Rice**		**Rice**
		Fallow crops	

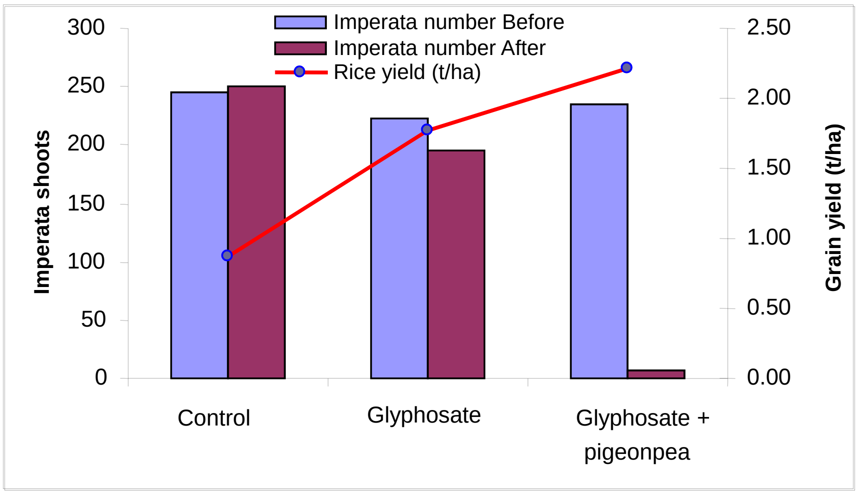
stylosanthes, pigeon pea, paper mulberry, rice bean, *Leucaena leucocephala*, *Gliricidia sepium*, *Crotolaria anagyroides*

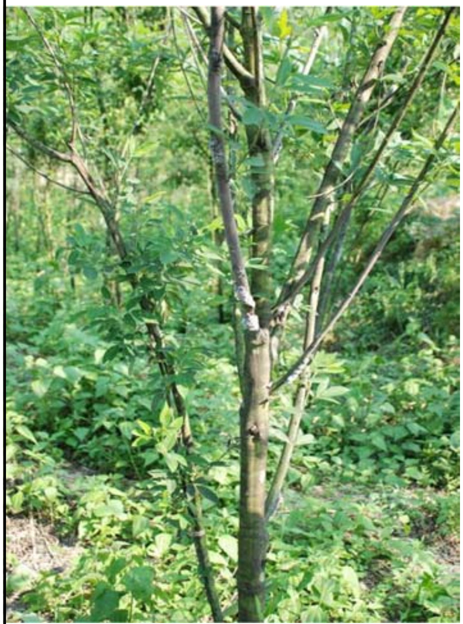
	Traditional system	Improved system
	1-yr natural fallow	**1-yr stylosanthes fallow**
Grain yield (t/ha)	**0.4**	**1.0 ****
	Dry season natural fallow	**Dry season stylosanthes fallow**
Grain yield (t/ha)	**0.9**	**1.3 ****
	Natural fallow (3 years)	**Paper mulberry fallow (3 years)**
Grain yield (t/ha)	**1.7**	**1.8**

From: Saito, 2005

Upland rice + *Stylosanthes* sp.




Imperata number Before
Imperata number After
Rice yield (t/ha)
Imperata shoots
300
250
200
150
100
50
0
Grain yield (t/ha)
2.50
2.00
1.50
1.00
0.50
0.00
Control
Glyphosate
Glyphosate + pigeonpea



Labor input for land preparation, sowing and weeding of upland rice.

Farmer	Sowing date	Harvest date	Labor input (d/ha)					
			Land preparation	Sowing	1st weeding	2nd weeding	3rd weeding	Total
Vanhthong	10-Jun	12-Oct	23	25	19	18	18	102
Thitchanthone	16-Jun	15-Oct	28	23	23	19	19	112
Ping	27-May	01-Sep	28	29	32	34	27	150
Thea	03-Jun	15-Oct	30	35	39	44	30	178
Maipeng	08-May	14-Oct	60	30	40	40	35	205
Maiin	06-May	10-Sep	68	30	30	28	25	181
Phone	04-May	13-Oct	30	25	30	40	25	150
Average			**38**	**28**	**30**	**32**	**25**	**154**

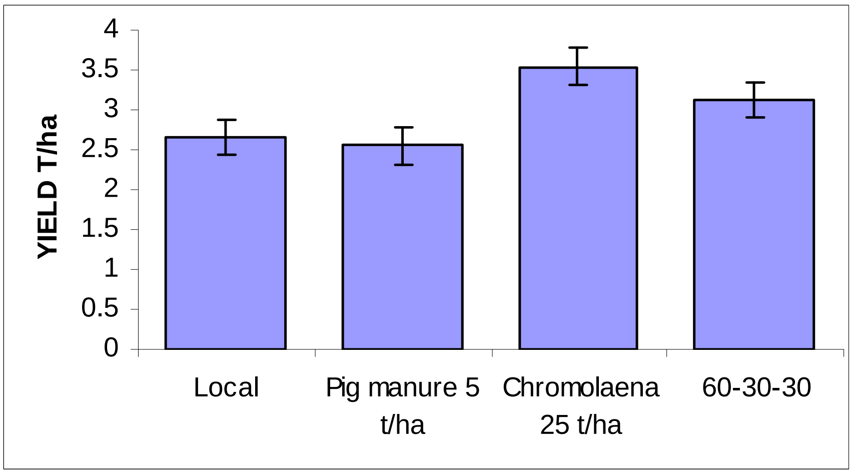
Yield gap due to weeds in sloping uplands.

Weeding	Grain yield ($g\ m^{-2}$)	Yield gap ($g\ m^{-2}$)	Yield gap (%)
Banh Silalek			
Researcher weeded	257		
Farmer weeded	219	38	17.4
Banh Fay			
Researcher weeded	362		
Farmer weeded	295	67	22.7

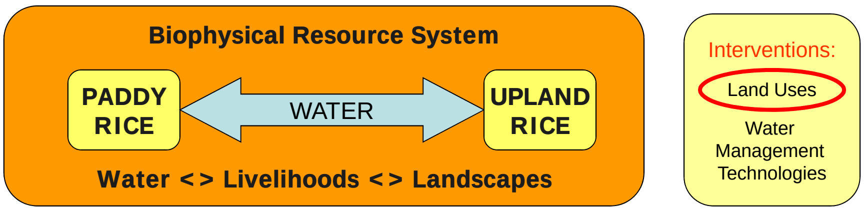
Comparison of local farmer practice, pig manure, *Chromolaena odorata* green manure and inorganic fertilizer on rainfed lowland rice rice growth and grain yield.

Treatment	Plant height (cm)	Grain Yield (t/ha)
Local	80	2.7
Pig manure (5 t/ha)	80	2.6
Chromolaena odorata green manure (25 t/ha)	92	3.5
Inorganic fertilizer (60-30-30)	85	3.1

Comparison of local farmer practice, pig manure, *Chromolaena odorata* green manure and inorganic fertilizer on rainfed lowland rice rice growth and grain yield

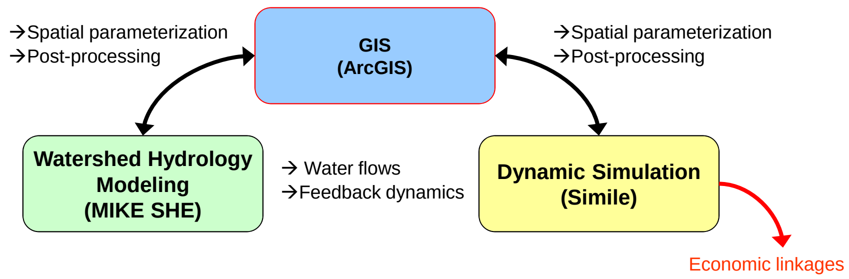


Upland-Lowland Rice Interactions



- Goal: Assess impacts to livelihoods, water availability, and rice production through integrated assessment of land use options on biophysical resource base of target sites.

Analytical Approach



Framework Characteristics:
- Distributed approach designed to capture spatiotemporal aspects of integrated biophysical resource flows
- Enables direct linkage with socioeconomics

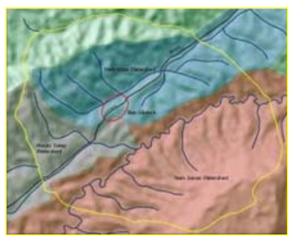
Scenarios:
- ✓ Base case
- ✓ Paddy expansion
- ✓ Upland land use mosaics & dry season paddy
- ? Alternative water management
- ? Alternative cropping systems

Land / Water System Characterization

Fay: 10 km², 57 HH's
Lao Leu

Silaleck: 26 km², 116 HH's
Hmong, Khmu

Track 1: Resource Linkage Appraisal
- Both villages
- Comprehensive qualitative assessment of BP resource base



Track 2: Land / Water Resource Characterization
- Houay Hom watershed (3.8 km²)
- Quantitative, detailed description of L/W resources

Goals:
1) *A priori* analysis
2) Model development
3) Model input data set
4) Identification of extrapolation domains

Methodology

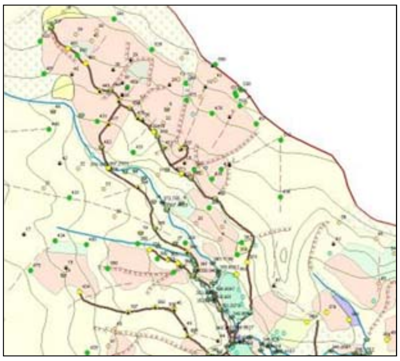
Field Hydrology

Participatory Assessments

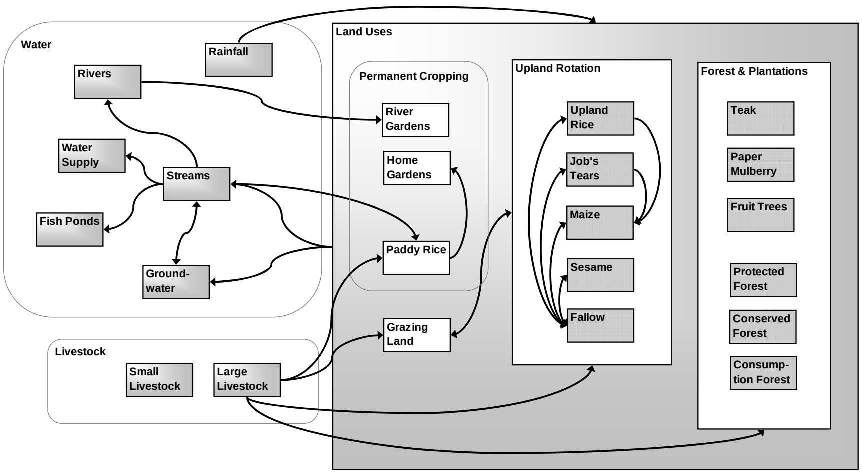
Hydrology infrastructure:

- Three climate stations
- Six stream gauging stations
- Two paddy study sites

Detailed topographic / land use surveys

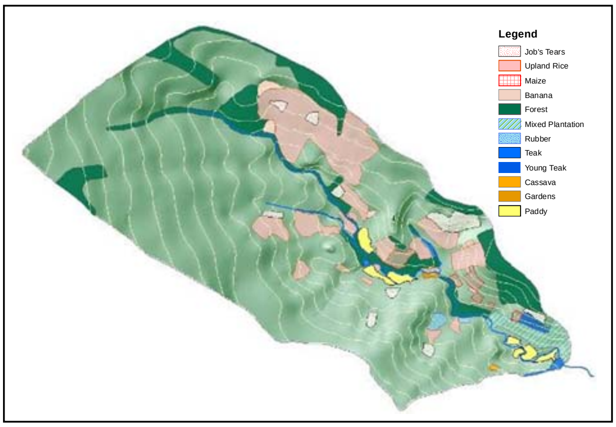


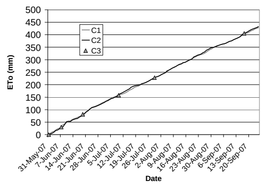
Initial Results: BP Resource Linkages

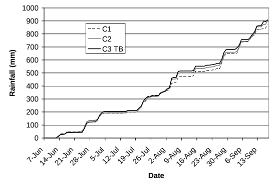


System characterization: *components*, *products*, and *linkages*.

Initial Results: Land & Water Characterization







Land:

- Detailed topography
- Land uses for 2007
- Production zonation with qualitative descriptions

Water:

- Rainfall, evapotranspiration
- Stream flows
- Paddy water levels
- Spring locations

Lessons 1

- Harness high genetic diversity
- High biophysical diversity
  - Discontinuities and micro-environments
  - Mixed strategies
  - Find points of integration
- High socioeconomic diversity
  - Low ability and propensity to pay
  - Work with available abundant resources
- Difficult to come up with generic solutions
  - Research for understanding
  - Research for adaptation of validated technologies
  - Research for development

Lessons 2

- Options, not pat solutions
  - End user/ farmer decides
- Biologically and technologically sound solutions are not sufficient
  - Economic viability (profitability) and social acceptability are major concerns
- Science alone is not enough
  - Political will, policy and action
- Externalities