NAFRI

HOUAY PANO CATCHMENT

(DISTRICT OF LUANG PRABANG)

FIELD GUIDE

Management and Soil Erosion Consortium

2 October 2003

Luang Prabang Province

The MSEC study site is located in the Luang Prabang province. The centre of this province is situated about 400 km north of Vientiane municipality. There are 63,582 households and a population of 396,110 (NSC, State Planning Committee, 1998). The population density is 23 inhabitants km-2 (Table 1) and an annual growth rate of 2.6%. There are various minority groups with about 84% belonging to Lao lum and Lao theuong. About 89% of the population live in rural areas .

Luang Prabang is predominantly mountainous, consisting mostly of hills, steep and very steep slopes (8% of the land having slope gradient exceeding 55%). The flat and gentle slope (0 to 2%) represents less than 1% of the area and occurs at foot hills and at the valley bottom. Elevation varies from 290 to 2257 meters above sea level.

The most common rock types are gabro, diorite, ande site and basic rocks, schist, gneiss, sandstone (Department of Geology and Mines,1990-1991). A detailed soil survey conducted by The Soil Survey and Land Classification Center (SSLCC) in 1996 showed that the most widespread soil groups are Acrisols, Alisols (FAO UNESCO/Systems) or Ultisols (US.Taxonomy). They are mainly found on the slopes ranking from 8% to 50%, i.e. on most of the surveyed area.

Table 1. General characteristics of Lao PDR and Luang Prabang province. Source: NSC, State Planning Committee, 1998.

Land area (km²)	236,800	16,875
Population (no.)	4,966,900	**396,110**
- Density (no.km^{-2})	21	23
- Growth rate (%)	2.5	2.6
- Urban (%)	17	11
- Rural (%)	83	89
Household	799,289	63,582
-Household size (no. Hh^{-1})	6.2	6.2
Crop production area (ha)		
- Upland rice	134,195	32,829
- Low land rice	430,207	9,530
- Maize	46,400	5,000
- Starchy root	21,740	1,570
- Mungbean	2,052	400
- Soybean	5,872	230
- Peanut	14,900	1,170
- Tobacco	6,580	680
- Cotton	7,235	750
- Coffee	28,640	71
- Tea	910	-
- Sugar cane	5,365	150
- Vegetable	30,930	3,500
No. of households practising Shifting cultivation	142,757	35,100
Area of Shifting cultivation (ha)	132,500	32,000

The province has a wet-dry monsoon tropical climate. The dry season (November to March) is cold and mostly dry, while the wet season (April to October) is hot and humid. The annual rainfall varies from year to year (minimum 1035mm in 1987 and maximum 1840 mm in 1986) with an average of 1403 mm year-1.

Climate data from 1986 to 1996 as recorded in the Luang Prabang's meteorological station, located at 102° 08' E longitude and 19° 53'N latitude at 305 m showed an average annual rainfall of

1,403 mm. Mean annual temperature is 25^0 C. There are two distinct seasons, the wet season starts from April to October, while the dry season is from November to March (Table 2).

Rainfall varies both in time and space. More than 90% of the total rain falls during the rainy season. Rainfall exceeds evapo-transpiration throughout the rainy season, but very much less during the dryer months (November to April.) Dry season crops would need thus supplementary water supply.

Table 2. Meteorological record, Luang Prabang province (1986-1996). Source: Meteorological station of Luang Prabang province

Month	Radiation *(Hrs/day)*	Prec. Total (mm)	Evaporation (mm)	Max. air temp (°c)	Min. air temp (°c)	Mean. air temp (°c)
January	6.1	5.7	64.2	22.9	19.3	21.20
February	6.9	18.5	96.0	22.9	19.3	21.20
March	6.1	44.4	120.3	28.0	23.5	25.90
April	6.8	110.6	125.7	31.7	23.4	27.67
May	6.4	149.0	111.0	30.1	27.6	28.65
June	4.2	194.0	84.9	28.8	26.5	28.02
July	3.4	259.6	70.8	29.0	26.8	27.63
August	4.4	275.4	75.9	28.6	26.4	27.63
September	5.6	136.9	75.0	27.7	25.7	26.98
October	5.8	133.3	72.9	26.9	24.0	25.68
November	5.7	51.8	74.7	25.0	21.3	23.49
December	5.5	23.7	50.7	20.8	???	20.36
Mean Annual	5.6	1,403	1,022	26.0	23.8	25.3

Luang Prabang is a typical upland crop area with approximately 35,100 families (Department of Forestry, MAF,1998), of which about 210,600 people (or 53% of population) are practising shifting cultivation. Assuming that each family plants 0.9 ha/year, the area used for shifting cultivation annually would be approximately 32000 ha. This has declined significantly since 1995.

The Houay Pano catchment

Site selection

After the training workshop on Project Management and Participatory Approach, Monitoring and Analysis in Phrae, Thailand, 4 – 13 October 1998, the site selection visit, 15 – 20 October 1998, was conducted by a team including IBSRAM soil scientist, hydrologist and local scientists. Houay Pano catchment was selected because it was highly representative of the shifting cultivation area and readily accessible.

Location and area of catchment

Houay Pano catchment is located at the km-10 village, Luang Prabang district in the province of Luang Prabang in northern of Laos, about 10 km south of central Luang Prabang province along the National road N° 13. The catchment area lies at 102^0 09'50'' to 102^0 10'20'' E longitude and 19° 51'0" to 19° 51'45" N latitude. The catchment to the river has a total of 67 hectares encompassing 5 nested catchments with different land uses. Four micro-catchments (<1 ha) have been added in 2002 to test soil and water conservation practices. The weir of the main equipped catchment has been located just before the irrigated rice fields, and the village, excluding thus 3.8 ha of the total natural first order catchment.

Geology and physiography:

The geological formation described in this report was derived from the photogeological map prepared by G. Whiltle, Institute of Geological Sciences, London. The field work had been carried out by H. Counillon, L. Dusazult, C. Jacob and E. Saurin 1972 (Source of Department of Geology and Mines, 1990-91). The geological formation is known as Permian to Upper Carboniferous Argilite series (pca): shale, mudstone, siltstone and fine grained sandstone.

Topographic features of the study area have been estimated using a digital elevation model (DEM). A DEM with a 5 meters mesh has been constructed for the whole watershed by interpolation from spot heights and digitized contour lines with a 5 m interval. Spot heights were preferentially localized along the watershed boundary whereas contour lines have been drawn by expert judgment based on level investigation. Contour lines have been digitized using WinDig software (1994). The DEM surface has been fitted using the tension-spline method. This DEM has been projected in Universal Transverse Mercator, zone 48 and North American Datum (NAD) 1983 using GPS data points survey. Altitudes range from 425 to 718 m and slope angles range from 3 – to more than 350%. The spatial distribution of altitudes and slope angles inside the watershed is shown in Fig. 2 and 3. Highest altitudes are mainly encountered in the northern part of the catchment (Fig. 2) whereas higher values for slope angle could be observed either in the northern and southern parts (Fig. 3).

Soils

A detailed soil survey was performed over the 67 ha watershed. 14 soil profiles have been described along several hillslopes in order to describe the soil variations. Additional sampling using 34 auger holes were used to precisely delineate soils extension (Fig. 4). For each point, several soil characteristics have been observed and measured at the laboratory for soil identification. The sampling locations were registered global positioning system GPS and an infrared laser theodolite. According to US. Taxonomy soil classification system, the soil in the catchment is classified in three major soil orders, namely: Entisols, Utisols, Alfisols. These are presented and described as follows:

Entisols- This soil covers an area of about 15 ha or about 20% of the catchment area. Based on physical and chemical properties, the topsoil texture is classified as clay and rated as medium in soil fertility with pH value of 6.45.

Ultisols- This soil covers an area of 20 ha or 30 % of the catchment area. Based on physical and chemical properties, the topsoil texture is classified as clay and rated as medium in soil fertility with pH value of 5.51.

Alfisols- This soil covers an area of about 36 ha or 50 % of the catchment area. Based on physical and chemical properties, the topsoil texture is classified as heavy clay and rated as medium in soil fertility with pH value of 6.23.

Table 3. Soil type proportion according for each sub-watershed.

	PROPORTION (%)						
	S0	S1	S2	S3	S4	S5	WHOLE
ALFISOLS	**18.1**	**35.6**	**47.5**	**74.4**	**47.2**	**38.6**	**48.5**
ENTISOLS	**0.0**	**16.5**	**19.5**	**17.7**	**21.5**	**0.0**	**18.5**
ULTISOLS	**81.9**	**47.9**	**33.0**	**7.8**	**31.3**	**61.4**	**33.1**

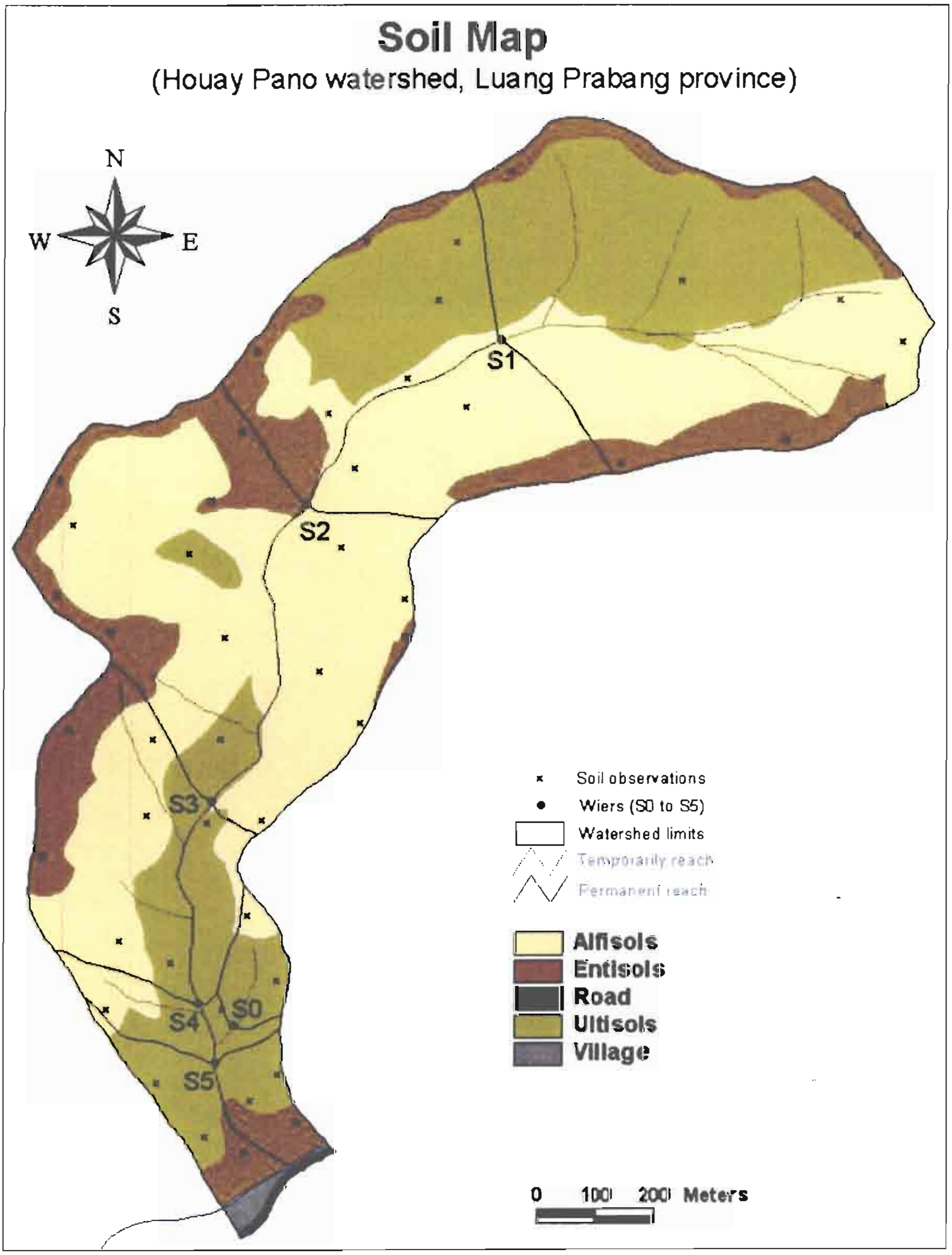


Figure 1. Soil map of the Houay Pano watershed. Location of soil observations.

Water resources

The stream of the Houay Pano catchment is a tributary of the Xon stream which is one of the tributaries of the Num Dong river before its confluence to the Mekong river south of Luang Prabang. The water in Houay Pano originates from the upper part of the catchment and runs down to Houay Xon.

Land use in 2002

	S1	S2	S3	S4	S5	S6	S7	S8	S9	Outlet
Forest	13.8	11.8	8.5	32.4	13.6	29.7	20.7	59.5	13.4	14.2
Teak		2.4	1.9	6.9	34.2					6.0
Banana	0.7		14.1	1.6		9.4				4.4
Orchard										0.9
Pineapple										0.2
Fish Ponds			0.4							0.1
Garden										0.3
Village										0.6
Job's tear	14.8	6.7	7.8	2.9		54.7	31.0	24.3		8.5
Upland rice	34.7	57.4	19.3				48.3			27.1
Paddy rice										0.4
Corn		3.0		4.9	1.5			16.2	23.6	2.1
Annual crops	**49.5**	**67.1**	**27.1**	**7.8**	**1.5**	**54.7**	**79.3**	**40.5**	**0.00**	**39.3**
Fallows	**36.0**	**18.6**	**48.1**	**51.3**	**50.8**	**6.3**	**0.00**	**0.00**	**63.0**	**35.1**

Land use in 2001

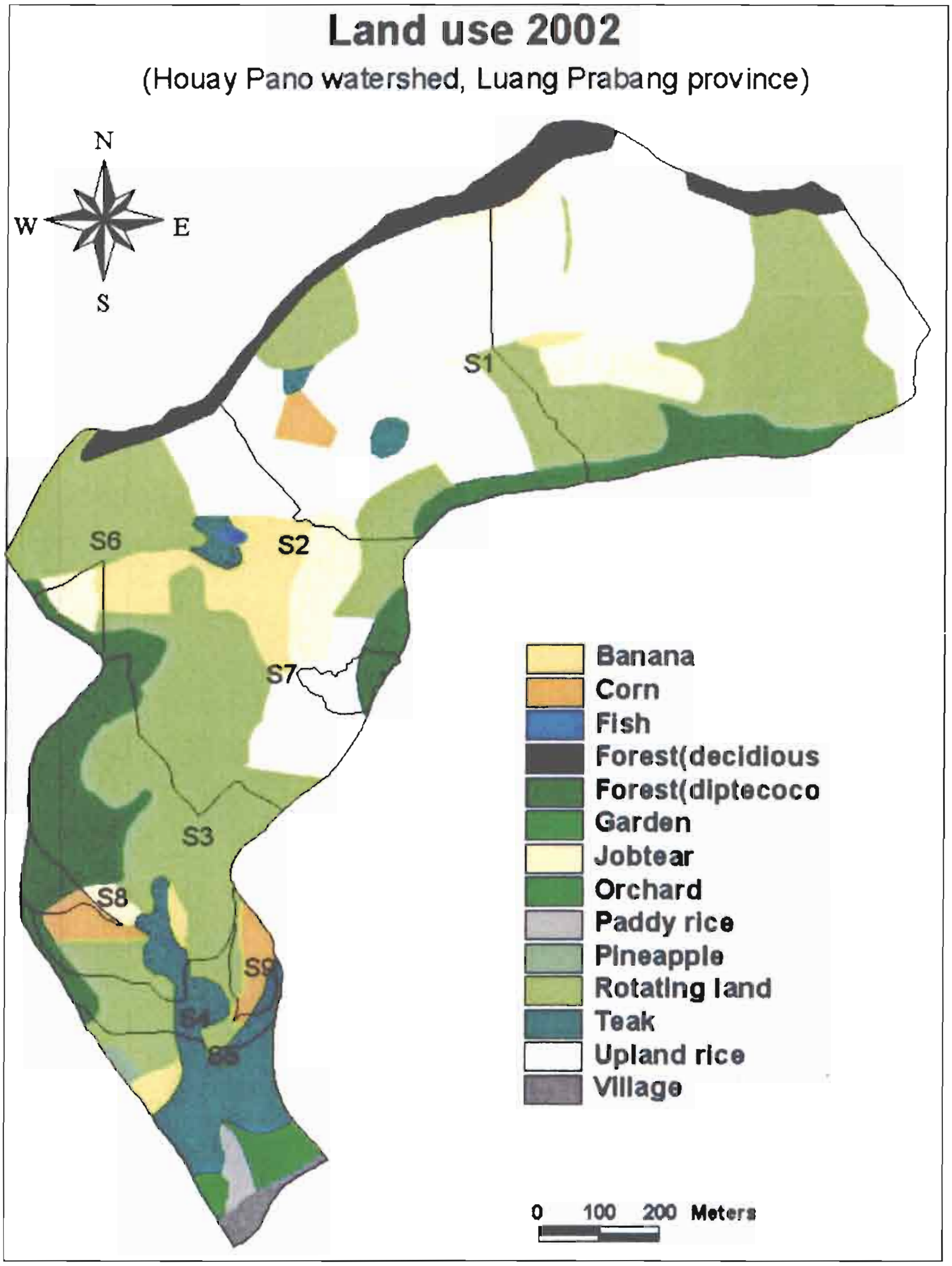
	S1	S2	S3	S4	S5	S6	S7	S8	S9	Outlet
Forest	23.9	13.4	11.5	32.5	13.4	29.9	30.2	78.2		18.2
Teak		4.7	1.8	6.9	34.2				13.4	6.5
Banana+corn+pine		2.7								0.6
Orchard										0.9
Pineapple										0.2
Fish Ponds			0.4							0.1
Garden										0.3
Village										0.6
Banana	0.7		10.3	1.6						3.3
Job's tear	3.9		10.6	1.4		66.6				4.6
upland rice	5.5	2.6	7.2			2.1				4.0
paddy rice										0.4
Annual crops	**9.4**	**5.3**	**17.9**	**1.4**	**0.0**	**68.7**	**0.0**	**0.0**	**0.0**	**10.7**
Fallows	**66.0**	**76.7**	**58.1**	**57.6**	**52.4**	**1.4**	**69.8**	**21.8**	**86.6**	**60.3**

Land use in 2000

	S1	S2	S3	S4	S5	S6	S7	S8	S9	Outlet
Forest	23.9	12.9	11.5	31.5	12.8	26.1	31.7	78.1		18.2
Teak		4.6	1.9	7.1	32.6				16.0	6.5
Banana+corn+pine	0.7	2.7								0.7
Orchard										0.9
Pineapple										0.2
Fish Ponds										0.1
Garden										0.3
Village										0.6
Banana			10.3	1.6						3.2
Job's tear		1.8	3.3							1.2
upland rice	22.7	11.1	8.6							11.1
paddy rice										0.5
corn			5.1							1.3
Annual crops	**23.4**	**15.6**	**17.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**15.9**
Fallows	**52.7**	**66.9**	**58.9**	**59.8**	**54.6**	**73.9**	**68.3**	**21.9**	**84.0**	**55.4**

Land use in 1999

	S1	S2	S3	S4	S5	S6	S7	S8	S9	Outlet
Forest	23.8	13.1	11.5	13.4	32.2	29.8	30.0	77.9		18.2
Teak		1.6	1.9	33.9	7.0				14.2	5.9
Banana+corn+pineapple		2.7								0.5
Banana		0.0	10.3		1.6					3.2
Orchard										0.9
Pineapple										0.2
Fish Ponds			0.4							0.1
Garden										0.3
Village										0.6
Job's tear	8.8	14.6	44.1	52.7	41.8		70.0	22.1		25.3
Upland rice	32.8	66.6	6.0		4.4					25.2
Paddy rice										0.4
Annual crops	**41.6**	**83.8**	**50.0**	**52.7**	**46.2**	**0.0**	**70.0**	**22.1**	**0.0**	**52.6**
Fallows	**34.6**	**1.4**	**25.9**	**0.0**	**13.1**	**70.2**	**0.0**	**0.0**	**80.1**	**19.3**



Production system and local economy

Settlement and land use history of the Lak Sip village

In the early years, the land of the catchment was covered by forest. In 1962, logging of trees started and four families from the neighbouring village settled in the area and began shifting cultivation mainly of upland rice. In 1972, nine families occupied the catchment.

After the revolution in 1975, Lak Sip village was established with 41 families. Eleven of them had fields in the Houay Pano catchment. Shifting cultivation continued with rice mixed with maize as the main crops. Cucumber and chillies were also encountered in the same fields.

Because of the need to leave fields in fallow for some times to restore soil fertility and reduce weeds and of the increasing population pressure, new fields progressively encroached on the forest areas. Farmers are forced to intensify land use by reducing the fallow period. As results, increasing erosion tends to reduce the fertility of soils through nutrient and organic matter depletion and crop yields declined.

In 1984, one farmer started cultivating lowland rice on an area of 0.2 ha. In 1986, 21 farmers attended the training on the management of sloping lands particularly focusing on soil conservation techniques. It was conducted and supported by the Food and Agriculture Organization (FAO). The main objective was to stabilize shifting cultivation by introducing spot digging for upland rice cultivation as soil conservation technique.

Since 1996, teak, bananas and Job's tear have been grown as permanent and cash crops.

Land tenure in the Houay Pano catchment

The government maintains that land is a state property and the state administers its uses "to generate livelihood and serve as a vehicle for socio-economic development". The recently promulgated Land and Forestry Laws are intended to support good land use planning and management. It provides participatory planning at village level. Land allocation is based on the households and village needs and resources, like labour capacity. Titles are provided to lands that are productively managed according to some flexible guidelines. Land can be allocated to individuals, groups or private companies.

The lands are leased to farmers for a long-term agricultural use. Agricultural land is defined as land for planting crops, raising livestock and agricultural experimentations. Based on the data collected, there are 26 households in the catchment area who have received land use rights. In most of the cases (73 %), only one parcel is attributed for each household. The maximum landholding per household is 9.9 ha with 2 parcels. The minimum area is 0.25 ha per household. Annual use for cropping lies in between 0.25 to 1 ha.Land tenure in Houy Pano catchment (26 households).The average land holding per household is 3 ha.

Number of parcels / household	**Number of households**	**Percentage of households**
1	19	73 %
2	5	19 %
3	2	8 %
Landholding	**Number of households**	**Percentage of households**
< 2ha	11	42 %
2ha	6	23 %
3ha	4	15 %
5ha	1	4 %
6ha	2	8 %
>6ha	2	8 %

Programme of the field visit

12 h 30 lunch at MSEC house, Ban Lak Sip

14 h 00 short introduction

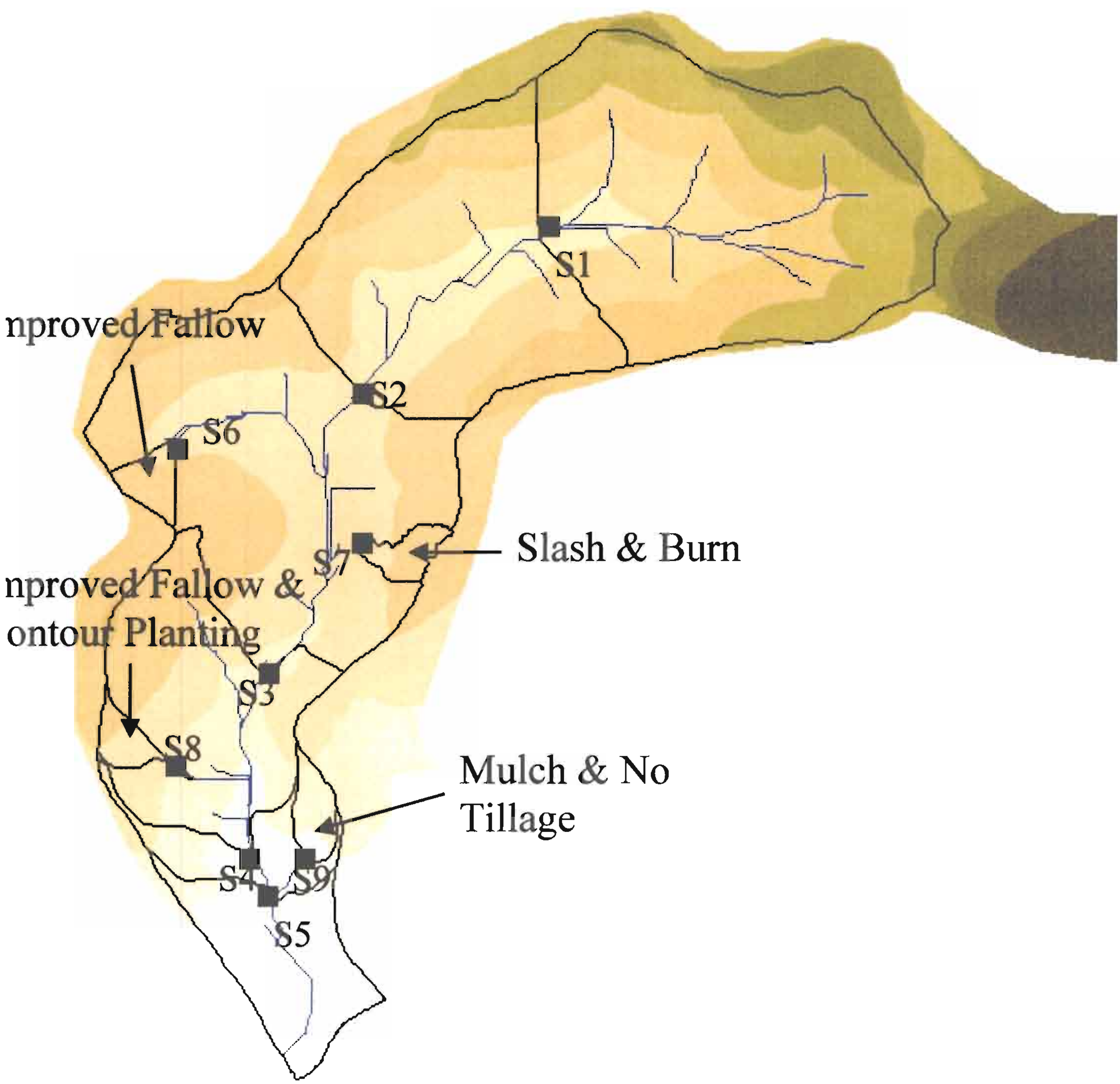
14 h 30 departure from MSEC house

Five stops

- Station 4, main weir
- Station 9, mini-catchment, treatment "Mulch planting, no till"
- Station 8, mini-catchment, treatment "Improved fallow + countour planting"
- Station 7, mini-catchment, treatment "Slash & burn", runoff plots, gully and Carbon stocks
- Pièzometers
- Station 6, mini-catchment, treatment "Improved fallow", panoramic view
- Camp, break with refreshments
- Facultative – Station 1, gully and rills.

18 h 00 return to Luang Prabang

HOUAY PANO CATCHMENT



A. Farming systems and weeds

The slash and burn cropping systems in the Luang Prabang region have evolved in recent years from short fallow periods 7 – 5 years, to locally very short periods of 4 – 2 years. An example of the latter is the Houay Pano catchment (MSEC 2000). Hand weeding is still the only effective method to control weeds in slash and burn systems on steep slopes, making weed control by far the most labour consuming task in upland rice production. In 2001, clearing and weeding operations accounted for 140 days or 61 % of total crop labour input in upland rice. These values are comparable with Roder *et al.* (1997) who recorded in the region an average of 146 days per ha in upland rice accounting for 40 – 50 % of total labour requirements.

Comparing Jobs' tears with upland rice we summarise that farmers in Houay Pano carried out less weeding rounds in Jobs' tears than in rice; secondly, that the amount of weed biomass removed is three times less in Jobs' tears compared to rice.. Thirdly, good soil cover by both crop and weeds is assured in Jobs' tears during most of the rainy season against poor soil cover during a much shorter period of the rainy season in upland rice. Finally, after the harvest, a heavy mulch cover of 4 – 5 t/ha of crop residues occupies Jobs' tears field compared to only 1 t/ha of crop residues in rice. With respect to erosion we conclude that frequent weeding and abundance of weeds are liable of increasing soil losses by tillage erosion in upland rice.

Roder, W. 2001. Slash and burn rice systems in the hills of northern Lao PDR. Description, challenges, and opportunities. Los Banos, Philippines, International Rice Research Institute. 201 p.

The progressive invasion of weeds in fields and the subsequent extra work to clean these fields induce tillage erosion, a type of erosion not induced by runoff. The objective of this study was to compare four farming systems: In contrast with other projects in Laos where testing of farming system is carried out on a plot of field scale, MSEC uses the watershed or catchment scale. This implies that landscape features as topography, gullies and rock outcrops are better accounted for. Practically it meant that all farmers cultivating within such a watershed had to apply the same farming system. The four farming systems studied were:

1. Conventional system consisting of slash and burn, with no inputs and reduced fallow periods ranging from 1 to 3 years.

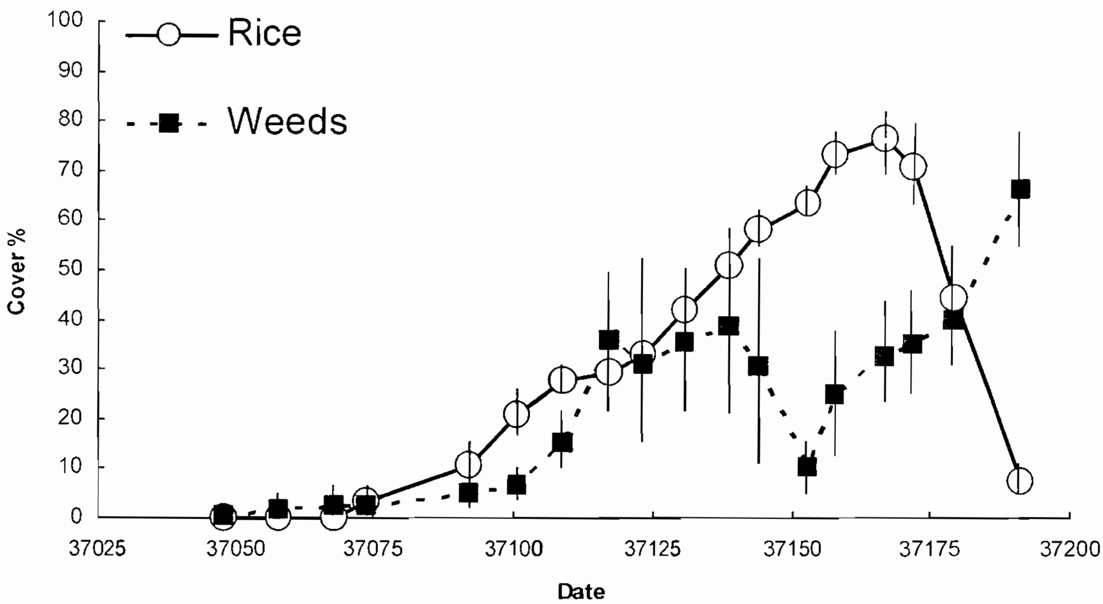
2. Improved fallow with Pigeon Pea (*Cajanus cajan* (L.) Huth.) and *Crolalaria micans* Link. as recommended by the Integrated Upland Agricultural Research Project (IUARP). Such systems aim to enrich the poor bush fallow with additional biomass, early ground cover and extra litter to improve the soil and suppress weeds in a short period. Improved fallows seem to be adaptable by farmers in the region within a limited period.

3. Improved fallow combined with contour strips of pineapple as recommended by the Asialand/Sloping land project. This system could be adopted when the fallow system is no longer possible.

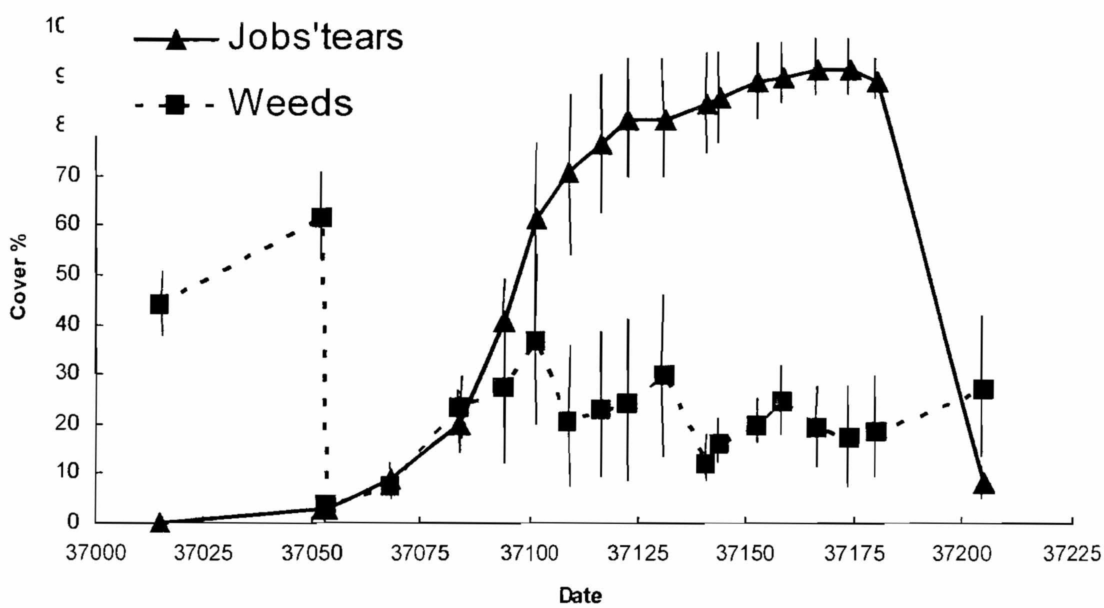
4. No-till and direct sowing in dead mulch of Ruzi grass (*Brachiaria ruziziensis* Germain & Evrard) with limited use of glyphosate as recommended by the CIRAD (French Research Centre for Agriculture and Development). During the dry season, Ruzi grass acts as a grazed fallow. The farmers would adopt this system only under better economic conditions

In each one equipped with a sediment trap and a water sampler. Soil losses in rotational slash and burn were 5.7 t ha^{-1} including 320 kg ha^{-1} losses of organic matter, whereas erosion decreased to a third or a tenth in the alternative systems due to superior ground cover and less weeding, yet yields were reduced by 26-53 % in the alternative systems compared to rotational slash and burn (1.9 t ha^{-1} rice, 1.4 t ha^{-1} Jobs' tears). Low yields in the alternative systems can be attributed to delayed work because farmers were relative unfamiliar with the alternative systems, and because the new technologies require further adjustment to local conditions.

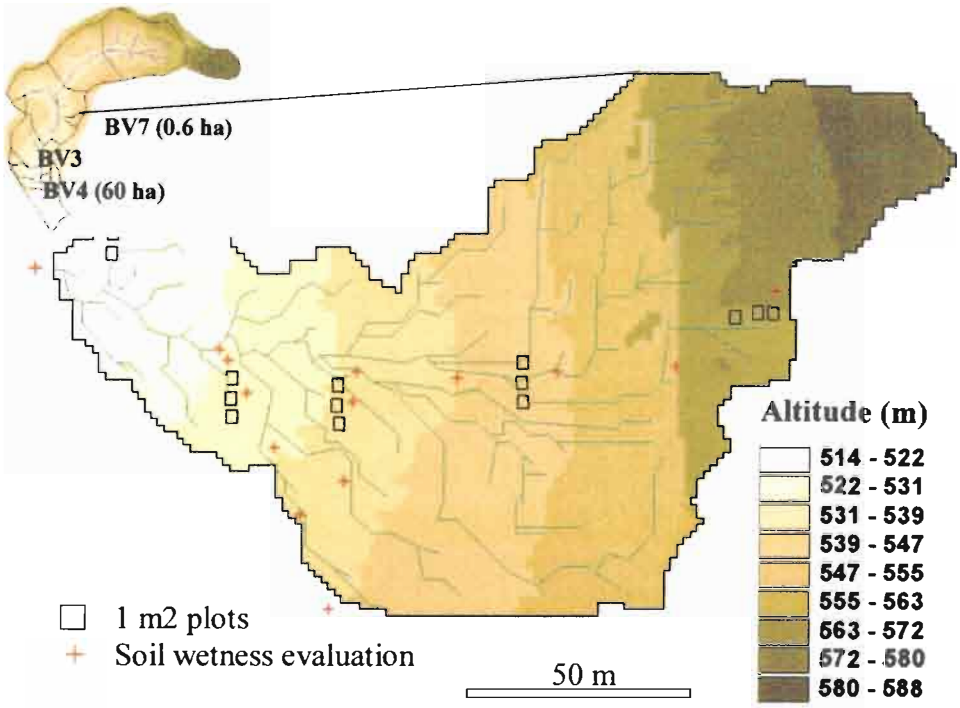
Cover by upland rice and weeds during the season 2001, Houay Pano. Vertical bars are 1 S.D.



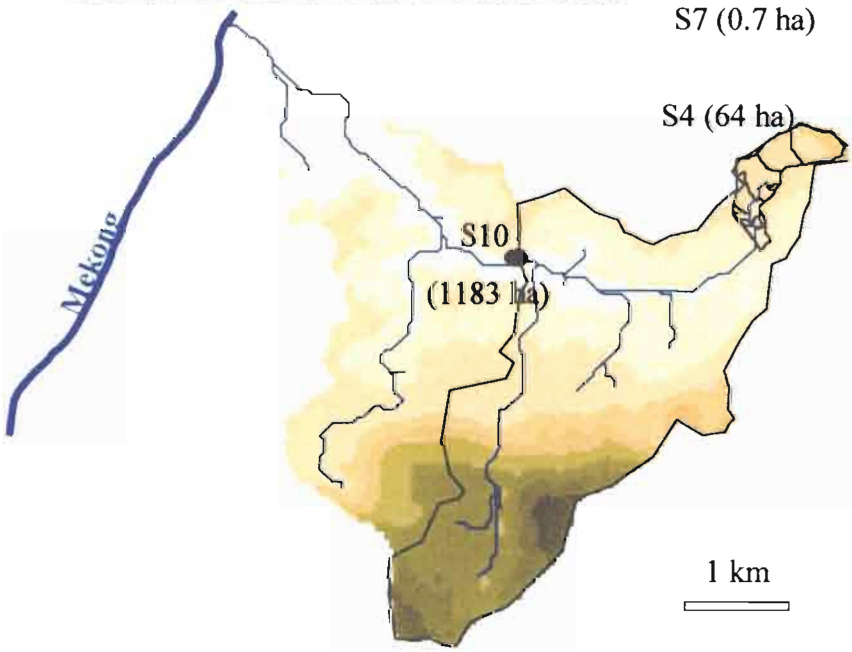
Cover by Jobs' tears and weeds during the season 2001, Houay Pano. Vertical bars are 1 S.D.



B: Soils, organic carbon and gully erosion



What would be eroded C at station S10?



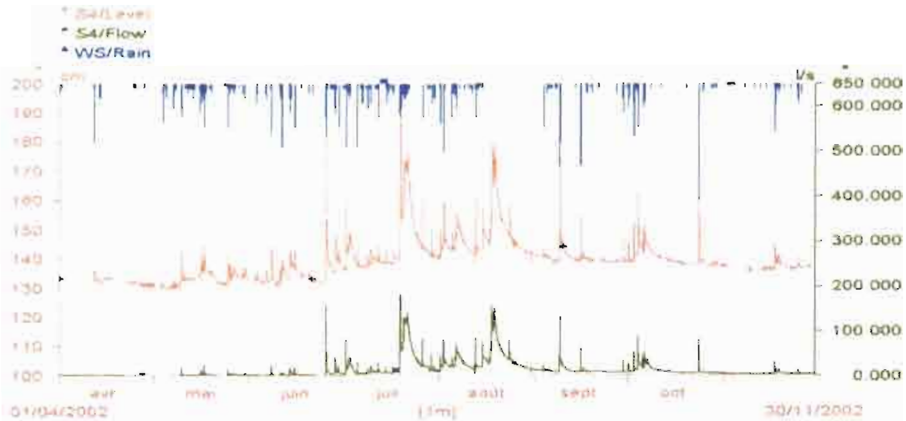
D: Best bet options to combat soil erosion

Catchment	Systems	Area	Runoff coefficient	Bedload	Suspended load	Total sediment yields
		ha	%	t/ha	t/ha	t/ha
S6	Improved Fallow	0.64	0.2	0.4	0.01	0.42
S7	Slash & burn	0.62	1.2	4.74	0.99	5.74
S8	Contour planting	0.567	6.7	1.95	0.56	2.51
S9	Mulch & No tillage	0.727	8.7	0.11	0.47	0.58

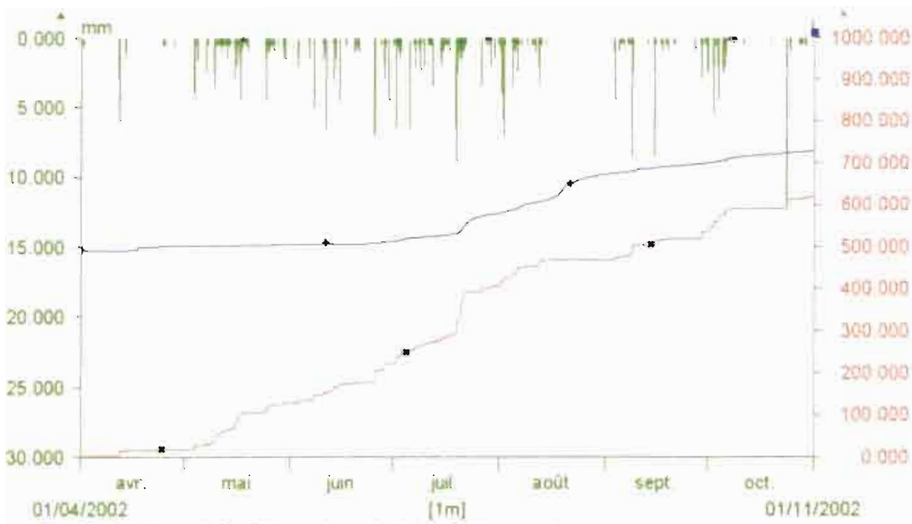
Normalized labour required (day ha-1) for the cultivation of upland rice and Jobs' tear, Houay Pano, 2002

Operation	Slash and burn	Improved fallow	Contour planting & Improved fallow	No tillage
Field preparation	41	43	71	29
Burning	1	1	1	
Second clearing	26	57	29	63
First weeding	36	28	**18**	21
Second weeding	38	2	**6**	
TILLAGE SUB-TOAL	142	131	125	113
Herbicide				5
Transport/Planting pineapple			**26**	
Planting main cereal crop	43	34	33	21
Planting cover crop		42	**30**	**6**
Harvest and transport	25	6	24	4
GRAND TOTAL	210	171	182	138

C: Runoff and soil erosion from the catchment



Level (cm), Flow (l/s) & Rain (mm) for station S4 (1/4/02 – 30/11/02)



Volume (l), Rain (mm) & Cumulated Rainfall (mm) for station S4 (1/4/02 – 30/11/02)

Runoff coefficient, bedload, suspended load and total sediment yields

Catchment	Area	Runoff coefficient	Bedload	Suspended load	Total sediment yields
	ha	%	t/ha	t/ha	t/ha
S1	19.6	31.4	0.46	0.25	0.72
S2	32.8	39.8	0.04	0.54	0.59
S3	51.4	67.1	0.9	0.52	1.47
S4	60.2	44.8	1.8	4.95	6.83

D: Experiments of 2003 (Lao and French students)

- Implication of gullies and rills for upland cultivation. Farmers identify major problems (i.e. causes of reduced yields) as weeds, rats, insects, drought and declining soil fertility but are little aware of soil erosion (IUARP 2002), possibly because erosion is expressed in terms of soil losses (t ha^{-1} $year^{-1}$) and this remains relatively hidden from farmer's perception. The present study aims to make erosion more visible by quantifying yield losses and field reductions due to rill formation, mini-land slides and the widening gullies that feature the upland fields in Houay Pano. The study is complementary to the 2001 and 2002 studies on tillage erosion, gully erosion and gully dynamics. These former studies investigate flows of water and sediments and concentrated on vertical processes, whereas this study will focus on horizontal extension of rills and gullies. Observations are made in transects consisting of a sequence of plots $1m^2$ width, the number of plots varying with occurrences of gullies and rills. Most of these transect are located in Station 1. Because fields are about to be harvested, visits to these trials by a large group of persons is difficult.
- On-farm experiment of Pigeon pea and Crotalaria, sown in various densities in Jobs' tears crop. The potential of Pigeon pea (*Cajanus cajan*) and Crotalaria (*Crotalaria micans*) as fallow crop are evaluated. Pigeon pea is a recommended multi-purpose tree for fallow improvement, agroforestry and rotation systems. Crotalaria is a fast growing shrubby legume, its pods can be used as a fodder for goats. The aim of the study is to investigate if the life span of the legumes can be extended over 2-3 years by increasing spacing. In fact, dense planting of 40-45 cm spacing are repored to reduce the life cycle of these legumes to a quasi annual plant (observations Lao-IRRI). However the student study comprises 7 months and therefore this study concentrates on early growth and development of both legumes during the rainy season of 2003 corresponding to the period the legumes are intercropped with Jobs' tears. Competition between Jobs' tears crop and legumes will particularly studied. The experiment is carried out in two sites (station 6 and 8, each site two repeats). The treatments are (i) Jobs'tears only, (ii) Jobs'tears and legume in high density, (iii) Jobs' tears and legume in low density (125 cm), (iv) legume only high density, (v) legume only low density.