ໂຄງການຄຸ້ມຄອງການເຊາະເຈື່ອນຂອງດິນ ໃນ ສ.ປ.ປ ລາວ: ສະພາບທາງດ້ານກາຍະພາບ - ເສດຖະກິດສັງຄົມ ແລະ ການວາງແຜນຄົ້ນຄວ້າທົດລອງ

ຄຣິສຕຽນ ວາເລນຕິນ, ກີໂຍມ ເລສເຕີລິນ, ກອງແກ້ວ ພະຈອມພິນ, ອານາເກ ເດີຣູ, ອາລຸນສະຫວັດ ຈັນເພັງໄຊ, ວັງຊັງ ຊັບໂປລດ, ເອມານູເອນ ບວກດົງ, ຊັງປີແອ ບຣິກເກ, ປີແອ ມາກຊັງ, ອາແລງ ປີເອເຣ, ໂອລີວີເອ, ຣິໂບນຊີ, ຊັງປີແອ ທີໂບ

ບົດຄັດຫຍໍ້

ນະໂຍບາຍການນຳໃຊ້ທີ່ດິນ ບວກກັບຄວາມຕ້ອງການຂອງຕະຫຼາດ ເຮັດໃຫ້ການນຳໃຊ້ທີ່ດິນໃນເຂພູດອຍ ມີການປ່ຽນແປງຢ່າງໄວວາ ໃນຊຸມປີທີ່ຜ່ານມາ. ການຫັນປ່ຽນດັ່ງກ່າວ ໄດ້ເກີດມີເຫດການ ການພົວພັນລະຫວ່າງ ການຜະລິດກະສິກຳ ແລະ ຜົນກະທົບທາງອ້ອມຕໍ່ສິ່ງແວດລ້ອມ. ເພື່ອແກ້ໄຂບັນຫາດັ່ງກ່າວ ໂຄງການເຊາະເຈື່ອນຂອງດິນ ໄດ້ສຶກສາການເຊາະເຈື່ອນດິນ ໃນເຂດອ່າງໂຕ່ງຫ້ວຍປ່ານໍ່, ບ້ານຫຼັກສິບ ເມືອງ ແລະ ແຂວງຫຼວງພະບາງ. ບົດນີ້ ໄດ້ສັງລວມຂໍ້ມູນທາງດ້ານກາຍະພາບ ແລະ ເສດຖະກິດສັງຄົມ, ວິທີການຕິດຕາມການປ່ຽນແປງການນຳໃຊ້ທີ່ດິນ ແລະ ຜົນກະທົບຂອງດິນຕົກຕະກອນ ແລະ ຄຸນນະພາບນ້ຳ.

The MSEC project in the Lao P.D.R. at a glance: biophysical and socio-economic background and project experimental set up

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Abstract

Land use policies together with growing market demand have resulted in rapid land use changes in the uplands of the Lao PDR over the past few years. These changes have led to questions concerning the link between agricultural activities and off-site impacts. To tackle this issue the Management of Soil Erosion Consortium has equipped a catchment in northern Laos, ten kilometres from Luang Prabang. This paper summarises the main biophysical and socio-economic characteristics of this catchment and the associated village community. It also presents the main methods used to monitor the land use changes and their impacts upon catchment hydrology and sediment yield.

Key words: *Upland agriculture; Soil erosion monitoring; Runoff monitoring; Benchmark site; Lao P.D.R*

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Introduction

As part of its poverty eradication programme, the government of the Lao PDR has resettled upland communities so that they can access services and commodities such as roads, education, health care and markets. A specific objective of this resettlement policy is to eradicate shifting cultivation which is considered a threat to the unique biodiversity of some of Southeast Asia's last remaining pristine tropical forests. These land use policies together with growing market demand have resulted in rapid land use changes in the uplands of the Lao PDR over the past few years.

Land degradation results from a complex combination of spatially and temporally dependent processes (Scherr, 1999; 2000). Recent work highlighted that for effective management strategies for Southeast Asian uplands to be designed, knowledge about the interactions between environmental and anthropic dynamics must first be gained through long-term catchment studies (Tomich et al, 2004; Sidle et al, 2006ab). A key element in achieving this goal is to integrate biophysical and land-use characteristics in a holistic approach. For example, several scientists have questioned the impact of deforestation on large-scale flooding, suggesting that these effects have been overestimated (Kiersch and Tognetti, 2002; Bruijnzeel et al, 2004) and that major sources of sediments can be roads, poorly constructed and maintained terraces, coffee plantations or bank erosion (Sidle et al, 2006b). In developing countries in particular, investment priorities should be switched from disaster recovery to the assessment of catchment vulnerability and resilience to change (Mirza, 2003). Questions that are central to the design of suitable environmental policies include: establishing firm evidence for causal links between agricultural activities and off-site impacts; examining the relevance of incentives-based management systems for the maintenance of watershed services; determining relationships between prolonged population growth and improved access to markets and adaptive responses for sustainable land management.

In an attempt to address these issues and provide sound data on the extent of accelerated soil erosion resulting from rapid land-use change, a regional network called 'the Management of Soil Erosion Consortium' (MSEC) was established in the late 1990s. The MSEC network, which was initially supported by IBSRAM and the ADB and is currently funded by IWMI and IRD, operates in five Southeast Asian countries, namely, Indonesia, the Lao P.D.R., the Philippines, Thailand and Vietnam. In the Lao P.D.R., the MSEC programme selected the Houay Pano catchment to implement long-term monitoring of changes in farming practices and the resulting runoff and sediment yields, at the whole catchment scale (Valentin et al., this issue). This consortium also aims to: 1) Train national scientists and students in catchment hydrology, soil science, agronomy and weed science; 2) Collect and interpret scientific data on the impact of land use changes on weed invasion, crop yields, soil erosion and water quality; and 3) assess various innovative land-use practices to reduce soil losses and enhance the livelihood of affected communities (Maglinao et al, 2004).

The objectives of this paper are to summarise the main biophysical and socio-economic settings of the Houay Pano catchment and the Ban Lak Sip community as well as the main methods used to monitor the land use changes and their impacts upon catchment hydrology and sediment yield.

Biophysical environment

The Houay Pano catchment was selected as the benchmark catchment of the MSEC project in the Lao PDR in 1998. The Houay Pano Catchment was selected because it is representative of a shifting cultivation area and has accessibility to roads and transport facilities. It is located near the Ban Lak Sip village (102° 10' 2" E; 19° 50' 54" N), 10 km South of the UNESCO world heritage city of Luang Prabang (Luang Prabang Province, northern Lao PDR) (Figure 1). The catchment covers an area of 0.62 km^2 and encompasses 9 sub-catchments (Table 1) with different land uses. It was first cleared of primary climax Dipterocarp forest in the late 1960s and has since been cropped using shifting cultivation practices, with no inputs. The duration of the fallow period has declined from an average of 8.6 years in 1970 to 3.2 years in 2003 (Lestrelin et al., 2005; Lestrelin and Giordano, 2007). The initial biophysical and socio-economic inventory was conducted in November and December 1998. Approximately two months were devoted to laboratory activities and map preparation.

The catchment elevation ranges from 400 to more than 800 m a.s.l. (Figure 2). Parts of the village land rise above 700 metres. The terrain is steep with a mean slope gradient of 30%, ranging from 0% to more than 100%. The climate is a wet-dry monsoon tropical climate, with an average annual rainfall of ~1300 mm/year (Figure 3). The rainfall pattern is highly seasonal, with 77% of the rainfall occurring during the rainy season from mid-May to mid-October, while the Novernber to March period is cool and mostly dry. The drainage system comprises a 1200 m long second-order perennial stream of irregular topography that receives water from several ephemeral streams. The stream within the Houay Pano catchment is a tributary of the Xon stream (see Ribolzi et al, this issue) which is a sub-tributary of the Num Dong River before its confluence with the Mekong River in Luang Prabang. The water in Houay Pano originates from the upper part (mountain) of the catchment and runs down to the Houay Xon.

The catchment's geological substrate is composed of Permian to Upper Carbonifer argillites and siltstones. Soil distribution (Figures 4 and 5) along the catena typically comprises: shallow Inceptisols along the crests; deep, clayey Ultisols and Alfisols (which cover 30 and 50% of the catchment area, respectively) along the slopes; and clayey Dystrochrepts with fluvic and redoximorphic features at the footslopes and along the stream banks (Soil Survey Staff, 1998). The Inceptisols are thought to have derived from Alfisols from which the sub-surface argillic horizon has been eroded (Chaplot et al., 2005a,b). As a general trend, soil thickness decreases from a few meters (up to 4m) to a few tens of centimetres in the uphill direction. Likewise, the thickness of organic topsoil horizons decreases dramatically from the base to the top of slopes.

Approximately 80% of the land use within the catchment is rotating land, under the no-input shifting cultivation system typical of Southeast Asia (Figure 6). In most years, less than 15% of the area within the Houay Pano catchment is farmed. Upland rice and job's tear production accounts for 80%. As mentioned above, the Houay Pano catchment started to be cleared for slash-and-burn agriculture in the late 1960's and by the mid-1990's the original vegetation had almost been entirely removed (Figure 7). In 1994, the Land and Forest allocation scheme assigned land use allocation in the Houay Pano catchment, considering both protection and production. At present, the Houay Pano catchment is composed of residual mixed deciduous and dry Dipterocarp forests, regenerated secondary forest mixed with grass (bush fallow), teak and banana plantation, orchard, and annual upland crops such as rice, maize, corn, job's tear and groundnut. One year cultivation of annual crops, mainly upland rice (Oryza sativa), maize (Zea mays), or Job's tears (Coix lacrima Jobi), is followed by a fallow period, which is currently 4 years long on average (Ribolzi et al, this issue), during which secondary vegetation covers the fields. Teak and banana plantations extend over 14% of the catchment, while vegetable cropping is concentrated in small patches along the stream. Riparian areas are mainly of convex or convex-concave shape, steep, and narrow. Most of the riparian land is covered either with a grass/shrub native vegetation dominated by Microstegium ciliatum, bamboos, or banana plantations.

In these systems, weed invasion is one of the most important constraints to upland rice cropping. Because of this weed pressure, which tends to increase with increased cropping intensity and shortened fallow periods, a larger number of weeding operations per cropping cycles is required. These weeding operations are responsible for tillage erosion, i.e. the process of downhill soil movement caused by the combined action of hand tools used for weed removal and gravity. Tillage erosion is an important form of erosion in the Houay Pano catchment, leading to soil losses equivalent to water erosion on 70% slope gradients (Dupin et al., 2002). Overall, because of more intense cropping, reduced fallow duration, increased weed pressure and the loss of soil fertility that ensued, yields have reportedly declined to about half the 3-4 t ha-1 which was achieved under long fallow shifting cultivation 20 years ago.

Socioeconomic environment

Settlement in Ban Lak Sip started in the 1960s with the arrival of families originating from northern provinces. The village was officially founded after the 1975 revolution. Five neighbouring communities were resettled in Ban Lak Sip in 1976, 1982 and 1996. By 2003, the village population totalled 503 inhabitants, of which more than 80% were members of the Khamu ethnic group. In terms of livelihood, Ban Lak Sip residents are currently involved in a variety of on-farm activities, though annual cropping – mainly upland rice for subsistence and Job's tears sold to export companies based in Luang Prabang – is the most important activity for almost all village households. Annual cropping is practised according to the rotational shifting cultivation system: plots are commonly cultivated for one or two successive years followed by a three year fallow period. In addition to annual cropping, vegetable production (e.g. chilli, beans, coriander and several grasses) based on a continuous cultivation system, forest product gathering (e.g. fuel wood, bamboo shoots, and grasses), hunting (mainly small rodents and birds), livestock farming (e.g. poultry, pig, cattle) and perennial tree production (mainly teak and banana) also form important land-based livelihood activities.

These activities take place in different parts of the landscape, depending on slope and elevation. In general, annual cropping as well as gathering and hunting activities occur in the high elevation areas while livestock production is almost exclusively conducted in and nearby the village and on lower slopes. Vegetable cropping and tree plantations are found throughout the landscape. It is noteworthy that almost one third of the activities from which households derive their livelihood take place in the high elevations and steep slope zones.

In general, since 1990 the village households have changed from relatively specialised production to diversification. While in 1990, an average household was engaged in two or three livelihood activities (usually annual cultivation of glutinous rice, collecting-hunting and poultry farming), in 2003, with a strong development of tree plantation (essentially teak and banana), vegetable cultivation (mainly cash crops sold at the Luang Prabang markets) and non-farm employment (e.g. small trading by the roadside, construction or factory worker, etc.), the same household had four or five different sources of income. As they diversified their activities, farmers also increased the area they cultivated and the amount of time spent on livelihood activities.

The land use that underwent the most conspicuous expansion is tree plantations, which nearly quadrupled in extent and now occupy nearly as much area as annual crops. Vegetable cropping has also shown a very significant expansion. The largest increase in labour input corresponds to vegetable cropping, non-farm activities and livestock farming (with the recent development of pig, goat and fish farming). As mentioned above, workloads associated with annual cropping activities also increased during the period both in terms of the number of workers and average workload. In fact, the average household workload increased sharply over the entire survey period, from 156 to 244 days of activity per year. Finally, there has also been a relative reorientation in the location of livelihood activities. Annual cropping and vegetable cropping have expanded mainly in the flattest parts of the landscape, while plantation agriculture has expanded across all elevations.

The gradual opening of the country to a more liberal economy together with the national land reform have played major roles in shaping the development trajectory of Ban Lak Sip (Lestrelin and Giordano, 2007). However, land degradation has also played a significant role. To some extent, many of the strategies adopted by the villagers have contributed to avoid soil erosion being a major constraint on their livelihood. By devoting additional labour to annual cultivation and cultivating larger areas, some farmers have simply attempted to stabilise agricultural yields and maintain agricultural production at an acceptable level. Yet, soil erosion is a persistent issue for these villagers. Engaging more radical changes, others have adopted full-time non-farm occupations and successfully untied their livelihoods from land-related constraints. Generally, by diversifying their activities, adopting non-farm occupations and spending more time on alternatives to annual cropping such as livestock farming, tree plantation or vegetable cultivation, a majority of villagers have indirectly reduced the limiting effects of soil erosion on local livelihoods.

At the same time some farmers have started to cultivate annual and vegetable crops in flatter parts of the landscape which, as observed by Forsyth (1996) in northern Thailand, can be seen as an adaptive change related to local perceptions of higher erosion risk on steep slopes. Unfortunately these flatter zones are very limited in extent. By cultivating on the few flat areas of the village land, farmers take advantage of the sediment eroded from the slopes. Finally, the major expansion of teak plantations may also be seen as a combined effort for both developing alternatives to annual cultivation and controlling soil erosion by maintaining land cover on the slopes. However, while many farmers confirmed the first explanation, teak plantation was never described as a way to control erosion. Actually, and this illustrates villager local knowledge, some scientists argue that soil erosion may be increased under teak plantation due to the absence of undergrowth, the concentration of raindrops on the large leaves and their amplified 'splash effect' when they reach the soil (e.g. Bruijnzeel, 2004). In fact, the plantation of teak in upland fields is often the main option chosen by the farmers when the land is too degraded and annual cropping has become unprofitable.

Environmental and land use monitoring

As the benchmark site of the MSEC programme in the Lao PDR, the Houay Pano catchment has been extensively instrumented for hydrological and sediment load monitoring. Four V-notch sediment traps (weirs) were installed along the perennial stream and in each of the 4 sub-catchments which act as drainage area for the ephemeral streams that feed the main stream during storms (Figure 8). In each weir, water level is measured at a constant distance upstream of the flume using an automatic water level recorder. Hand-held gauges are also used in association with this automatic set up. The relation between water level and discharge (rating curve) was determined for each stream-gauging station, using a current-meter along a section across the stream to measure simultaneously flow velocity and water level. Water level data collected at the weirs are downloaded weekly.

During flow events, water samples are collected using automatic samplers (operational since 2002). These samplers collect water with a time-step which varies from 5 to 10 min. depending on flow stages (rise, peak, rapid and slow decrease). In the laboratory each sample is flocculated using alumina sulphate, filtrated, oven-dried at 60°C and weighed to assess the sediment concentration (g l^{-1}). Bedloads, i.e. sediments trapped at the bottom of weirs, are also collected after every main rainfall event. Five to ten samples are collected, starting from the upper part of the weirs, weighed, oven-dried and weighed again to assess their water content, and thus the total dry mass of sediments. The total sediment yield at the catchment level is derived by adding the suspended load to the bedload.

A rain gauge network consisting of six manual totalizers and one automatic weather station was installed to account for the spatial and temporal rain distribution and the environmental variability. The automatic weather station's rainfall recorder is used to calculate rainfall intensity at a 6 min. time-step. Weather data thus collected are downloaded weekly.

Annual land use maps were prepared every year from detailed field surveys. Observed land use included fallow (Fw), degraded secondary forest (Forest), teak plantation, bananas, upland rice, Job's tear (Coix lacryma-jobi L.), sesame, maize. Experimental equipment was set up in four sub-catchments to compare four farming systems: (i) the current rotational slash and burn system as the control, and three innovative systems (ii) improved fallow with Cajanus cajan and Crotalaria micans, (iii) improved fallow with contour planting and (iv) mulch planting without tillage (de Rouw et al., 2003).

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***Table 1** - Main environmental characteristics of the 9 study sub-catchments: the total surface area (area), the minimum (Min), maximum (Max) and mean altitude (Z); the mean slope gradient (S); the sub-catchment perimeter (Perim), the index of compactness of Gravelius (Rc) which is the ratio of the perimeter P of the sub-catchment to the perimeter of a circle which have the same surface area (after Chaplot et al., 2005a).*

Catchment number	Area (ha)	MinZ (m)	MaxZ (m)	MeanZ (m)	S (%)	Perim (m)	Rc (m^{-1})
1	19.6	558	718	623	61	1745	0.1
2	13.6	515	669	571	53	1576	0.11
3	16.7	488	621	544	51	2163	0.13
4	8.2	430	592	513	48	1637	0.14
5	2	415	518	429	56	1254	0.22
6	0.64	530	585	562	52	358	0.11
7	0.6	514	588	553	62	392	0.13
8	0.57	477	580	534	54	452	0.15
9	0.73	423	505	459	54	421	0.12
Whole	62.4	415	718	567	54	4196	0.15

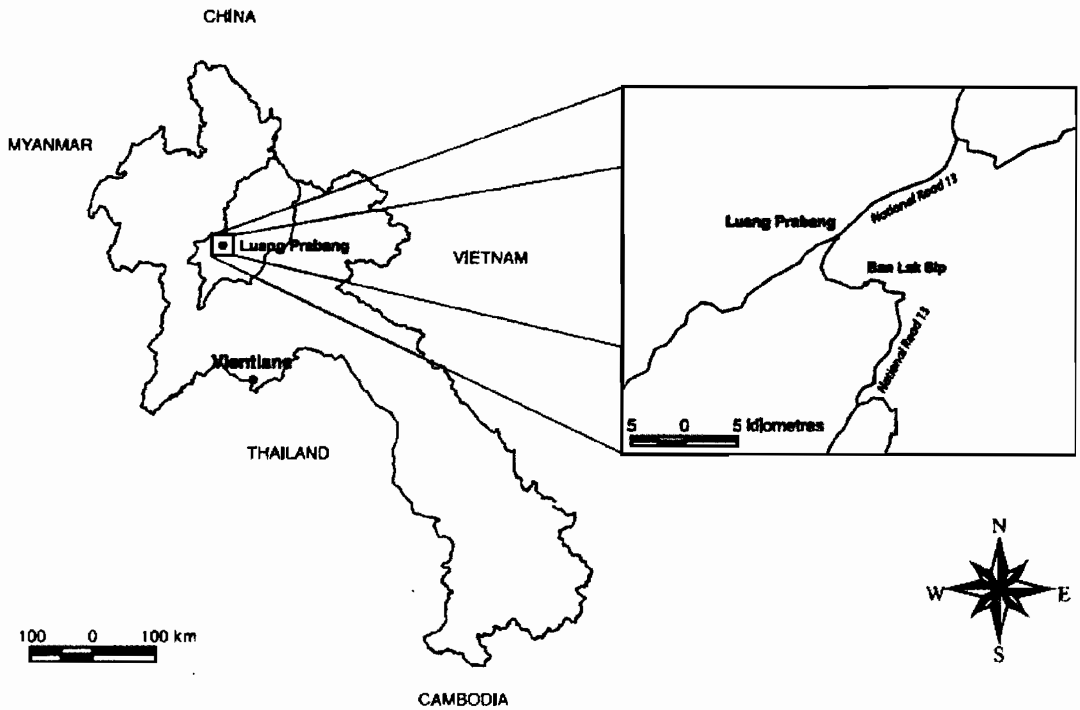

Figure 1 – *Location of the MSEC experimental site (Houay Pano) in Laos.*

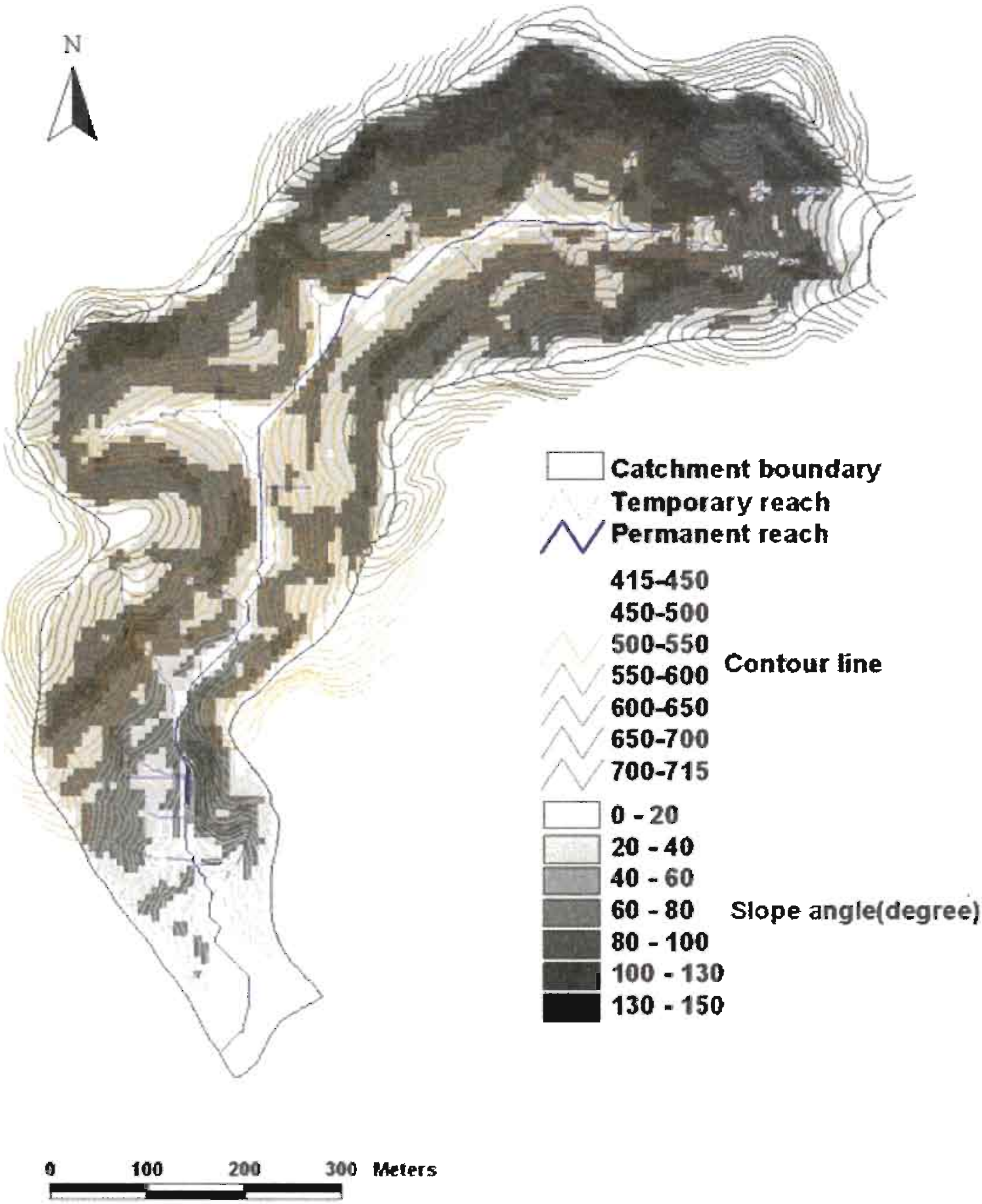

Figure 2 – *Topography and main morpho-hydrological features of the Houay Pano catchment.*

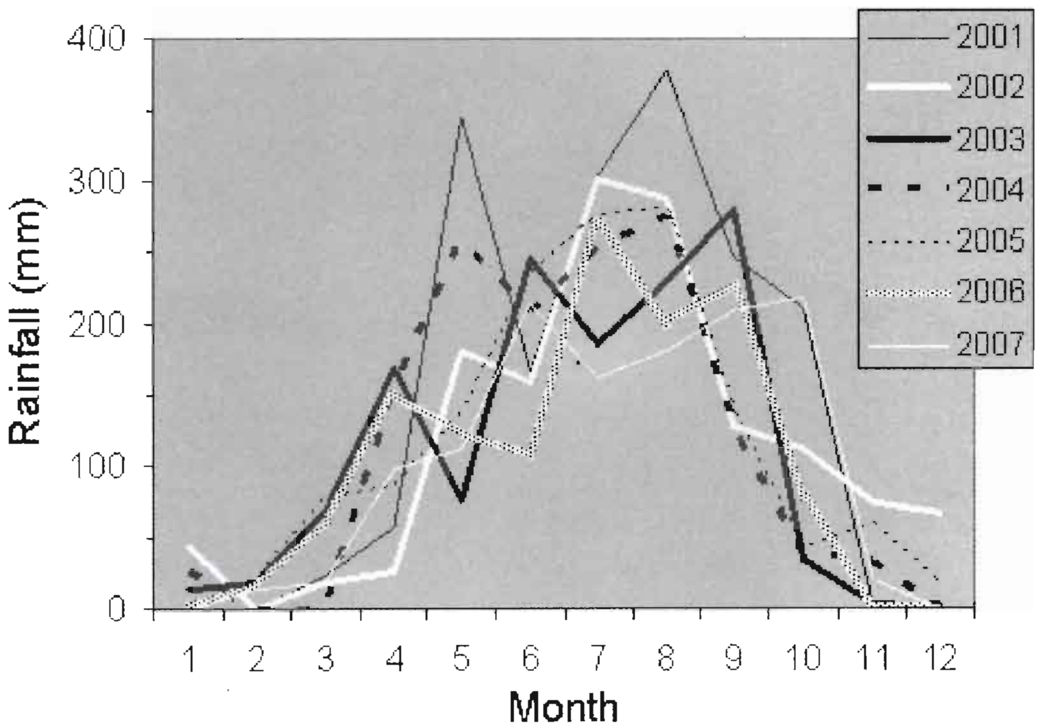

***Figure 3** – Annual rainfall distribution within the Houay Pano catchment.*

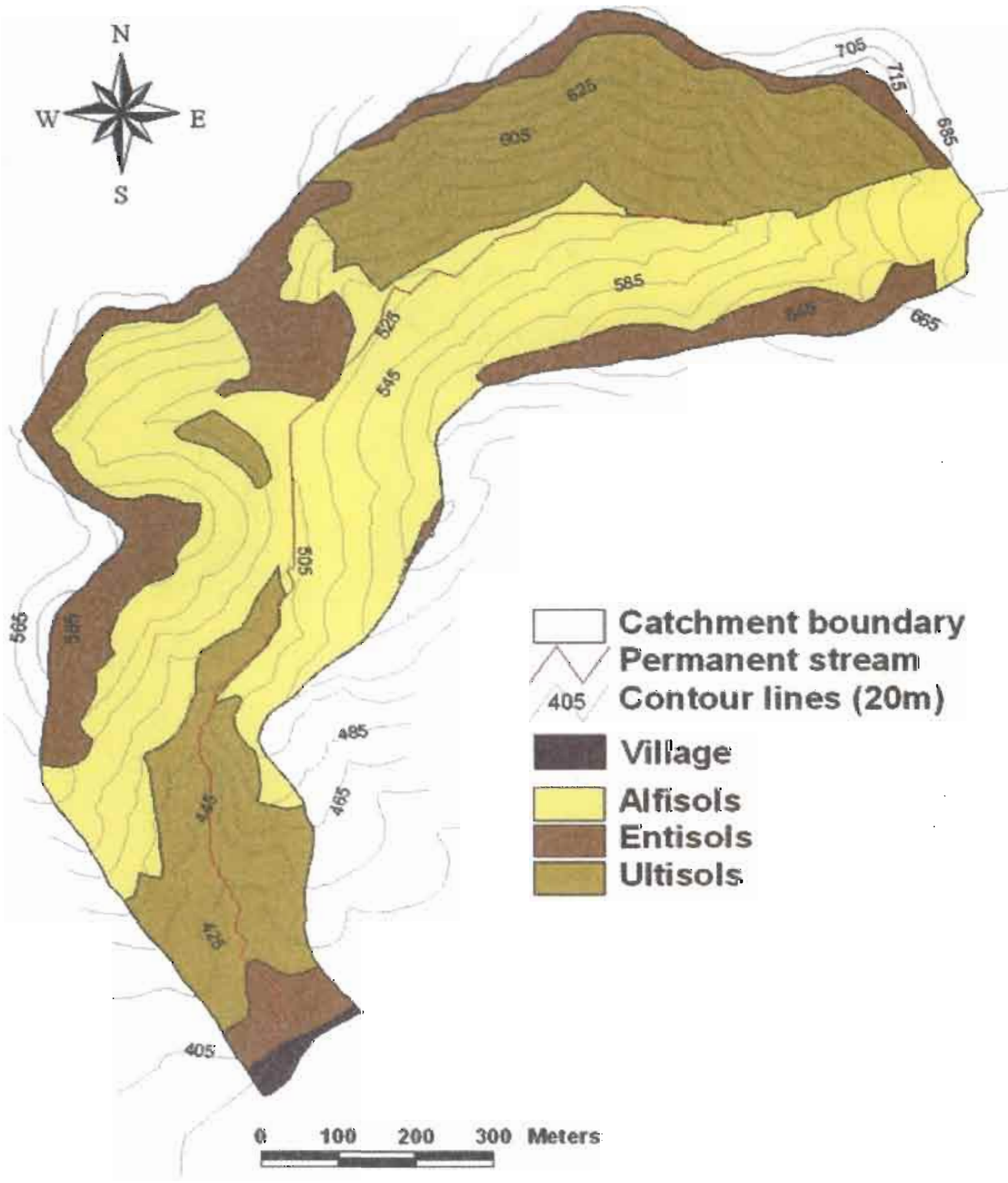

Figure 4 – *Soil map of the Houay Pano catchment.*

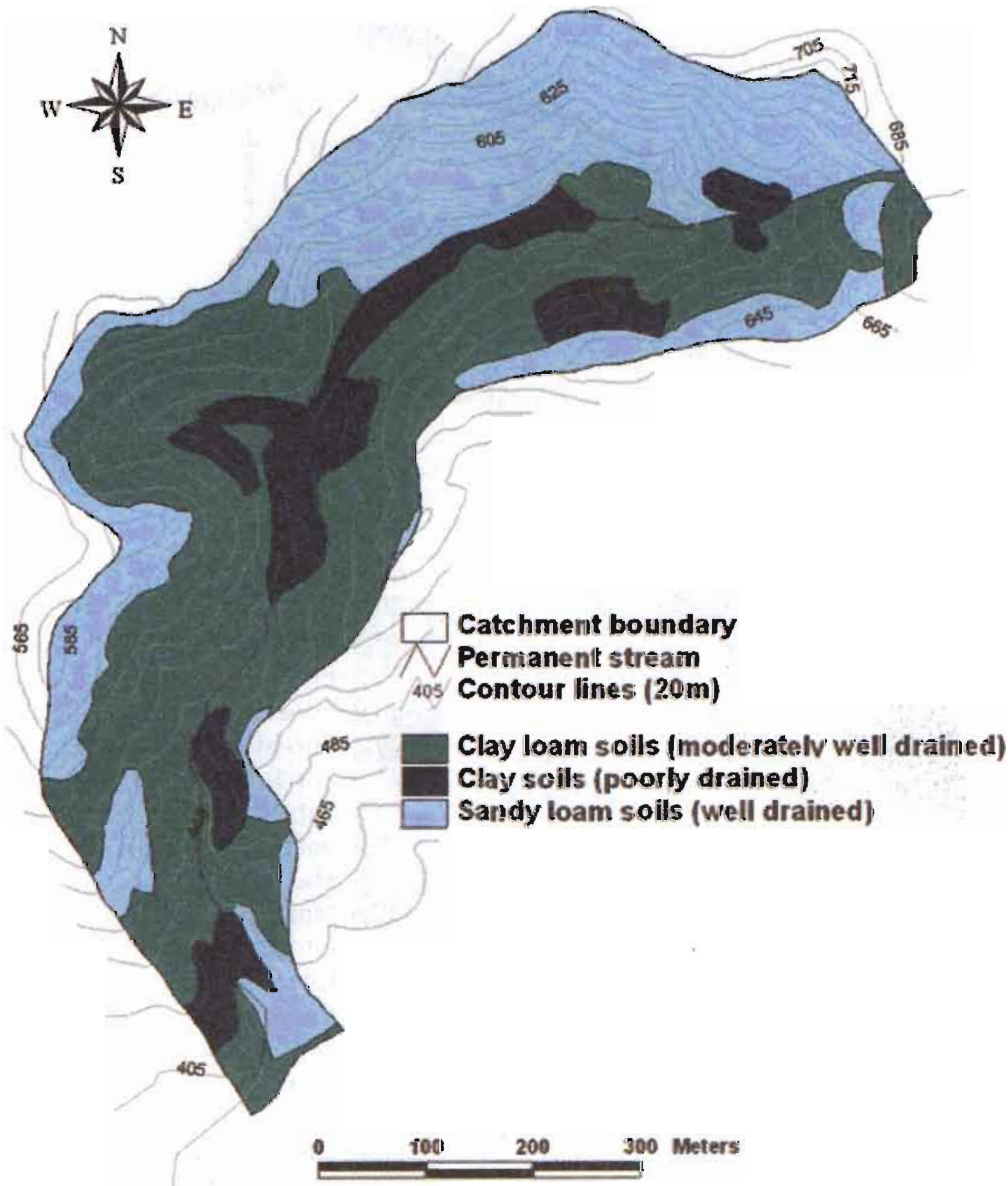

***Figure 5** – Soil texture map of the Houay Pano catchment.*

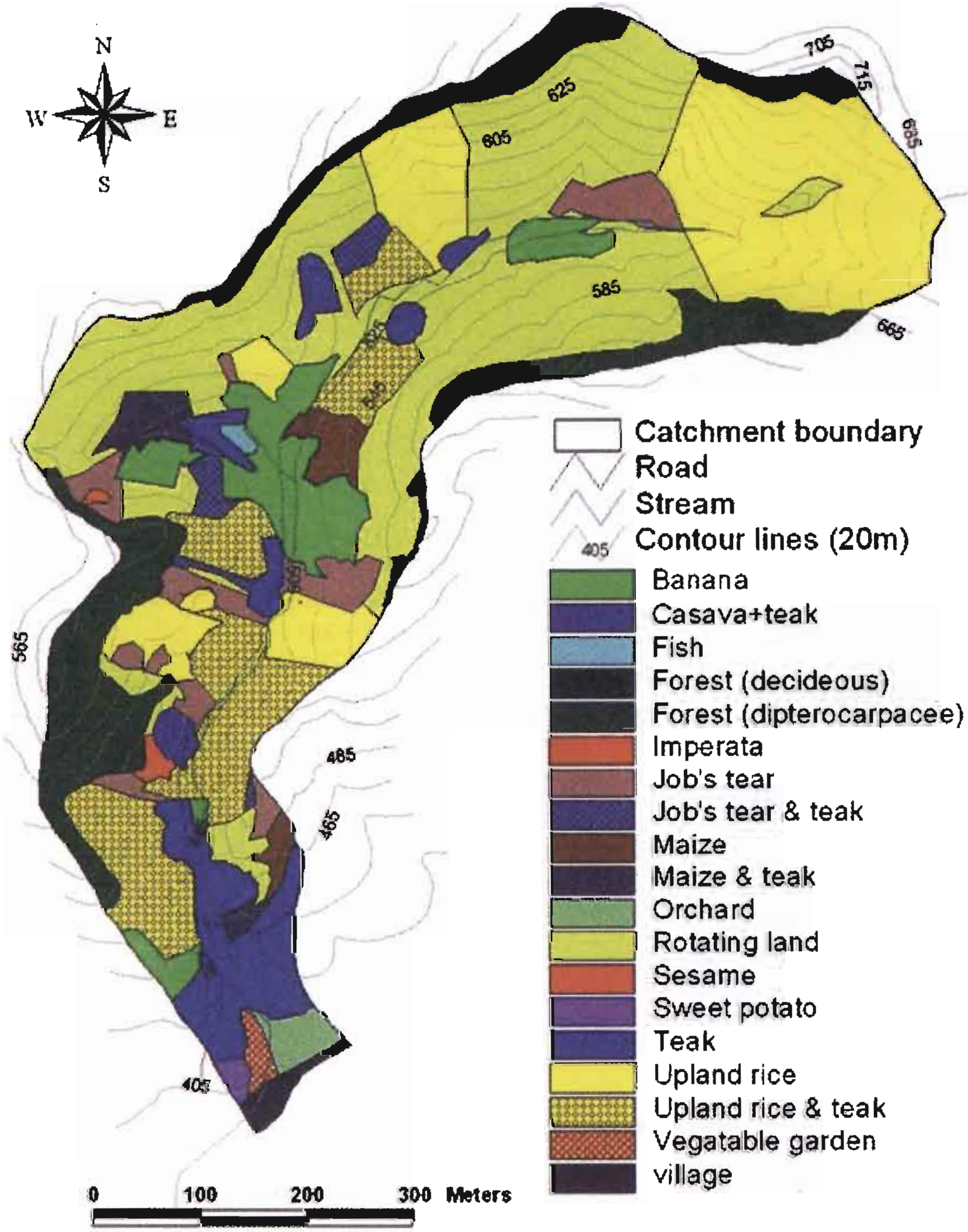

Figure 6 *– Land use map of the Houay Pano catchment in 2007.*

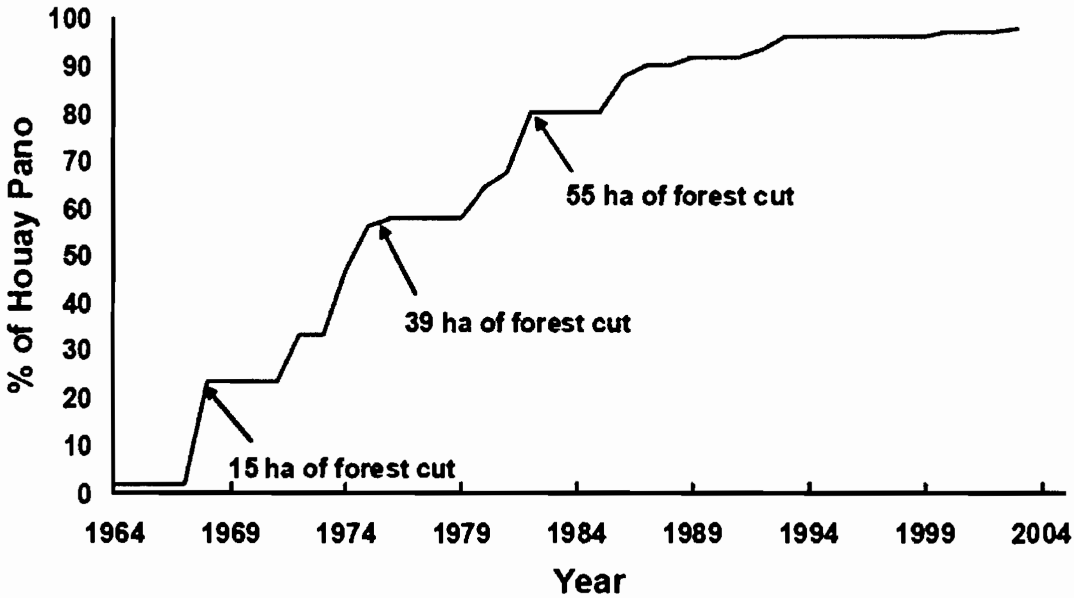

Figure 7 *– Mature forest cut for slash and burn cultivation.*

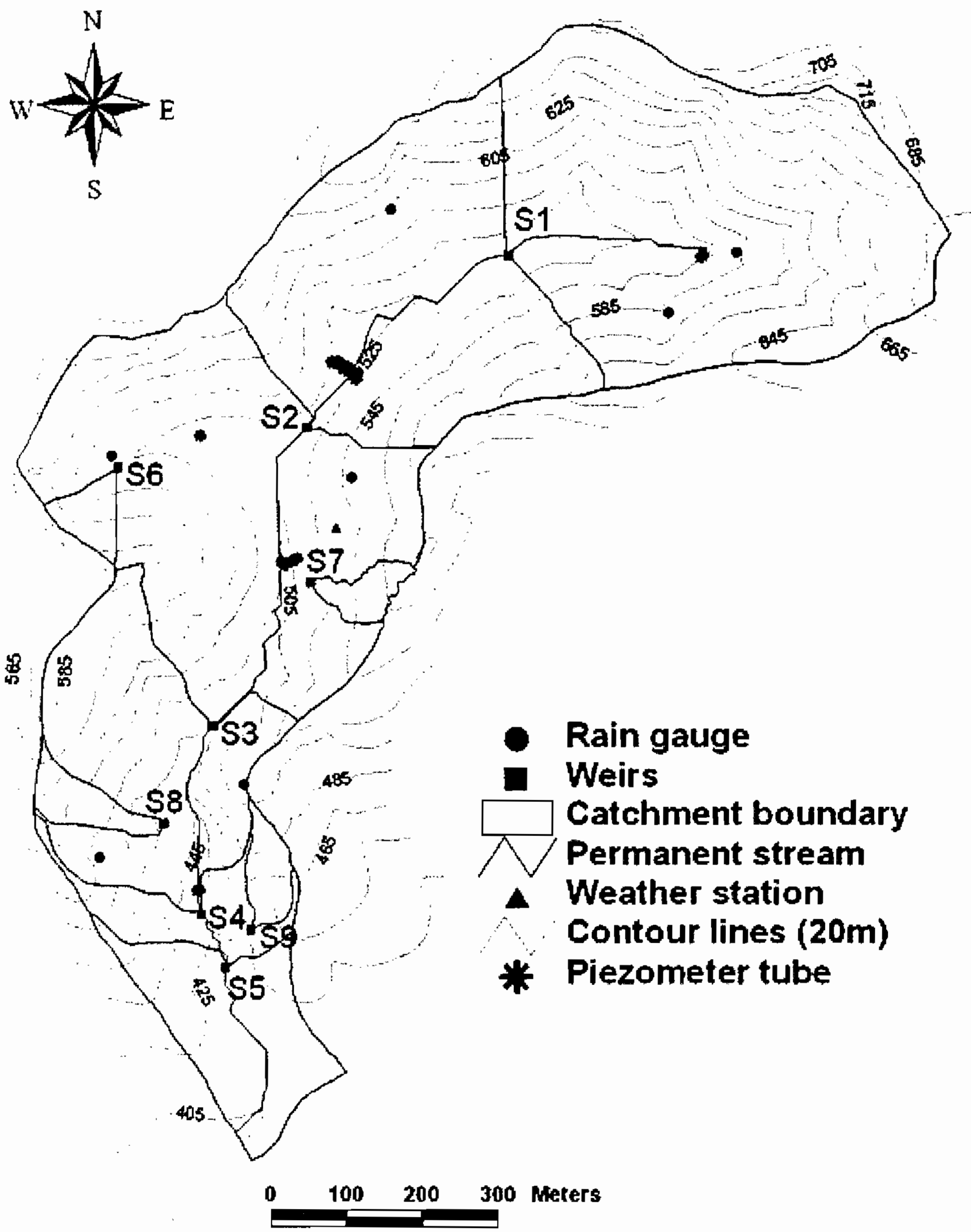

Figure 8 *– Main hydro-meteorological equipment in the Houay Pano cathment.*

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IRD Institut de recherche pour le développement

IWMI International Water Management Institute

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ອອກແບບ ແລະ ຈັດໜ້າ ໂດຍ: ຂັນຄຳ ອ້ວນອຸດົມ, ສູນຂໍ້ມູນຂ່າວສານ, ສຄກປ