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Monitoring land use changes in the Nam Phung Valley of Lom Kao District in Thailand

C.D. Dedzoe, B.A. Raji and M. Staljanssens*

ABSTRACT

A study on monitoring land use changes was conducted to assess the environmental impact of earth moving activities - mainly excavation and dumping of soil - in the Nam Phung valley within the Lom Kao District of Petchabun Province in Thailand. Two sets of aerial photographs taken in 1986 at scales of 1:50,000 and 1:15,000 were interpreted as well as Landsat TM images. The photo interpretation map of 1:50,000 was used for the semi-detailed survey of the Nam Phung river catchment. The 1:15,000 map and Landsat images provided information on the existing environmental conditions in the low terrace of the Nam Phung valley around Lom Kao District in 1986. An interaction matrix and environmental impact network were constructed to facilitate scoping and subsequent baseline studies. The thickness of the dumped soils were measured and further characterised. Participatory Rural Appraisal (PRA) techniques were used to obtain information on reasons for the observed land use changes in the valley. Dumping of soil in the low terrace was the major earth moving activity in the valley. About 27% of the dumped soils were for agricultural purposes while about 60% constitute non-agricultural uses. This resulted in the conversion of rice fields to plantations of tamarind, mango and neem and also the development of real estates. Excavation was done in the piedmont landscape to create a lowland for which a land title could be obtained from the Department of Land Development (DLD) and also to construct fish and irrigation ponds. The major soils of the valley are Inceptisols while Alfisols are dominant in the piedmont. About 100ha, representing four per cent of the land area in the valley, was lost between 1986 and 1992. The major environmental problem in the valley is flood hazard, and others include air and water pollution.

INTRODUCTION

Land, in particular, is a commodity that is very much treasured by everybody as it forms the basic natural and non-renewable resource for agriculture, forestry and other uses. In the past, industrial, urban or agricultural development in many countries appears to be undertaken as a matter of expediency and also as a result of the availability of raw materials rather than on the basis of any careful appraisal of the effect of these activities on the environment (Abrokwa-Ampadu and Ampadu-Agyei, 1987).

With low population pressure and extensive land use, there is little or virtually no effect on the inherent, characteristics of land (Verheye, 1998). However, with increased competition for land, reserves of fertile areas are reducing at an alarming rate as new production needs are met by either encroaching on existing cropland or opening up new lands. Sombroek and Antoine (1995) stated that this situation imposes excessive demands on fragile lands thus resulting in uncontrolled deterioration and a resultant inability of the land's capacity for production. McNeely *et al* (1990) also observed that the latter part of the twentieth century saw an extraordinary change in the relationship between people and the natural resource upon which they depend. Consequently, human activities have progressively reduced the earth's capacity to support life at the same time that population increase and high consumption levels are making ever greater demands on the planet's resources.

Mankind in the past decades, has apparently underestimated the extent of environmental damage (Beets, 1990). Issues of environmental concern only began in the last decade or so and as such there is a growing realisation now that the effects of environmental deterioration are much more severe than hitherto imagined. The impacts of environmental hazards are the product of the interaction between events in the physical environment and in society. Therefore, irrational land use and inappropriate land management can be attributed to either lack of knowledge or economic, social and political pressures which force people to use land in the way they do.

According to Goldsworthy and Duiker (1995), it is imperative to have information on the likely results of the various choices for the use of land resources so as to be able to expect the consequences of the growing demands on them. This can be obtained through the application of remote sensing techniques, such as aerial photographs and satellite images, which have made significant contributions to soil inventorization and variability studies (Goosen, 1967; Fadul, 1995) and also facilitated the monitoring of land use dynamics in both developed and developing countries (Sehgal *et al.,*1973; Prince *et al*., 1990) Studies using Landsat and SPOT data (Deshler, 1974; Dent and Young, 1981; Fovling, 1988; Luscombe, 1990; Bouma, 1999) helped in providing and updating specific information on land and land use with respect to growing season, changes in primary production, land use classification and land

*C.D. Dedzoe, Soil Research Institute, Academy Post Office, Kwadaso-Kumasi, Ghana, ; B.A. Raji, Ahmadu Bello University, Zaria, Nigeria; M. Staljanssens, Formerly of International Institute of Aerospace Survey and Earth Sciences (ITC), The Netherlands. *Corresponding author: soilwat@ighmail.com or soils@africaonline.com.gh

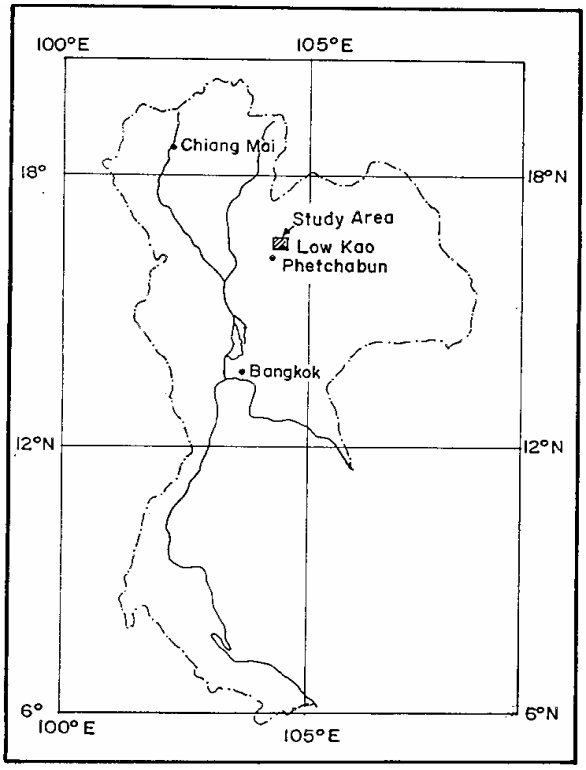

Figure 1. Location of study area in Petchabun Province, Thailand.

degradation within manageable financial resources (Harris, 1990) in a relatively short time. Visual interpretation of Landsat imagery resulted in the (Bingham et al., 1983) while a combination of aerial production of national land use maps for some countries photographs and Landsat TM data assisted in detecting an intensive anthropogenic effect on land use (Gläber and Gläber, 1995) by monitoring changes in soils in open-cut mining areas.

Earth moving activities by human beings, which can be considered as the precursor of various land use changes, is a two-phase activity that involves the excavation and dumping of soil for particular purposes. Martin et al. (1991) found that in the past three decades in the Lom Kao District , this activity was labour-intensive and carried out in the valley and piedmont landscapes, mainly for rural housing and agricultural purposes at an unnoticeable scale. With the activity becoming highly mechanised, various land use changes have occurred in the Nam Phung valley of the district. The objective of this study is to examine the various land use changes due to the accelerated earth moving activities and their resultant environmental impacts in the Lom Kao District.

MATERIALS AND METHODS

The study area

The study area (Fig. 1) is located in the province of Petchabun in Thailand. The province is about 400km north of Bangkok and can be located between latitudes 15° 20' and 17° 07' N and 101° 47'E. The study area falls within latitudes 16° 50' - 16° 55'N and longitudes 101° 09' - 101° 15'E. The general elevation varies from 150 to 450m above sea level. The valley covers an area of about 2600ha.

Aerial photo interpretation

Aerial photographs of the area (1986) at scales of 1:50,000 and 1:15,000 were interpreted using the geopedologic approach (Zinck, 1989) in addition to Landsat Thematic Mapper (TM) of 1987. The small-scale photographs (1:50,000) and the Landsat images provided baseline information. The photo interpretation map obtained from the 1:50,000 scale was used in the semi-detailed soil survey and characterisation of the soils in the area.

Geological map (1:250,000) and detailed-reconnaissance soil map (1:70,000) of Petchabun province were also used to provide secondary information for the semi-detailed soil survey. The information obtained from the soil survey was used in characterising the soils in the district and delimiting the area for the land use change monitoring study in the valley landscape. The large-scale aerial photographs (1:15,000) were used extensively in detecting the land use changes that took place during the period from 1986 to 1992.

Data collection and handling

There was a reconnaissance phase which involved taking inventory of the new features developed in the valley between 1986 and 1992. This included a determination of the total valley area, area covered by settlements, other constructional works and the extent of earth moving activities in the valley. The new features observed in the field were plotted on a map to reflect the current state of land use in the valley. On the basis of these data and a study by Martin et al. (1991), an interaction matrix of the earth moving activities and land use changes and a tentative environmental impact network were constructed. These also facilitated the scoping process of identifying further potential impacts of the land use changes through detailed field research as new information was gathered. Participatory Rural Appraisal (PRA) techniques such as semi-structured interviewing, direct observation, key informants and oral histories involving farmers, contractors, residents of condominiums and others were used to gather more information on the reasons for the observed land use changes (especially from rice to tamarind cultivation) as a result of soil dumping and excavation. The interaction matrix (Table 1) and environmental impact network were updated with the latter showing the effect of the land use changes on the quality of life of the Lom Kao population and the eventual degradation of land resources of the area.

RESULTS AND DISCUSSIONS

General observations

Occupying about 25% of the district area, the valley which has an extensive low terrace, is drained by the Nam Phung river and its tributaries. The major soils in the valley are Inceptisols (i.e. *Fluvaquentic* and *Typic Endoaquepts*) which are deep, imperfectly to poorly drained and medium- to fine-textured while on the piedmonts, Alfisols especially *Typic* and *Ultic Haplustalfs* are found (Raji et al. 1992). These soils are well drained, very deep, gravelly, concretionary and medium- to fine-textured. Previous land uses in the valley were solely rural settlements located along the Nam Phung (Fig. 2) and the cultivation of annual field crops dominated by tobacco, rice, soya and mung bean.

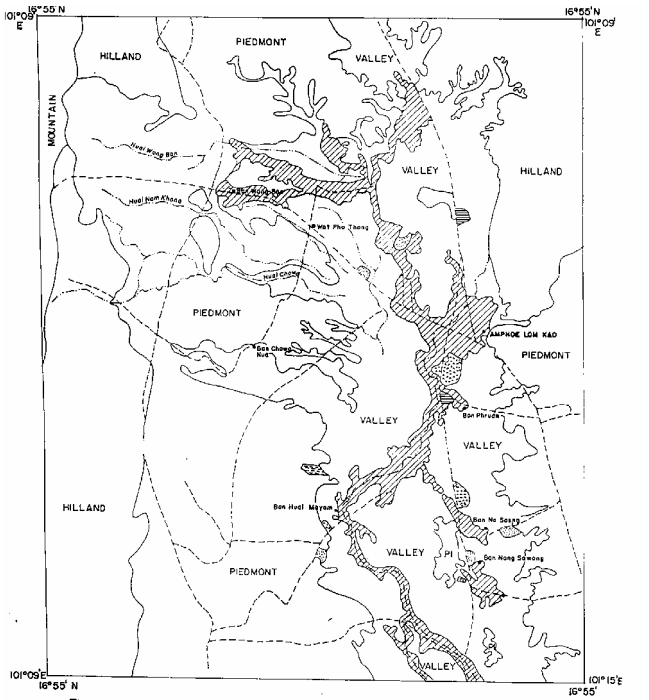

Figure 2. Land use in the Nam Phung Valley in 1986. Scale 1:50,000.

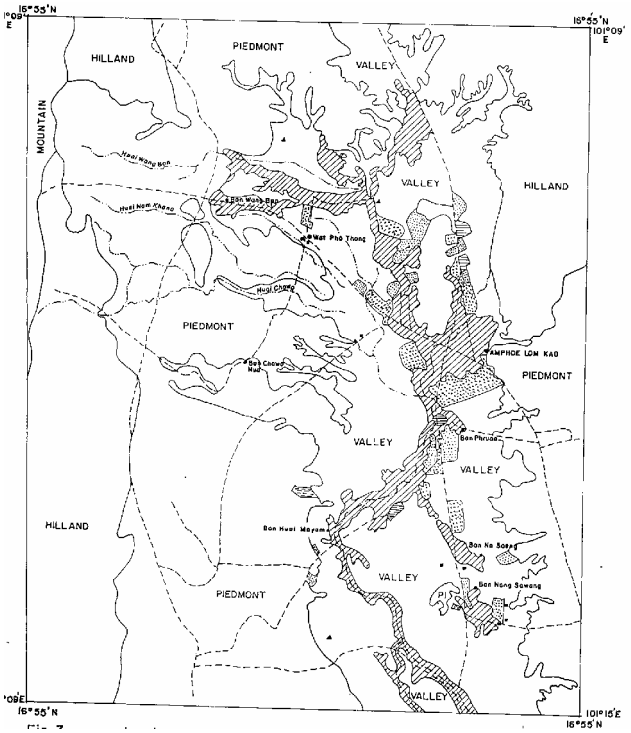

Figure 3. Land use changes in the Nam Phung Valley, 1986, 1982. Scale 1:50,000.

Vegetables like chilli and cabbages were also grown. By 1992, there was a very rapid change in land use, with most of the new land uses concentrated on the eastern part of the district (Fig. 3). Currently, agricultural land use is a mixture

Table 3a. Spatial changes in land use in the Nam Phung valley between 1986 and 1992.

Land use/Landscape	1986 ha	1992 ha	Increase/decrease (%)
Settlements	500	605	21.0
Industries	15	23	53.0
Agriculture*(Tamarind)*	24	47	96.0
Valley	2600	2500	3.8
Piedmont	4000	3720	7.0

Table 3b. Percentage of valley area occupied by various land uses.

Type of land use	1986 %	1992 %
Settlements	19.2	23.3
Industries	0.6	0.9
Agriculture *(Tamarind)*	0.9	1.8

of perennial and arable cropping made up entirely of tamarind and mango plantations, rice and tobacco. Others include agro-based industries and new settlements which comprise private houses and condominiums.

Soil dumping was the dominant earth moving activity in the valley. This was done mainly to effect a change in agricultural land use. Apart from excavations from the piedmont, soil obtained from the ponds dug in the valley was usually spread around or sold to farmers who wish to change their land use. Over the period, construction of new settlements accounted for about 60% of the area dumped with soil removed from the piedmont, with agriculture and industrial uses taking 27% and 13% respectively .

The soils dumped for industrial uses and for the development of real estates or condominiums were much thicker than those meant for agriculture (Table 2) and were also characterised by gravelly material at the base so as to provide a good foundation for the structures to be built. A greater percentage of the 27% of land area dumped for agriculture was used entirely for tamarind cultivation which has almost doubled (Table 3a and b). In the case of settlements, 64% of the 60% was for private houses and the rest for real estates or condominiums. Altogether, settlements within the valley have increased by about 21% (i.e. from about 19% in 1986 to about 23% in 1992, Table 3a and b) within the period. The increase in the number of settlements is due to increasing population growth and urbanisation. The change from rice to the cultivation of tamarind has also led to the construction of more houses in the valley on the dumped soils so as to take advantage of the existing amenities.For purely agricultural uses, the main land uses were annual and perennial cropping. The former is dominated by rice and maize, and the later tamarind, with few mango and neem plantations. Also observed were excavated areas in the valley for ponds meant for irrigation and fish production.

Reasons for land use changes

a) Farmers' reasons for land use change from rice to tamarind cultivation - There are several reasons for land use change from rice to tamarind cultivation:

i. Decreasing producer rice prices and correspondingly high price for tamarindii.
ii. Quicker and higher returns from tamarind cultivation
iii. Proximity to good marketing facilities
iv. Availability of enough water in the valley for raising tamarind seedlings and grafts
v. Tamarind cultivation is less demanding in terms of inputs as compared to rice
vi. More favourable export market for tamarind especially the grafts in countries like Burma.
vii. The promotion of the development of fruit tree plantations by the Asan Kaeo Project (or the North-East Green Project).

b) Land tenure and its influence on land use -Interviews with officials of the Department of Land Development in the Lom Kao District revealed that there are three main types of land title deeds namely:

i. Chanode (or permanent title) - This is also called No So Si (NS4). A land with this deed can be sold by the owner without notice since its boundaries are properly surveyed and easily recognisable.
ii. No So Sam Kor (NS3K) - This is the same as NS4 except that it's boundaries are not accurately surveyed.
iii. No So Sam (NS3) - Land with this title can only be sold after thirty days notice.

These lands are not covered by cadastral maps.

No title is issued to the uplands such as piedmont, hilland and the mountains as these are state-owned. The high demand for land with Chanode title is a major factor leading to the increase in the observed land use changes in the valley and piedmont. In the valley, rice farmers with Chanode titles sell their land mostly to estate developers since no notice is required in the process. Apart from this, once a title is granted, there is no monitoring mechanism to ensure that the land is put to its appropriate use. This has led to a rapid loss in prime agricultural land for rice farming in the Lom Kao area.

In the piedmont, soil material is removed by levelling to expand contiguous rice fields in the swales and consequently facilitate the acquisition of Chanode title. In some cases, the new rice fields are changed again to tamarind plantations after the superior Chanode title is acquired.

Table 1. Interaction matrix for earth moving activities and land use changes in Lom Kao.

	PIEDMONT (UPLANDS)						**VALLEY (PLAINS)**							
ORIGINAL	**STRAIGHT SLOPES**				**TERRACED SLOPES**		**RICE BUNDS**							
CURRENT LAND USES / EARTH MOVING ACTIVITIES	TAMARIND ORCHARDS	RICE	QUARRY	FISH POND	TAMARIND ORCHARDS	RICE	RICE	TAMARIND STOCKS	TAMARIND GRAFTS	TAMARIND ORCHARDS	CONDOMINIUM	INDUSTRY	POULTRY	IRRIGATION POND
SCRAPING OF STRAIGHT SLOPES					●									
SCRAPING TO BASE LEVEL		●				●	●							
EXCAVATION		●	●	●			●							●
DUMPING AND LEVELLING					●			●	●	●	●	●	●	
RESERVOIR DIGGING	●	●		●	●	●	●	●	●	●	●	●	●	●
BUNDS		●				●	●							
NO EARTH MOVEMENTS	●					●	●							

Table 2. Classification of dumped soils according to land use.

	Parameter		
Land use	***Thickness (cm)***	***Color***	***Average area(m^2)***
Agriculture	50 – 100	Brown / Dark brown (10YR 4/3 - 10YR 3/3)	2000
Industry	150 – 200	Yellowish red / Strong brown (5YR 5/6 - 7.5YR 5/8)	1000 - 2000
Private houses	100	- do -	3000
Condominiums	150 - 200	- do -	20,000 - 45,000

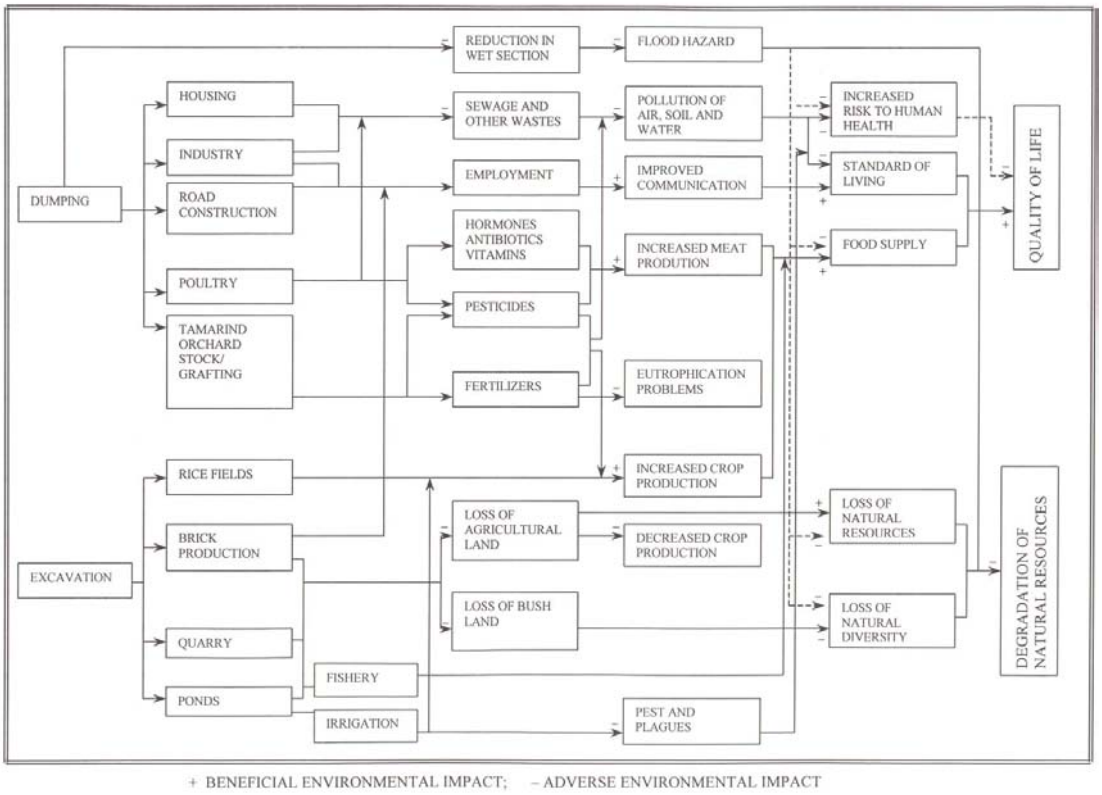

Figure 4. Enviornonmental inmavt network of earth moving avctivities and land use changes in Lom Kao.

Figure 5a. Excavation of piedmont to enlarge rice fields on a swale.

Figure 5b. Remnants of an excavated piedmont used as a corral. In the foreground is an exposed pale yellow subsoil to be used for rice cultivation.

Environmental impacts of land use changes in the Nam Phung valley

The land use changes brought about by excavation and dumping of soil have affected mainly the piedmont and the valley. These activities have both beneficial and adverse effects on the Lom Kao environment (Fig. 4).

The observed changes in land use during the period from 1986 to 1992 have resulted in a loss of about 100ha of the low terrace in the valley to non-traditional uses. This represents about 4% loss in rice fields within a six-year period. Though the change from rice to tamarind production and other non-agricultural uses resulted in better income and improved quality of life for farmers, the most significant adverse effects noticed were flooding due to reduction in the low terrace area and pollution of the air, water and the soil. Ojanuga and Ekwoanya (1995) stated that floodplains or low terraces are unsuitable for buildings, since apart from sewage disposal problems, these structures also help in intensifying flood generation. Flooding in the past in the Lom Kao area, was usually contained within the original rice bunds which were about 50cm high (Dedzoe et al., 1992) Besides increasing the area of rice fields in the swales within the piedmont, excavation of the piedmont has largely resulted in landscape disfigurement which can be seen as a decrease in visual complexity and visual disfiguration of the landscape (Fig. 5a and b). Excavation has created new flatlands for rice production.

However, these lands are developed from very mature soils (*Typic* and *Ultic Haplustalfs*), which, although has high base saturation, are poor in other major plant nutrients. In order to attain high yields from rice, these new fields are heavily fertilised - a practice that may cause eutrophication problems. Plinthite, found in the B-horizon of these soils, was at different stages of hardening irreversibly into ironpan as a result of the exposure due to excavation to expand rice fields in the piedmont. The degraded soils were abandoned while those not yet degraded were dumped with excavated soil to convert them to tamarind nurseries and plantations, and settlements as in the valley (Fig. 6).

Figure 6. Conversion of rice field to tamarind nursery and plantation.

CONCLUSION

Rural land use in the Lom Kao District has undergone tremendous transformation as a result of increased earth moving activities within a short period. Associated with this, is a dramatic change in the quality of life of the rural population. The changes in land use are incompatible with the land's original suitability thus resulting in the unnoticed loss of prime agricultural land at the decision making level. The new land uses imposed on the environment have created serious environmental problems such as increased flood hazards in the valley and a gradual degradation of the district's land resources.

The use of remote sensing data in the form of aerial photographs and satellite images enhance soil surveys and help in monitoring changes in land use. In addition, they improve knowledge about the impacts of various development projects on the environment thus giving an early warning about possible harmful impacts before the full potential for damage is realised. It is recommended that a comprehensive land use plan be developed for the Lom Kao District so as to ensure efficient and sustainable land use in the area. Apart from this, the land tenure system needs a review in order to make any land use plan workable.

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