Agricultural Development of the Nam Ngum Watershed, Laos

from

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PREFACE

This report was elaborated after the seminar "Development of Nam Ngum Watershed", which was supported, co-ordinated and organised by Dr.-Ing. W. Klemm and Prof. Dr. D. Prinz at the Institute of Rural Engineering from the University of Karlsruhe from 17. - 21. May 1999.

There have been four different groups working on four different aims to develop a Watershed Management Plan for the Nam Ngum Watershed of the Lao People's Democratic Republic (Laos):

- The hydropower group
- The ecotourism group
- The agriculture and irrigation group
- The group combining hydropower, ecotourism and agriculture and irrigation.

I participated in the agriculture and irrigation group. The results of our research, planning and additional informations are reported, interpreted and discussed in this work.

For the great support and ideas during the seminar I would like to thank my group members Mirella Gallardo, Mobadda Al-labadi, Wei Zhenfeng, Mengistu Geza, Hailegabriel Tadesse.

Tobias Bleninger

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1 INTRODUCTION

The study was focussed on the Nam Ngum Watershed, in the country of Laos. Our duty was to provide a proposal of an integrated Watershed Management Plan (WSM) from an agricultural point of view.

1.1 Laos

The Lao People's Democratic Republic (Laos) is a landlocked country surrounded by Thailand, Cambodia, Vietnam, China and Myanmar. Its area covers 236,800 km² (slightly larger than Great Britain) and its current population is estimated to be around 4.3 million (only 8% of Great Britain). Laos lies within the tropics and its topography is dominated by mountains and rivers of them the Mekong River is the biggest and most important one of the country because of its fertile flood plains used the majority of the country's wet-rice lands as also for fishing and transportation.

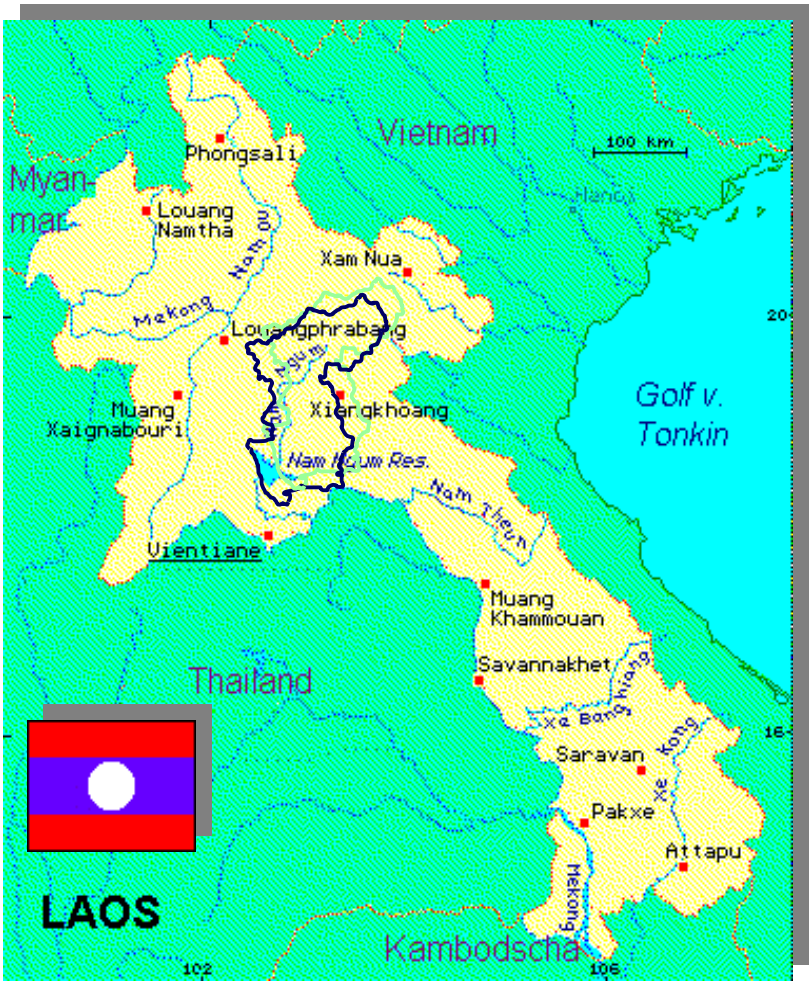


FIGURE 1 - LAOS, THE FLAG AND THE MARKED WATERSHED AREA OF THE NAM NGUM RIVER

Source[1]: CUMMINGS 94, KLEMM 94, Pictures and maps taken from the INTERNET

[1] All the names and words written in capital letters are the sources followed by the year of publication. At the end of this work the references are listed in alphabetical order with further informations. Pictures are taken from the internet, their adresses are also listed in the references.

1.2 The Nam Ngum Watershed

The Nam Ngum River flows into the Mekong across a broad alluvial plain in Vientiane Province. This river is the site of Laos largest hydroelectric plant (150 MW) that is a primary source of power for Vientiane area towns and due to the export of electricity (75% of all produced energy) to Thailand also an important source of revenue for the whole country.

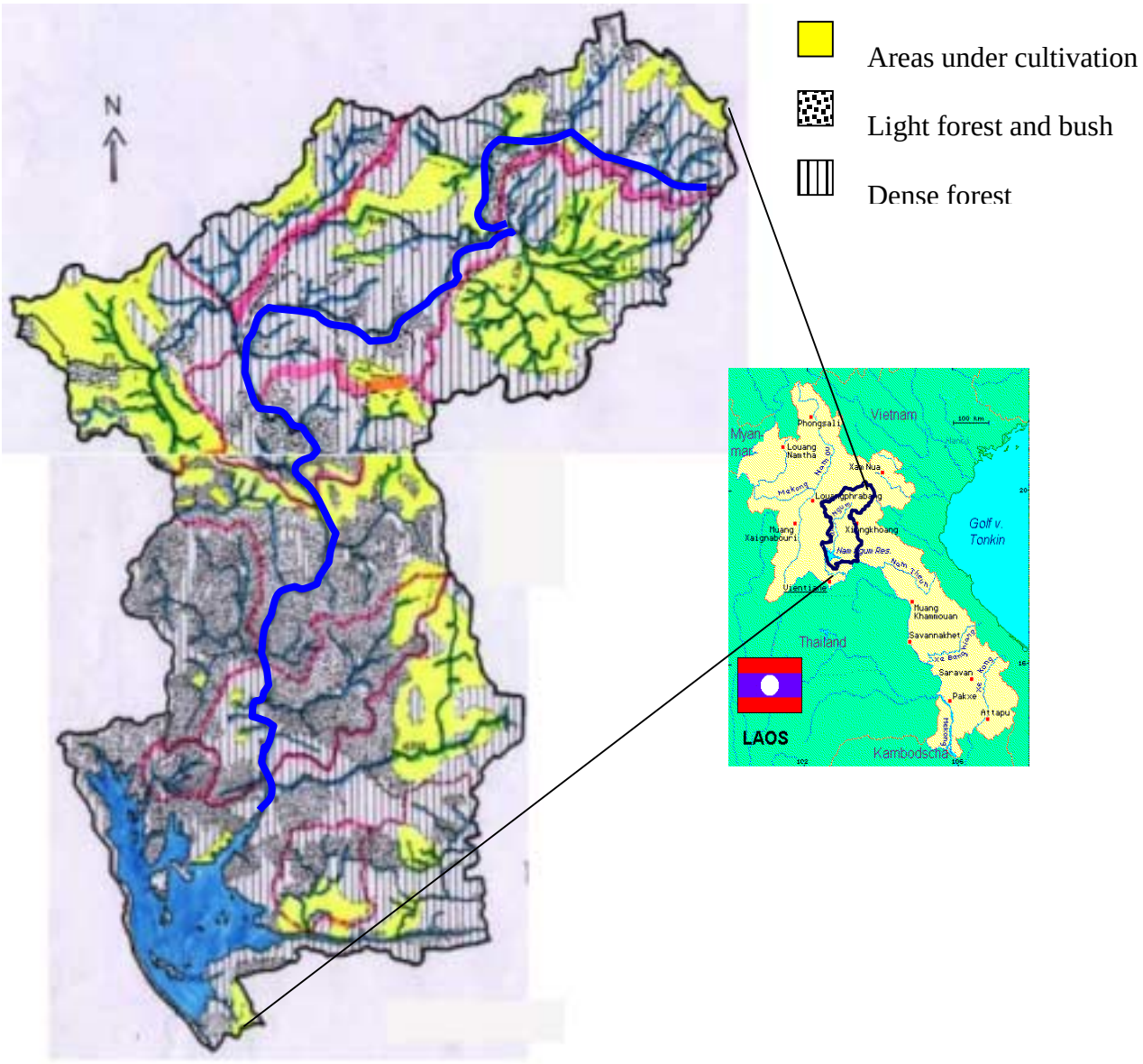


FIGURE 2 - THE AREA OF THE WATERSHED OF NAM NGUM RIVER WITH FURTHER LAND INFORMATIONS

1.2.1 The area

The Nam Ngum drainage basin is the major one in Laos and covers 17,830 km² (7.5% of national territory) and is divided into 3 sub-basins: The Nam Lik (a tributary joining Nam Ngum 4 km below the dam with 5,230 km²), the Nam Ngum lowland (situated downstream of

the confluence of Nam Lik and Nam Ngum with 4,140 km²) and the chosen watershed project area: the Nam Ngum highland catchment area (identical with the Nam Ngum (dam) reservoir catchment area with 8,460 km² and the mean annual water inflow amounted to 304 m³/s corresponding to an annual total volume of 9,600 Mio m³.

The project area is cut off from all major economic activities in the country due to its geographic and topographic situation which is characterised by a hilly plateau and steep-sloped mountain ranges. It is completely devastated landscape and people were obliged to resettle after the Indochina War (where herbicides and defoliants -not to mention bombs- were used).

1.2.2 The population

There are four major population centres in the region: the upper watershed in Xieng Khouang province, containing 60% of the region's population of 132,600, the Xaysomboun corridor with 30%, the area around the Nam Ngum Reservoir, including the Nam Xan River valley and the northern lake shore and islands up to Vang Vieng District in Vientiane province, 10%.

FIGURE 3 - PICTURE OF A LAOTIAN FAMILY WITH A CARPET HANDWORK

There is ethnic diversity with Lao Loum Phuan comprising 61%, Hmong 28% and Khamu 11% (MINISTRY OF AGRICULTURE AND FORESTRY 98). The population growth rate was estimated 2.6% (that means double population (260,000) in 20 years. The urban population growth is estimated to be in the order of 10% per year (GTZ 94).

Rural poverty is endemic. Forty percent of the region's residents in 20,700 households report annual rice shortages of four months of more.

FIGURE 4- PICTURE OF A VILLAGE NEAR THE MOUNTAINS

Excluding earnings from hydropower, derived mainly from export sales to urban consumers in Thailand with few tangible benefits flowing to inhabitants of the Watershed, the per capita GRP is a low US$ 38 and thus well below the national per capita GDP (MINISTRY OF AGRICULTURE AND FORESTRY 98).

Due to cultivation methods, population growth and migrations still related to the Indochina war the population is highly mobile (66% of all households sampled in the Watershed reported moving at least once - and some as many as four times - since 1972) and highly heterogeneous (MINISTRY OF AGRICULTURE AND FORESTRY 98 and STAT. BUNDESAMT 94).

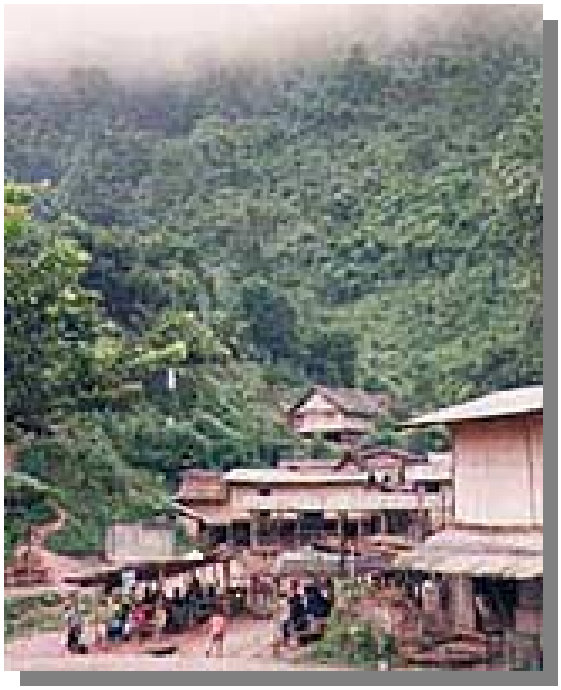
FIGURE 5 - A VILLAGE AT A TRIBUTARY OF NAM NGUM RIVER

1.2.3 Land

There is no sufficient cultivable land area to support present and future population (only 10% of whole Laos are suitable for agriculture, where only 4% are used (STAT. BUNDESAMT 94). But the potential to increase the cultivable areas of the Watershed area is constrained by a reported 1,100 km² contaminated by UXO from the Second Indochina War (MINISTRY OF AGRICULTURE AND FORESTRY 98) and by the lack of irrigation facilities. There is no possibility to increase agricultural production sufficiently by increasing the total area cultivated.

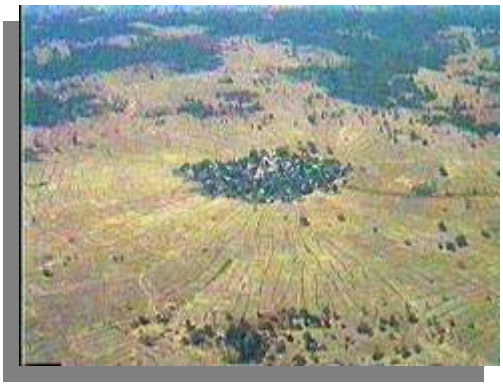
1.2.4 Forest

Forty-five percent of the area of whole Laos is forest from which the half is primary forest. A huge amount of teak and other hardwoods is sold to China or Thailand, although the official export of timber is tightly controlled. For selling purposes only about 10% of the forest area is of interest, where the admission to only the half of these is possible.



In spite of the legacy of war and extensive population migration during the past 30 years, the unpopulated areas of the watershed (42.21% of the total project area) have natural geographical barriers, which have allowed forest regeneration and re-growth. Presently, 28% of the Watershed has varying categories of forest cover (including 2.88% in dense evergreen and 0.07% in dense evergreen/deciduous forests) (MINISTRY OF AGRICULTURE AND FORESTRY 98).

FIGURE 6 - A VILLAGE AT THE BORDER OF THE MOUNTAINS AND THE RIVER



The forests only have regenerated and re-grown in areas where they are located on high elevation, high sloping land, are far from village settlements and they are far from lines of communication. In all the other areas there is a huge degradation of the forest areas where the nomadic population groups are called responsible for and so far caused soil degradation, which leads to soil erosion.

FIGURE 7 - AERIAL VIEW OF A VILLAGE WITH STREETS LEAVING IN ALL DIRECTIONS AND NO MORE FOREST NEAR THE VILLAGE

Eighty percent of energy consumption is based on fuelwood while 85% of the population remains fully dependent on exploitation of the natural resource base (GTZ 94). Ninety percent of logging is for fuelwood only and ten percent for timber selling (STAT. BUNDESAMT 94).

1.2.5 Soils and landscape

The topography of the watershed is sharply delineated with elevations ranging from 170 m.a.s.l. - the minimum level of Nam Ngum Reservoir - to 2820m at Phou Bia, the country's highest point of land. Where outcrops of limestone exist - showing the typical features of a "karst" landscape -, good soils are formed in deep friable and fertile pockets.

FIGURE 8 - VILLAGE NEAR THE MOUNTAINS

Besides the steep-sloped mountains there is a hilly plateau in the north-east of the watershed, the country's largest mountain plateau, the Xieng Khuang Plateau, which rises 1200 metres above sea level, where also the most famous part, the Plain of Jars (an area dotted with hug prehistoric stone jars of unknown origin and also the major battle field during the Indochina War) is situated. There the soils are of fine texture, highly erodible deeply weathered and of acid reaction. When originating from sandstone, shale and mudstone, soils tend to be shallow, acidic and of low inherent fertility.

FIGURE 9 - PLAIN OF JARS

1.2.6 Climate

The climate varies significantly within the basin. Average annual rainfall exceeds 3000mm on the west boundary, and decreases to below 1400mm in the North. Average annual temperature is around 20^{o}C,rising to a mean maximum of 29 ^{0}C in April and decreasing to a mean minimum of 8^{0}C in December. At altitudes below 800-900 m a.s.l., the climate is tropical monsoonal with precipitation of about 1400mm (mainly during the south-west monsoon between May/July and September / October) and at higher altitudes the climate ranges through sub-tropical to temperate with increasing elevation, with dry-season rainfalls also becoming more frequent and annual rainfall to more than 2,500 mm (at 2,000 m a.s.l. and above).

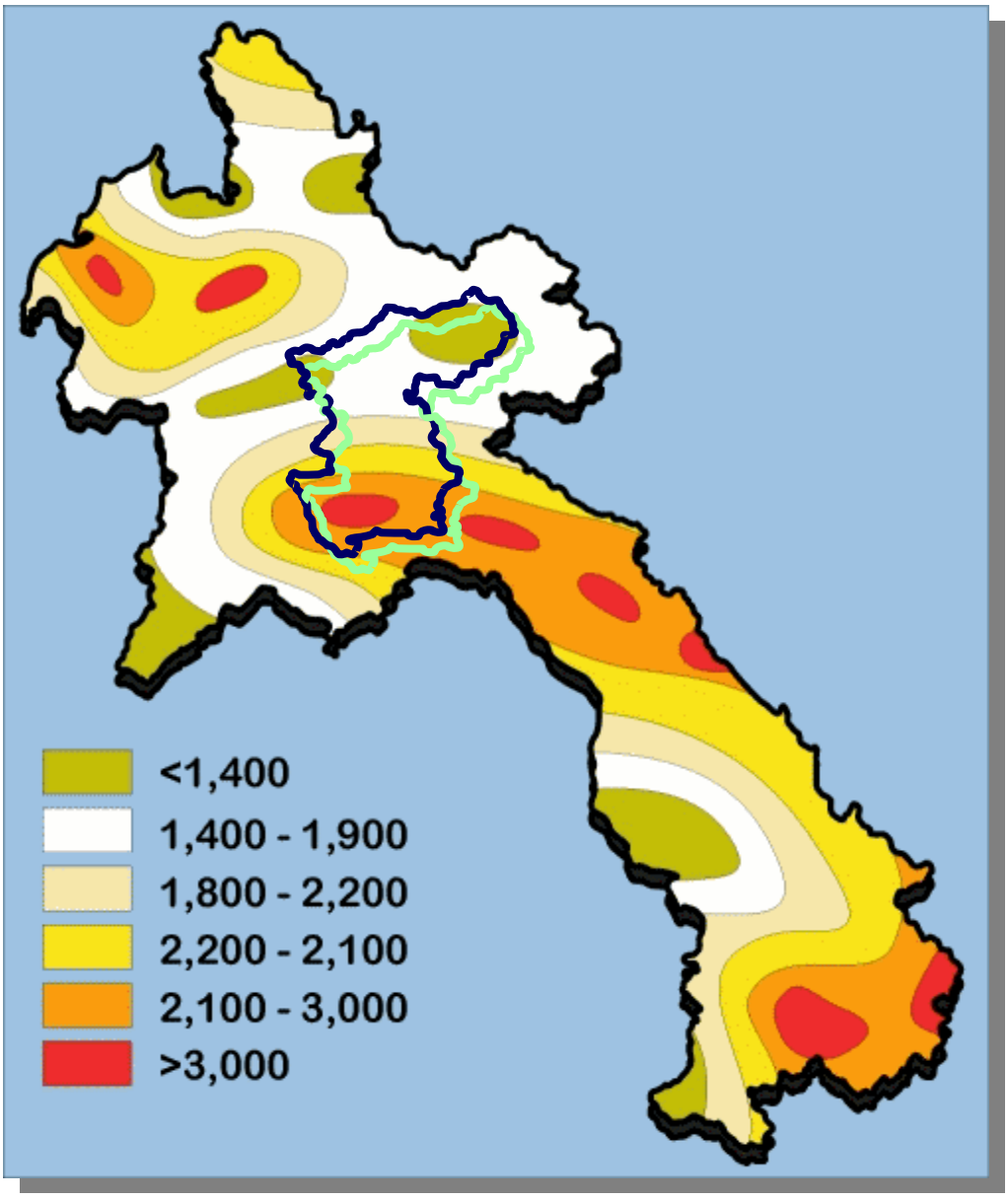


FIGURE 10 - ANNUAL RAINFALL IN LAOS AND IN THE MARKED WATERSHED AREA

1.2.7 Irrigation and water resources

The watershed has a high potential of hydropower, which already is analysed, and will be used in future projects. There are already four defined dam sites investigated that have to be involved in all planning processes.

Dry season irrigation is limited because during the dry season water level drops considerably in the river and pumping is costly. There are 4 big rivers in the catchment one of them being Nam Ngum up to now, no extensive ground water resources have been identified but shallow ground water aquifers commonly exist in the numerous river valleys. Although irrigation by groundwater is considered by the officials as a possible way of irrigation development, areas irrigated by groundwater do not exceed 100 ha (whole Laos) at present. River diversion is the major origin of water for irrigated schemes, particularly the small ones.

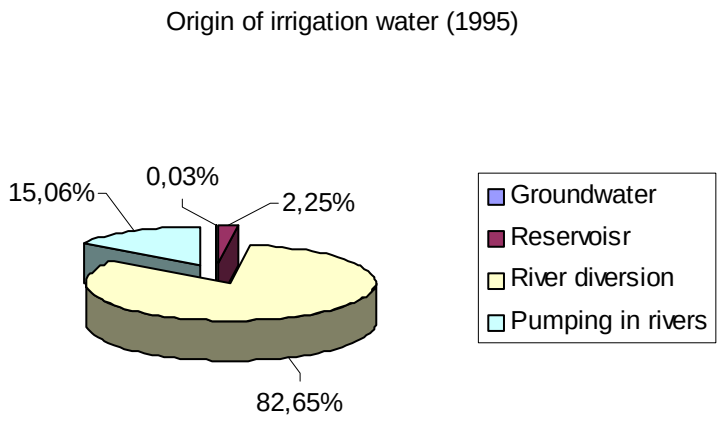


FIGURE 11- ORIGIN OF IRRIGATION WATER (1995) OF WHOLE LAOS (SEMINAR, Aquastat 95)

All areas are irrigated by surface irrigation. There are weir schemes for wet seasons and pump and reservoir schemes for both, dry and wet season distinguished in Laos, which have been built by households, villages and communities, up to their dimensions (50-500 ha). The management of weirs and reservoirs, the schemes irrigated by gravity, lies by the farmers themselves. Pump schemes account amongst the irrigation department services and are only used in the lowlands and in higher populated areas. Only the huge constructions for irrigation above 500 ha irrigated land are generally under-exploited and face difficulties in operation and maintenance (SEMINAR, AQUASTAT 95).

The main irrigated crop is rice.

1.2.8 Infrastructure

Transport and market access is severely constrained and problematic. Only 35% of the populated upper watershed report access to transport services in both wet and dry season, 21% report no access to transport at all. Many existing roads are hazardous and open for dry season travel only (from more than 1,000 km of roads, mainly in the populated upper watershed, 640 km are dry season roads only (MINISTRY OF AGRICULTURE AND FORESTRY, 98). Therefore there is inadequate marketing infrastructures and linkages as well for external inputs like fertiliser, seeds and herbicides.

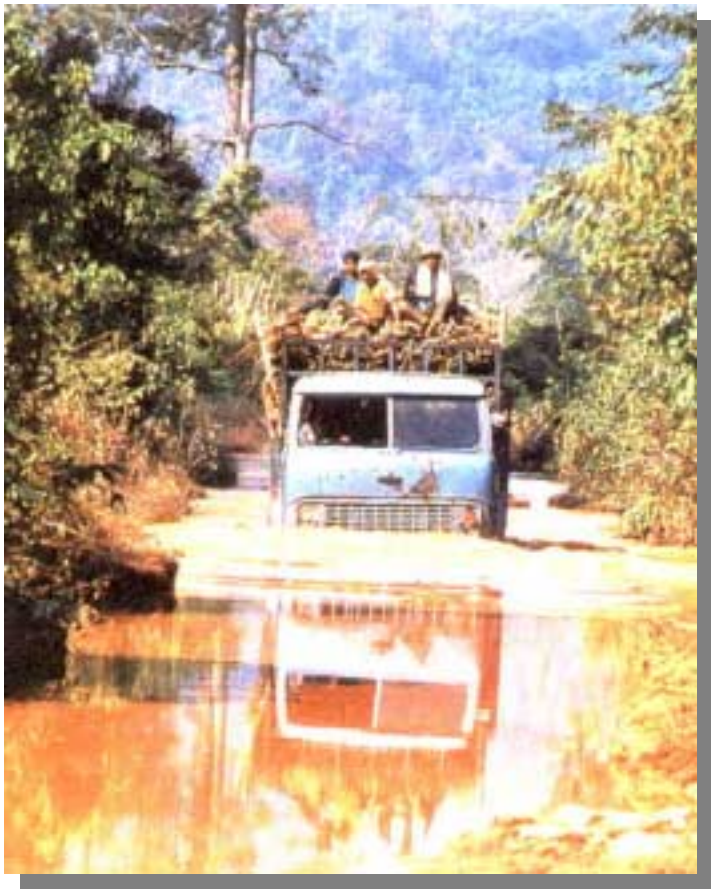


FIGURE 12 - ROAD DURING WET SEASON (SOURCE BMZ 96)

FIGURE 13 - ROAD IN A BIG VILLAGE

1.2.9 Education and health

Access to government social services (education and health) is limited by the institutional constraints. 50% of the regions are without adequate medical and educational facilities. Only 10-15% of the population has adequate year round access to potable drinking water and about 45% report acute drinking water shortages one month or more during the year (MINISTRY OF

AGRICULTURE AND FORESTRY 98). Due to poor transport situation the supply of external inputs remains to be a problem.

Source: CUMMINGS 94

FIGURE 14 - A LAOTIAN VILLAGE

2 AGRICULTURE AND FORESTRY

Major agriculture of Laos is primarily an area of subsistence rice based cultivation where 90% of farmers are cultivating rice on 70% of the agricultural used land area which brings about 50% of the agricultural productivity (STAT. BUNDESAMT 94): Paddy, shifting cultivation and mixed paddy and shifting cultivation.

FIGURE 15 - LOWLAND RICE FIELD

Livestock is a major secondary occupation and there is a comparative advantage in upgrading livestock and livestock products for sales in regional markets (MINISTRY OF AGRICULTURE AND FORESTRY 98). The livestock animals in Laos are Buffaloes, cows, pigs and chicken, which are used for the meat support (depending on the religions) and as working animals, fertiliser producer and investment source. The milk production only very few animals are used.

FIGURE 16 - A BUFFALO NEAR THE HOUSINGS

There are two cultivation patterns existing, one for the lowland and one for the highland:

Lowland agriculture involves permanent farming communities, which employ irrigated fields of wet rice (mainly only wet season cultivation due to wet season irrigation only), corn, wheat, cotton, fruits and vegetables.

FIGURE 17 - PADDY FIELDS

In *highland agriculture* farming communities are to some extent migrational, preferring to use shifting cultivation also known as swidden agriculture or slash and burn cultivation (it is estimated that around a million Lao farmers still practice this form of cultivation (CUMMINGS 94)) with a range of secondary crops such as maize, cassava, taro, vegetables, dry rice, fruit trees and the major cash corps, tobacco, tea, coffee and Opium. Also the forestry with wood for export earnings takes place mainly in the highlands.

Additionally fishing plays an important role only by the dam reservoir. In the other areas fishing is done only extensively in fishing ponds or rice fields.

The degree of mechanisation is rather low. The FAO reports in 1990 about 870 tractors. The use of fertilisers is similarly low, whereabout 2552 t where used in the agricultural year 91/92 (2/3 of this amount have been nitrogenous fertilisers (STAT. BUNDESAMT 94).

2.1 Reasons for the development of agriculture and forestry

- Laos is obliged to import 40% of the agricultural products to fulfil the needs in alimentation.
- Sixty percent of the population lives on subsistence level, largely autonomous from all government involvement, in small villages scattered throughout the country (5% of agricultural-goods reach the market, all the rest is either consumed or changed with other goods (STAT. BUNDESAMT 94)).

FIGURE 18 - MARKET

- Fifty-seven percent of the GNP comes from agriculture (STAT. BUNDESAMT 94)
- Between the years 89 and 94 about 40% of the national income in convertible currency resulted from the export of logs and wood products (KLEMM 94)
- Eighty percent of the working population is involved in agriculture, fishing and forestry
- In twenty years population will double and the food available will be cut to half.
- The forested area has decreased from 63.3% in 1970 to about 53.6% in 1994

SOURCE: KLEMM (94) and STAT. BUNDESAMT (94)

3 WATERSHED MANAGEMENT

The Watershed is, literally, the area that sheds water to the river. It includes all the land, from the watershed divide to river, from which runoff water flows toward the river.

Watershed Management is the process of formulating and carrying out a course of action involving manipulation of the natural system of a watershed to achieve specific objectives. (FAO 86)

Watershed Management is the process of guiding and organising water, land and forest resource use on a watershed in order to provide desired goods and services without adversely affecting water, soil and vegetation resources. Embedded in this concept is the recognition of the interrelationships among land use, soil and water, and the linkages between uplands and downstream areas (BROOKS ET AL. 91)

An adequate watershed management approach incorporates the following four major subjects:

- *Watershed analysis:* agro-ecological data (e.g. precipitation, temperatures, runoff, slope, lithotype, biodiversity, animal population, land use, etc.) and socio-economic data (e.g. total number of people and households, population density, food deficit, source of income, cultivation techniques, etc.) where every data has to combine "official information" (e.g. aerial photographs, GIS and topographical models) and "local knowledge" (e.g. interpretation and evaluation of aerial photographs).
- *Participatory land use planning*: the traditional practices based on indigenous knowledge and skill must be exploited first; the required demarcation of land and the definition of resource tenure by the villagers has to be supported by capable government staff at district, provincial and central levels
- *Resources use and management practices*: The final product of this exercise is a Watershed Management Plan which incorporates those changes in land use, vegetative cover, and other non-structural and structural measures that are made in order to achieve specific watershed management objectives.
- *Institutional mechanisms* provide the means to implement the practices mentioned above, namely the organisation, the legal framework (e.g. water rights, land tenure, etc.), manpower and funds.

Source: IRWIN, WILLIAMS

The occurrence of any particular native ecotype already expresses the interaction of all the pertinent environmental parameters: elevation, microclimate, soil depth, soil acidity, soil fertility, soil moisture, drainage, slope, etc. There are thus very predictable relationships between native ecotypes and present land use, and between naive ecotype and possible future sustainable use of the land. Once these relationships are determined, land classification mapping aided by aerial photography is generally simple, speedy and straightforward, without the need to go into complex and expensive soil survey and topographic mapping (KLEMM 94).

Forest and land use management

Land use planning is understood as a decision-making process that facilitates the allocation of land (soil, water, fauna and flora) to the uses that provide the greatest sustainable benefit to a variety of local users and in line with provincial and national development strategies.

3.1 What are the problems?

The problems mentioned by farmers and to some extent the government are listed under the following points which are all interacting and existing in combination with each other.

- **Low yields** (reported in about half of the villages) caused by:
  - Insufficient number of district agronomists, the lack of know-how and knowledge of better techniques especially by cropping on sloping land. This leads also to difficulties in extension levels.

FIGURE 19 - FOREST DEGRADATION AT THE VILLAGES NEAR THE TRANSPORTATION LINES (HERE: RIVER)

  - Inadequate irrigation facilities lead to undependable yields from paddy field cultivation and even lot of arable land is not irrigated because there are no storage facilities (in dry season only 43% of the equipped area are actually irrigated; in wet season 96%). Although considerable investments have already been made in the last twenty years in irrigation development the returns on public investment in irrigation were low to negative (SEMINAR, AQUASTAT 95).
  - low productivity due to the low quality of native fruit trees and the thinking of rice production only

- soil erosion caused by shifting cultivation and logging

- **High population pressure, scarcity of arable land**

  The rapidly growing population (due to the growth rate and resettling refugees) and the limited paddy field area (topography) has forced farmers to undertake cyclical shifting cultivation in hillside forests to supplement paddyfield production.

  The production is still at subsistence level and not produced for larger market

- **Shifting cultivation**

  Although shifting cultivation covered 9.4% of the Watershed in 1975 and still in 1992 is reduced in 1997 to 3.8% (MINISTRY OF AGRICULTURE AND FORESTRY 98) there are lots of problems related to this kind of cultivation. Together with the above mentioned points it has to paid attention not only on the area of shifting cultivation, but especially on the decrease of shifting-cultivation-cycles (rotation cycles decreased from 15-20 years in the past to 2-5 years at present). This reduction leads to the degradation of the natural resources (i.e. soil erosion) and additionally, will inevitably invoke opportunity costs in lost timber sales. Shifting cultivation with adequate cycles and methods and perennial crops could increase the yields for longer periods of time.

FIGURE 20 - FARMER PRACTISING SHIFTING CULTIVATION IN LAOS (SOURCE: BMZ 96)

- **Reduction of forest area**

  Rapid increase in rural population, combined with a large expansion of commercial logging, is leading to serious diminution and degradation of natural forests (fuelwood, shifting cultivation, fire escaping or forest fires) and biodiversity, increased sedimentation of streams and water bodies, aggravated flash flooding an diminished dry-season streamflows (KLEMM 94).

FIGURE 21 - SOIL EROSION DUE TO SHIFTING CULTIVATION, FOREST DEGRADATION, AND SOIL DEGRADATION

- **Organisation and management**

  People do not respect governmental regulations/law because of inadequate social infrastructure and control mechanisms.

  Most serious problems in land use planning are not technical but institutional, because the implementation depends highly on the existing or created institutions and their development and strategy.

  The poor lines of communication and market access are problematical.

3.2 What are the objectives?

The needs of stakeholders are a better living standard with the national interest in preserving and partially rehabilitating the country's natural resources. Agriculture and forestry is one possibility to increase the living standard, but only if the agricultural development is accompanied by the development of the other mentioned areas (hydropower, ecotourism).

To find out alternatives to increase agricultural production under the existing constraints the objectives are

- **Exploit fully yield potential**
  - Exploit fully water storage potential to allow to
  - Exploit fully irrigation potential (especially in dry season)
  - Exploit fully land potential for agriculture
  - orient the farmers to cash crops (incl. forest products)
  - increasing and upgrading of livestock, grazing techniques

FIGURE 22 - PIG IN A PART OF THE HOUSINGS

  - introduction of sustainable cultivation methods (i.e. to avoid shifting cultivation)
- **Preservation and rehabilitation of natural resources**
  - To seek ways to minimise and stop shifting cultivation (Decrease the cycles of Shifting Cultivation, Introduce sustainable cultivation)
  - Reduce the amount of deforestation and reforest areas vulnerable to soil erosion
  - reduce wood consumption to sustainable use
  - minimise forest fires
  - to make the District able to manage and to control

3.3 Policies:

Generally the Government of Laos is implementing the "New Economic Mechanism" for a free market economy, where special attention is given to those government authorities which are responsible for the conservation of natural resources, namely the National Office for Nature Conservation and Watershed Management (NOC) and the Ministry of Agriculture and Forestry. The latter and the provincial authorities are still jointly responsible for investigation and implementation of maintenance, repair and construction works for agricultural hydraulics, land development, dikes and flood protection structures. Thus they are moving from direct involvement in financing and management of farms, irrigation schemes, livestock production and feed production, to a role of support and regulation. Certain sectors such as protection of natural resources, disease control and research and extension remain within the government and will be expanded, while services such as input supply and marketing are being taken over by the private sector.

The watershed management strategy is based on the stipulations of the Tropical Forest Action Plan (TFAP) as well as on the Environmental Action Plan (EAP) (see http://www.uia.org/uiademo/org/f1787.htm).

The government policies are also in line with the objectives mentioned before. Government policies include:

3.3.1 Village level:

- Communal land use planning (promote sustainable use of forest, land and water resources
- Support for an integrated rural development approach
- Rainwater harvesting for non-irrigated lowland rice production
- Strengthening and restructuring irrigation development projects
- Farmer irrigated agriculture training

3.3.2 District/provincial level:

- Limitation of upland slash and burn shifting cultivation Reduction of shifting cultivation by 60% by year 2000 (one of the main national priority programmes in 1989)
- Organisation and management of extension activities

3.3.3 Central level:

- GIS application to facilitate nation-wide watershed management planning as well as visualisation and dissemination of results
- prohibiting logging and wood export
- Promotion of cash crop production
- ensure conservation of biodiversity
- expand and diversify the market oriented agricultural system, moving from subsistence level
- increase of dry season production by building small scale irrigation systems

Source: JENKINS AND SHOEMAKER 93; KLEMM 94; SEMINAR, AQUASTAT 95; GTZ 94

3.4 Assumptions:

The following scenarios are built upon the mentioned data and underlie possible solutions:

- 3% population growth from now 146.000 to 300.000 in year 2020 (in the watershed)
- royalties of hydropower revenues will be used for the agricultural part of the watershed management plan (This is required by Article 24 of the Water and Water Resources Law)
- off farm opportunities will increase (although very slow, because there is no market and labour is expansive (few people in Laos and workers are not skilled))
- free market conditions will prevail
- potential to increase irrigated paddy land

(MINISTRY OF AGRICULTURE AND FORESTRY 98).

3.5 Constraints:

- limited data base
- shortage of cultivatable land
- strong commitment of farmers to customs and traditions
- funds (80% of national budget is external aid)

- conflicting aims of water use for hydropower production and paddy irrigation (time conflict in dry seasons; benefits from hydropower to agriculture)

3.6 Solutions:

A sustainable land use, good planning and management.

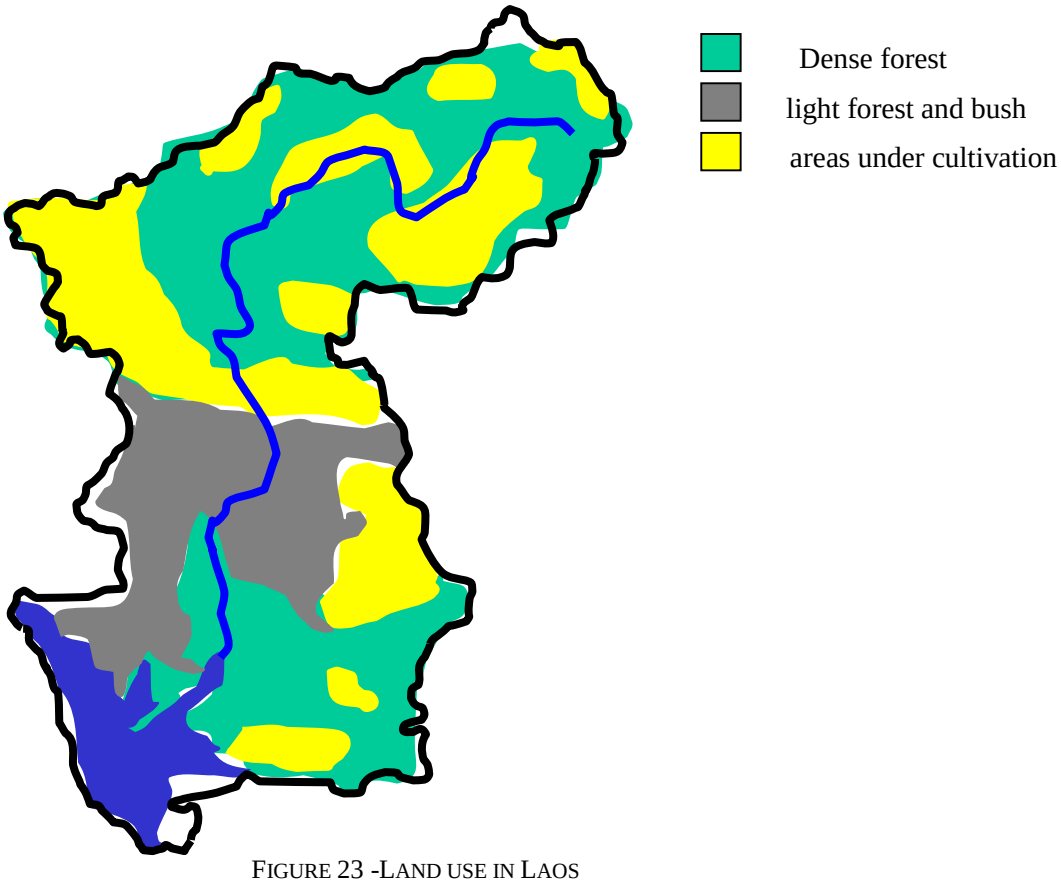


FIGURE 23 -LAND USE IN LAOS

Figure 23 shows an overall overview of the watershed area and its cultivated areas. A lot of the yellow coloured areas are on steep hills and cultivated by shifting cultivation (which can be seen on one of the following maps). With the existing data the forest could only be classified to dense forest and light forest and bushes, which is not enough to develop a specific land use plan in between this work. Using this map together with the following maps we are able to interpret the situation on a general level and suppose a general watershed management plan including land and forest use plans. Although we are not able to localise specific areas and their socio-economic relation we already could receive a major and general plan.

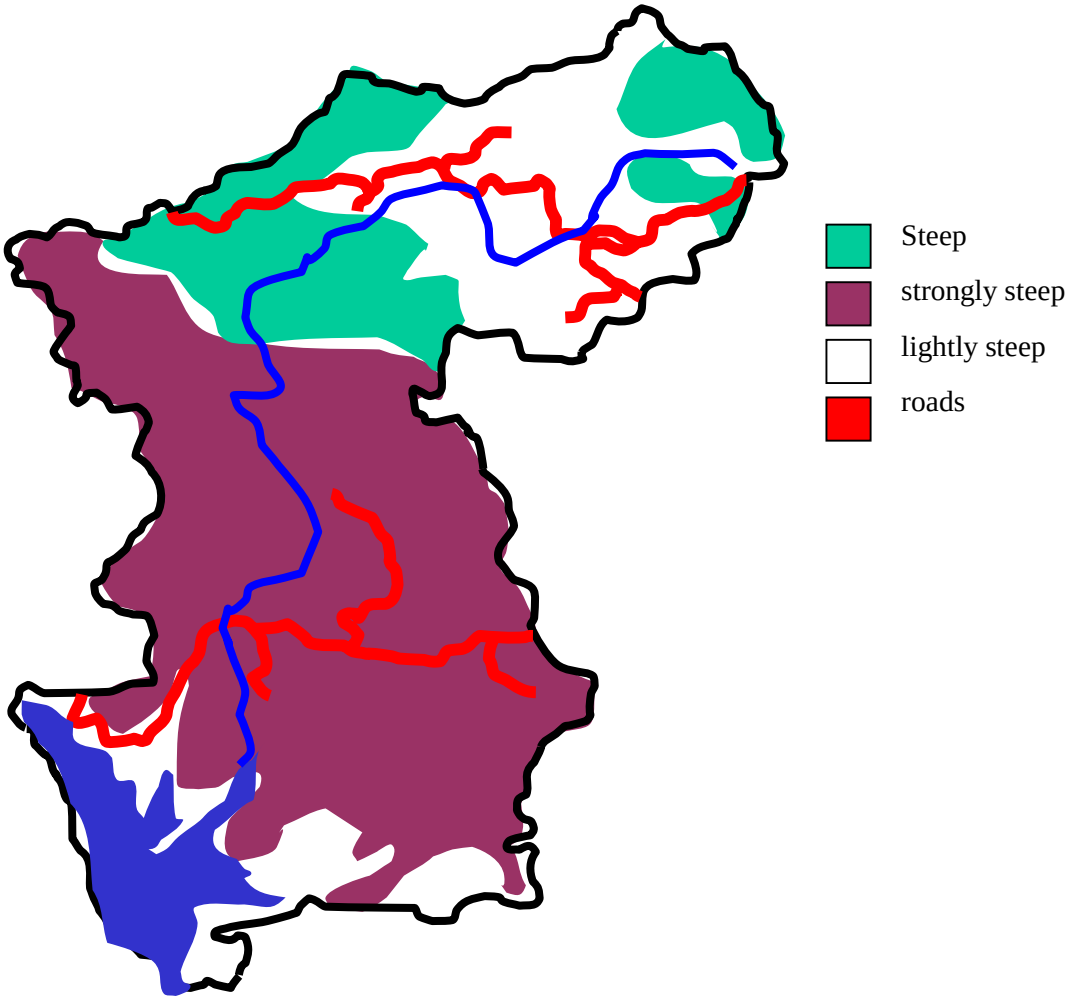


FIGURE 24 - GENERAL SLOPE MAP

Figure 24 shows a very generalised division of the areas of the watershed in relation to the slopes found in the region. Additionally there are printed the main roads, which are important for the in- and outputs for the population. It can be seen that the southern part is very steep, there are thousands of hills and mountains with steep slopes. The northern part instead includes the plain of the jars and several other plain regions. For additional information it is referred to the detailed map of Laos in the Appendix of this work.

Together with **figure 23** we receive the **figure 25** on the next page combining informations about the slopes, the cultivated areas and the roads.

There it could be seen that there are areas of cultivation, which seem to depend on the roads, especially in the northern part of the watershed. In the northeastern part only a lightly steep landscape could be recognised which leads to the conclusion that this area is cultivated with irrigated paddy rice fields. Looking instead on the southeastern part of the watershed the cultivated landscape is very steep, where shifting cultivation is practised intensively.

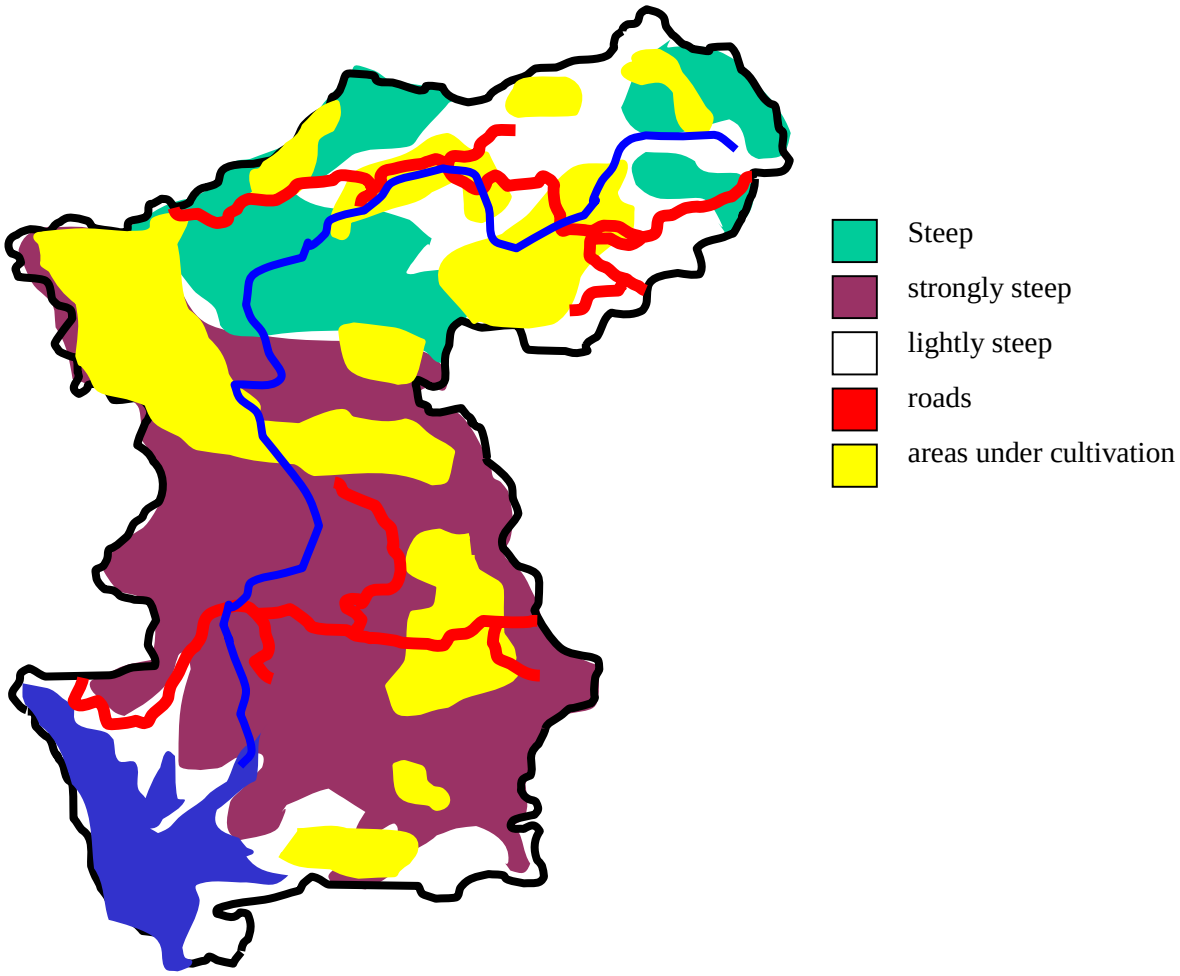


FIGURE 25 - COMBINING FIGURE 24 AND 23

The other cultivated areas without significant access to the main roads are cultivated also by shifting cultivation and additionally exploited by logging. The latter normally is not possible near populated areas, because it is already forbidden.

In the following paragraphs there are listed several proposed solutions for the different regions (lowlands, highlands) and cultivation methods. These solutions have to be assigned with one or more of the feasible options listed in the next chapter to the villages chosen as "key villages" for the first introduction of the watershed plan.

The concentration of the Watershed into four populated zones and three unpopulated zones sets the stage for a development zoning strategy. The unpopulated zones should be designated as protected areas. The populated zones should be the focus of socio-economic development whose activities are delineated by the Watershed classifications.

3.6.1 Highland

1. There is an urgent need to discourage shifting cultivation in the highland. This can be achieved through improving the fertility or the regenerating capacity of the soils in the already cultivated land through crop residue management, animal manure, mulching etc.

2. One variation of shifting rice cultivation is pioneer cultivation where fallow is replaced by perennial vegetation such as pasture or trees. Rice is intercropped with young fruit and forest trees for 2-3 yr. (intercalary cultivation). As the trees grow, they shade more area and less rice is planted. After a few years, the rice crop is transferred to a new area. It is suggested to focus on growing cash crops in the highlands (tobacco, coffee, and tea). These crops being perennial will help minimise shifting cultivation and increase the country's export earning. This requires proper management of land and water resource.

FIGURE 26 - EXAMPLE FOR SUBSTITUTING SHIFTING CULTIVATION WITH OTHER CROPS AND OTHER CULTIVATION METHODS (HERE: LAOS)

3. In the highlands crop yields can be increased through the use of external inputs, irrigation and also water harvesting: Training farmers in irrigation management and land development technology: Assistance of families having inadequate paddyfields to survey and construct "self-building" terraces for permanent rainfed mixed arable and treecrop cultivation using sustainable farming systems. To maintain their intensive cropping system, farmers have to use inputs from animal manure, organic matter, chemical fertilisers, and pesticides. However, the use of these inputs, particularly chemicals, is far less than the recommended rates because of cost. The draft animal is commonly used in this system in Asia. (See http://www.cgiar.org/irri/riceweb/envi_upland.htm).

4. Agroforestry techniques can be employed that will enable the farmers to grow agricultural crops and at the same time keep compatible trees on the cultivated lands and to reforest especially the erodible areas of secondary forest and manage the primary and cultivated forest by monitoring logging, shifting cultivation, etc.

3.6.2 Lowlands

1) Focussing on food crops like rice, corn, wheat, etc. yields can be increased through upgrading the existing irrigation schemes and establishing new small and medium scale irrigation systems to increase the number of households having access to irrigation (i.e. in dry seasons). This can be achieved through developing irrigation for all lowland paddy fields in the wet season and developing dry season irrigation.

FIGURE 27 - RICE FIELDS IN THE LOWLAND AREA OF LAOS

2) Irrigation projects based on farmer needs, farmer-driven and farmer-managed combined with the hand over of responsibilities of existing facilities to the farmers. Government will disengage from large-scale schemes; these would be reorganised under farmer control with technical assistance provided by the government.

3) A detailed analysis is required to rank and select among the crops which are already grown in the catchment like rice, wheat, and corn, etc. based on different criteria like suitability (rainfall, temperature, soil, slope), labour demand, farmers preference, profitability, water requirement, food self sufficiency and export earning by using weighting techniques.

4) Transport and marketing infrastructures should be improved. This can be achieved through improvement and construction of rural roads and the usage of the Nam Ngum River for navigation purpose, so that farmers will be able to take their produce to marketing places and they will have access to supplies (inputs).

5) Installation of permanent "cut-and-carry" forage plots will help reduce animal mortality due to disease and, by feeding them closer to home for more of the time, from wild animal attacks.

FIGURE 28 - DONKEY DRINKING WATER FROM AN OLD US-BOMB

6) Pond aquaculture expansion is also feasible.

7) Install seedling and fish nurseries.

8) Promote livestock (accompanied by disease control) for animal manure, meat production for consumption and export, for cultivating the fields and animals as source of capital.

FIGURE 29 - BUFFALO

3.7 Options:

Although the extension support strategy does not neglect the strengthening of the technical capabilities of individual civil servants from the various agencies at various levels, the main thrust of technical assistance is towards the development of the capability of rural institution at village level in planning and managing their own economic activities especially in relation to the sustainable and equitable management and exploitation of the natural resources.

For example KLEMM (94) mentioned a special upgrading procedure of farm level capabilities by a "Task Force", an activity outside the normal scope of governmental line agencies, where participatory activities of each Task Force is initiated and catalysed by a Community Organiser, who is responsible for arranging the intra- and inter-village sharing of information and experience. The latter task by establishing "Village Development Committees" in a ring of "Satellite Villages" no more than a half-day journey by foot from the "Key Villages" selected for initial Project implementation. After two years Satellite Villages will have established "Village Volunteer Workers" network and demonstration of sustainable intensified land use, and will in turn attain "Key Village" status in respect of a further shell of "Satellite Villages.

FIGURE 30 - WATERPLACE AT THE VILLAGE BORDER

3.7.1 Irrigation options

The selection of the irrigation technique has to be done based on the existing technical and socio-economic conditions prevailing in the specific area of the catchment. The use of irrigation water has to be integrated with other external inputs and improved varieties.

a) Building reservoirs, weirs for floodwater harvesting (i.e. "Wadis" and stream diversion with lined canals or PVC pipes)

b) Introduction of groundwater use without water lifting (Qanat systems, groundwater dams, horizontal wells, and artesian wells.

c) Rain water harvesting

d) Use of pumps and therefore the use of wind power (steady winds (mean annual wind velocity is 3.2 m/s) are a feature of the Xieng Khouang plateau and possibilities exist for harnessing wind energy for small-scale water pumping and electricity generation) (GTZ 94)

e) Use of hydraulic ram

f) Aquaculture systems (also as water storing systems)

3.7.2 Erosion protection options:

There are existing several methods to reduce the soil erosion of them are supposed:

1. Green manure tree system: This is done by the establishment of a contour hedgerow by planting acacia (nitrogenic plant). The interval of two contour hedgerows depend on the gradient of the mountain which is normally at 7-8 m. These reduce the pressure of soil erosion for about 30% (Source: DSE SEMINAR)

2. Forest tree system: Forest trees are planted on top of the hill as a hat (e.g. Canary trees and acacia trees).

3. Fruit tree system: E.g. Plum, hybrid apricot and lychee have been strongly growing as it has been recognised during experiments in Trang Xa village (Source: DSE SEMINAR).

4. Cereal and legume system: New varieties and Bioseed had twice or triple yield as compared with old indigenous varieties (Source: DSE SEMINAR) and also new varieties always go parallel with new technologies, therefore, the project may transfer farming methods of the new varieties to the peasants.

5. Micro-terraces,
6. brushwood barriers
7. managing trees in alley cropping
8. induced terraces

FIGURE 31 - LAND USE MANAGEMENT WITH SEVERAL MEHODS PRACTICED IN LAOS

9. Giving farmers land titles if farming is carried out in a sustainable manner (land management, crop management, protection and regeneration).
10. Encouraging population settlement by providing infrastructure, agricultural facilities and providing new technologies.
11. Reforestation by farmers for return of incentives
12. Monitoring and control of deforestation by the government

3.7.3 Cultivation options:

1) To minimise runoff losses there might be introduced ridges (constructed along the contour), stone lines, trash lines (made of organic residues such as straw, maize stoke, weeds), furrows and tied ridges (PRINZ 99).
2) To improve rainwater use there has to be paid attention on the selection of crop species / varieties, the crop density and the planting dates
3) One great advantage lies in the use of mulching, especially instead of burning the forests. The trees are cut of and used for example for building and energy purposes; the received organic material instead is used for mulching. Of course there is a huge demand of labour for this change in cultivation, but there is also an extension of soil protection, infiltration, and fertilising.
4) Creation of seedling production and nurseries together with a distribution system to generate a constant exchange of knowledge, new seeds and livestock. Afterwards the products will be sold in between the same distribution system.
5) There are lot of cultivation methods existing, which have to be investigated in the case of Laos and its special needs in socio-economic relation. There have to be mentioned techniques as:

- Mixed cropping, intercropping, polyculture, multiple cropping
- Agroforestry, which is in comparison to monocultures a complex system with needs in detailed information of the nutrient balance, the interactions and needs.

FIGURE 32 - FOR EXAMPLE CULTIVATION METHODS (TERRACES) PRACTICED IN THE BLACK FOREST (GERMANY)

The following figure shows the variety of possibilities in Land use planning:

3.8 Indicators

The following indicators are supposed to monitoring evaluation and interpretation purposes:

- Reforested land (ha/yr.)
- Burned forest (ha/yr.)
- Annual baseflow (m^3/sec)
- Sediment yield (ton/ha/yr.)
- Soil conservation areas (stabilised slopes, terraced land, treated gullies, stopped overutilisation and overgrazing, rehabilitated land) (ha/yr.)
- Net income by activity (crop, livestock, forestry and related)
- Net household income
- Number of farmers marketing their output
- Crop productivity (kg/ha)
- Managed agroforestry systems ha/year
- Irrigated area downstream of reservoir, ha/year
- Improved irrigation canals, km/Year
- Percentage of population willingly adopting appropriate technology
- Presents of rural development institutions in the watershed
- Fuelwood availability (m^3 per year) in forests established by the project

These indicators have to be used and if necessary changed by the stakeholders together. Afterwards there has to be an analysis of the reached objectives using the quantities of the indicators.

4 CONCLUSION

Financing watershed management is à priori the responsibility of the Government. Even when individual investors in natural resources use cause additional watershed protection measures the responsibility to sustain watershed integrity remains with the Government. However, following the principle of cause, the cost of watershed management arising from measures to be implemented in a particular watershed due to a particular resource use cannot be shouldered by the Public Sector alone which has to provide budgets for all watersheds in the country. Hence, the costs of watershed management should be appropriately distributed among all stakeholders: the government, the communities and the individual users, obliging each part involved to take over an equitable share.

FIGURE 33 - RICE FIELDS

The Nam Ngum Watershed Plan framework includes a private sector component (dams and resorts) amounting to $1,983 million in direct investment over 20 years. The public sector component, designed to be self-financed by hydropower revenues is $58.15 million in direct investment over 15 years. The ratio of proposed public sector to private sector investment is 2.9% (MINISTRY OF AGRICULTURE AND FORESTRY 98).

The development of the watershed can only be achieved by the co-ordinated effort between the different sectors. The need of integrated participatory watershed management, which comprises all sectors (i.e. hydropower, agriculture and forestry), is very high.

Especially this watershed with its high potential in hydropower is destined for a watershed management plan with all its interactions and dependencies.

FIGURE 34 - US BOMBS USED AS FLOWERPOT

It has to be said again, that there is no possibility to reach the objectives mentioned in this work only by the realisation of the proposed solutions and their options, because:

- The funds for these changes are coming from other inputs (i.e. hydropower, foreign aid, etc.) and not from the agriculture and forestry itself.
- The development of one sector has to go hand in hand with the development of other sectors, for example there has to be access to the market if new seeds, fertilisers or new livestock are implemented.
- The socio-economic facts have to be studied more intensively to assign suitable solutions to the specific regions (taking care about the heterogeinity of the population).

Nevertheless the development of the sector of Agriculture and Forestry is very important to reach directly almost 80% of the working population. This direct implementation makes it easier to discuss, introduce and realise a Watershed management with all its positive consequences in production development and preservation of resources for the major part of the society.

5 APPENDIX

Detailed map of Laos

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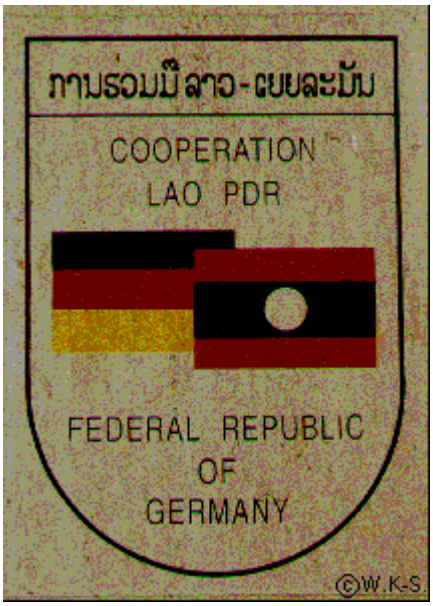

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