

# ECOLOGICAL CONCERNS IN CROP-LIVESTOCK INTEGRATION IN SLOPING LAND

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## ABSTRACT

*Crop-livestock integration for smallholders in slopelands has significant ecological considerations. It influences patterns of nutrient and material flow at the farm and landscape level, overall productivity, transfer of pests and diseases, soil and water conservation and emission of greenhouse gases. These ecological functions must be considered in the design and management of crop-livestock integration of slopelands, to enhance the productivity and sustainability of fragile ecosystems in the humid tropics. Several recommendations are made on how to integrate these ecological considerations in slopeland management.*

## INTRODUCTION

In the beginning, let me clarify some premises that I use in this Bulletin. Firstly, the term “crop-livestock integration” implies two kinds of systems: **Livestock keepers** who also do some cropping but for whom livestock are the main source of livelihood, and **Crop farmers** who also keep some animals, and perhaps culture fish, but who depend mainly on their crops.

“Crops” in this Bulletin include tree crops, grown either for timber or for fruit. This Bulletin focuses on the small-scale crop-livestock farmers which constitute the majority of rural people in Asia (Wates-Bayer *et al.* 1992).

Secondly, the term “slopelands” refers to hilly lands, regardless of their elevation. In the context of Vietnam, they include both the midlands (15-200 meters above sea level) and the highlands (more than 500 meters above sea level).

Some kind of crop-livestock farming system is common in many countries of

Southeast Asia. While the importance of the crop component is readily recognized, the role of livestock in the system is often taken for granted. Livestock make an important contribution to Asian agricultural production, providing food, draft power and fertilizer. They also make possible the utilization of land which is marginal for crops, and serve as a form of insurance for farm households through additional income generation (Amir and Knipscheer 1989).

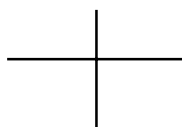
## CROP-LIVESTOCK INTEGRATION PATTERNS IN SOUTHEAST ASIA

Many patterns of smallholder crop-livestock integration patterns can be seen in various countries of Southeast Asia.

### VAC in the Midlands of Vietnam

The components of this crop-livestock integration are a garden (“Voun”), fishpond (“Ao”) and livestock pen (“Chuong”), hence the term VAC. The term is somewhat

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misleading, since not all farms have fishponds (Cuc *et al.* 1990). The VAC is usually integrated with a rice field whenever natural conditions favor a rice paddy system. The garden is diverse, containing fruit trees, hardwoods (*Melia sp.* etc.), bamboo, vegetables, sugarcane and others. Livestock include cattle, buffalo, pigs and chickens (Fig. 1). VAC is generally described as an integrated and relatively closed nutrient cycling system (Fig. 2).

### Paddy Rice - Buffalo - Forest Grazing at Phu Wiang Watershed, Northeast Thailand

This system has paddy rice in the lower portion of the landscape, and water buffalo which are used for land preparation and draft power, but which are allowed to graze in the paddy fields after harvest. During the rice-growing period, buffalo are grazed in hilly and mountainous areas (Suan-Eapl 1987).

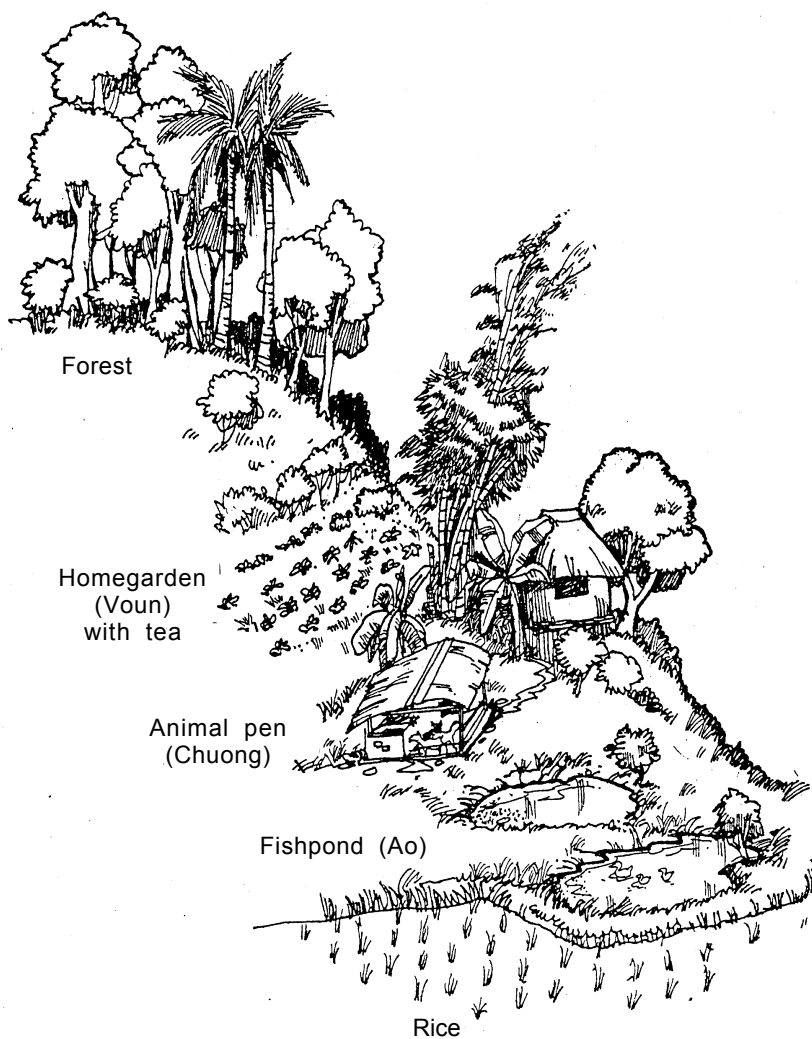


Fig. 1. Diagram of a model VAC farm  
Source: Cuc, L., K. Gillogly and A.T. Rambo 1990



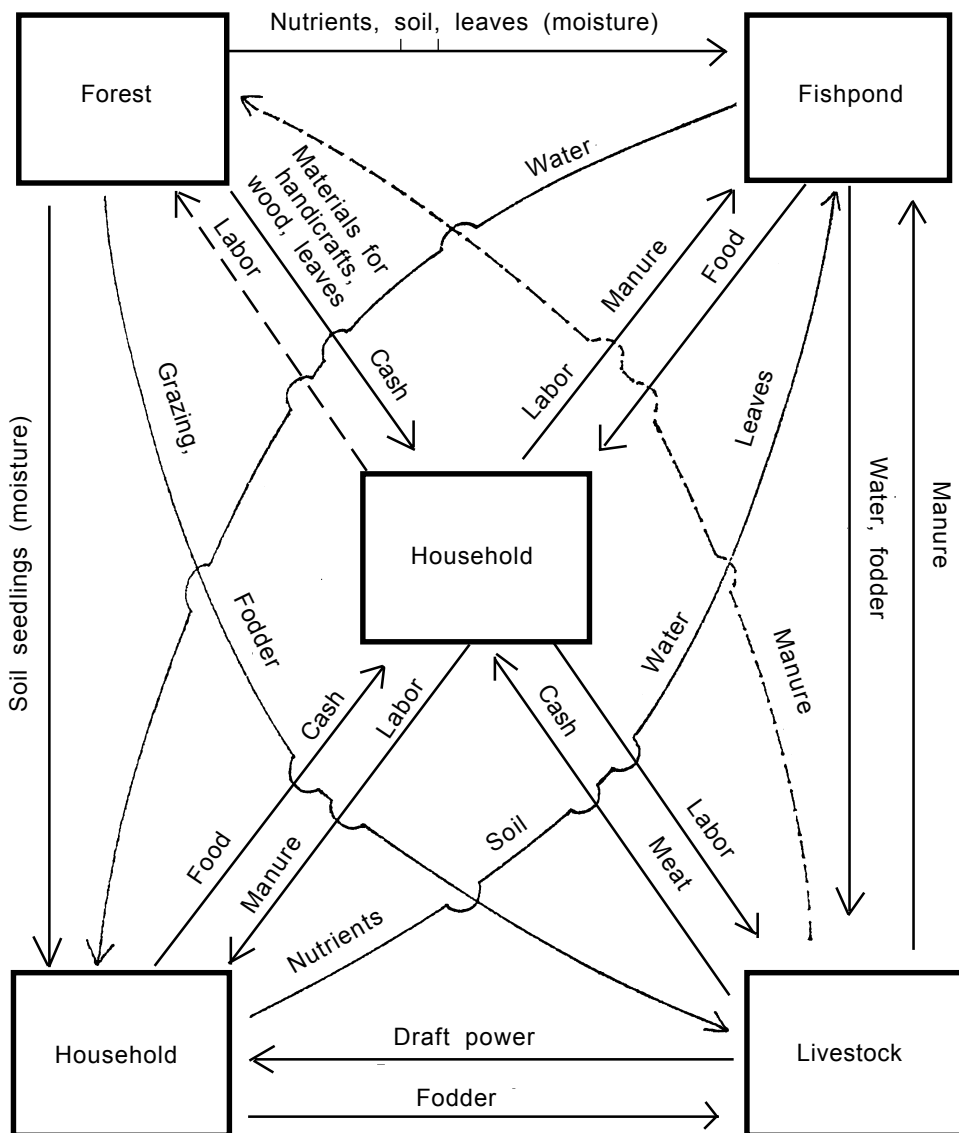


Fig. 2. Flow of energy and materials in the VAC system  
 Source: Cuc L., K. Gillogly and A.T. Rambo 1990

Whether they spend the day in fallow fields or in the mountains, the water buffalo are kept in a pen under or near the house at night. Accumulated manure is used as fertilizer for rice fields or the home garden.

**Sloping Agricultural Land Technology (SALT), Mindanao, Philippines**

SALT is a technology developed by the

Mindanao Baptist Rural Life (MBRLC), in the southern Philippines. Farms have hedgerows, usually legumes, planted along the contours for erosion control. The hedges also provide forage for goats in a cut-and-carry system. Crops are grown between hedgerows on gentler slopes, and bamboos and trees in steeper areas. The goat manure is used as fertilizer. The goats are raised for meat and milk.

### Ecosystem concept

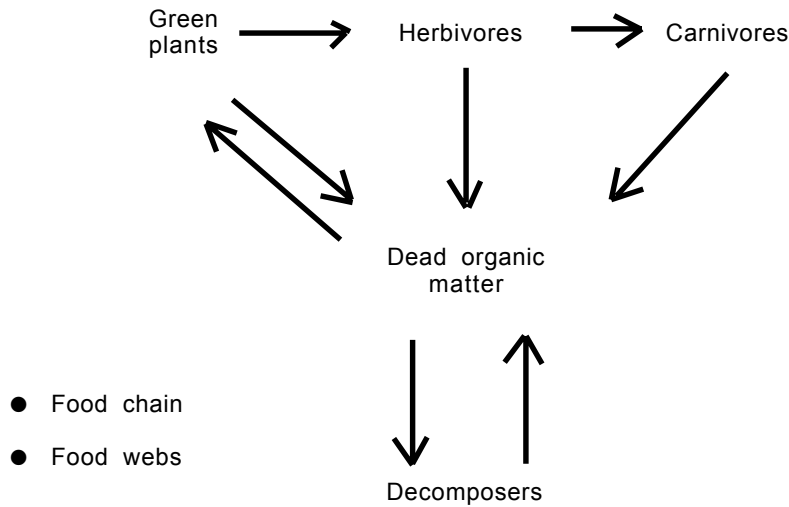


Fig. 3. Trophic level niche of livestock

### Cattle-Forest/Forage Crop Integration in Central Java, Indonesia

In central Java, at elevations higher than 400 m, cattle are raised in pens near water sources. The cattle are fed on grasses harvested from the forest floor of communally owned pine forest. Their manure is discharged into the water system. They are the major source of income for local smallholders.

These are just some of the patterns of smallholder crop-livestock integration found in the slopelands of Southeast Asia. The purpose of this Bulletin is not to describe all patterns of crop-livestock integration, but to use the ones described above to analyze the ecological implications of this type of farming.

#### ECOLOGICAL ROLE OF CROP-LIVESTOCK INTEGRATION

In the context of Southeast Asia and the humid tropics in general, there are two basic ecological principles which must be taken into consideration to understand the implications of crop-livestock integration in slopelands.

1. Devoid of adequate vegetation cover, slopelands in the humid tropics are prone to soil erosion. They suffer from water

shortage, and become marginally productive and unstable. The most stable ecosystem in the humid tropics is a tropical rainforest ecosystem, which is multi-layered, diverse, protective of the soil, hydrologically stable, productive and protective of other ecological processes. An ecologically sound pattern of crop-livestock integration in Southeast Asia will be one which mimics this original ecosystem.

2. Crop-livestock integration follows the trophic level structure of ecosystems, where crops represent primary producers and livestock the grazers or herbivores. It therefore follows the regular food chain, and energy and nutrient transfer processes, characteristic of natural ecosystems (Fig. 3).

These frameworks help provide a better understanding of the ecological role of crop-livestock integration. Some of its most significant ecological functions are as follows.

#### Determining Biomass Production and Overall Productivity

Generally speaking, crop-livestock integration increases the overall productivity of ecosystems. While primary productivity can be attributed to the crop component, livestock as herbivores can add to the overall productivity, especially if they make use of



otherwise waste products and indigestible portions of crop plants. Livestock in smallholder farming systems not only increase food production and the protein supply, but also provide raw materials, draft power and manure, and are a risk buffer and a form of savings.

### **Regulating Nutrient and Material Flow**

According to its trophic level (Fig. 3) and ecological principles of the food chain, crop-livestock integration will determine the pattern of nutrient cycling, as well as the flow of materials and energy in the agroecosystem (Fig. 4). The patterns of these flows will determine the stability and sustainability of the slopeland agroecosystem. When these patterns of nutrient, energy and material flow are relatively “closed” and integrated, the agroecosystem is relatively sustainable, compared to one in which these flows are more “open”. An open agroecosystem usually causes more pollution, as it is characterized by greater soil erosion and “leaking” of nutrients. It therefore has greater off-site impact, and requires more inputs to maintain its productivity level in the long term.

### **Determining the Level of Biodiversity**

Crop-livestock integration generally enhances biodiversity in slopeland agroecosystems, compared to monoculture. The level of biodiversity, and the compatibility of the different crops and livestock in the farming system, will influence how stable productivity is on fragile and marginal slopelands.

### **Serving as Biotic Carrier for Transfer of Diseases and Pests**

Crop-livestock integration, while regulating the flow of nutrients and materials, also serves as a carrier of biotic elements which may affect the spread of pests and diseases.

### **Influencing the Balance of Globally Important Gases**

Crop-livestock integration contributes to the production of globally important gases

such as methane (Conway and Pretly 1991). Methane production by livestock is the result of activity by anaerobic bacteria in the animals’ gut as they break down organic matter. Ruminant animals worldwide contribute about 15% of the world’s methane emission. Cattle and buffalo account for around 80% of the total methane produced by animals.

## **ECOLOGICAL IMPLICATIONS OF CROP-LIVESTOCK INTEGRATION**

### **Cropping Pattern and Crop-Livestock Compatibility**

The SALT system developed in the Philippines is an example of a compatible system in which legume hedgerows give soil erosion control and are a source of fertilizer for the crops planted between the hedgerows, and of feed for the goats raised in a cut-and-carry system. If goats were allowed to graze freely, vegetation cover would be removed or reduced significantly, leading to soil erosion and loss of nutrients.

In the case of the Phu Wiang Watershed, Northeast Thailand, the cassava crops planted on the upper slopes of the watershed are a major source of nutrient outflow. This could lead to long-term depletion of soil fertility (Fig. 5). In other forms of crop-livestock integration in Southeast Asia, such as a coconut-livestock integration system, cow dung may be a habitat for the beetle that attacks the young shoots of coconut. The crop-crop and crop-livestock compatibility would, therefore, influence the productivity and sustainability of smallholder integrated farming systems.

### **Nutrient and Material Flow**

Crop-livestock integration in slopelands generally contributes to nutrient and material cycling and conservation. However, data obtained from studies at the Phu Wiang Watershed in Northeast Thailand and the VAC of upland Vietnam indicate that the pattern of livestock grazing influences the long-term productivity of uplands (Suan-Eapi 1987, Cuc *et al.* 1990). If grazing management consists of livestock being kept in the uplands and transferred to the lowlands for sale, nutrients

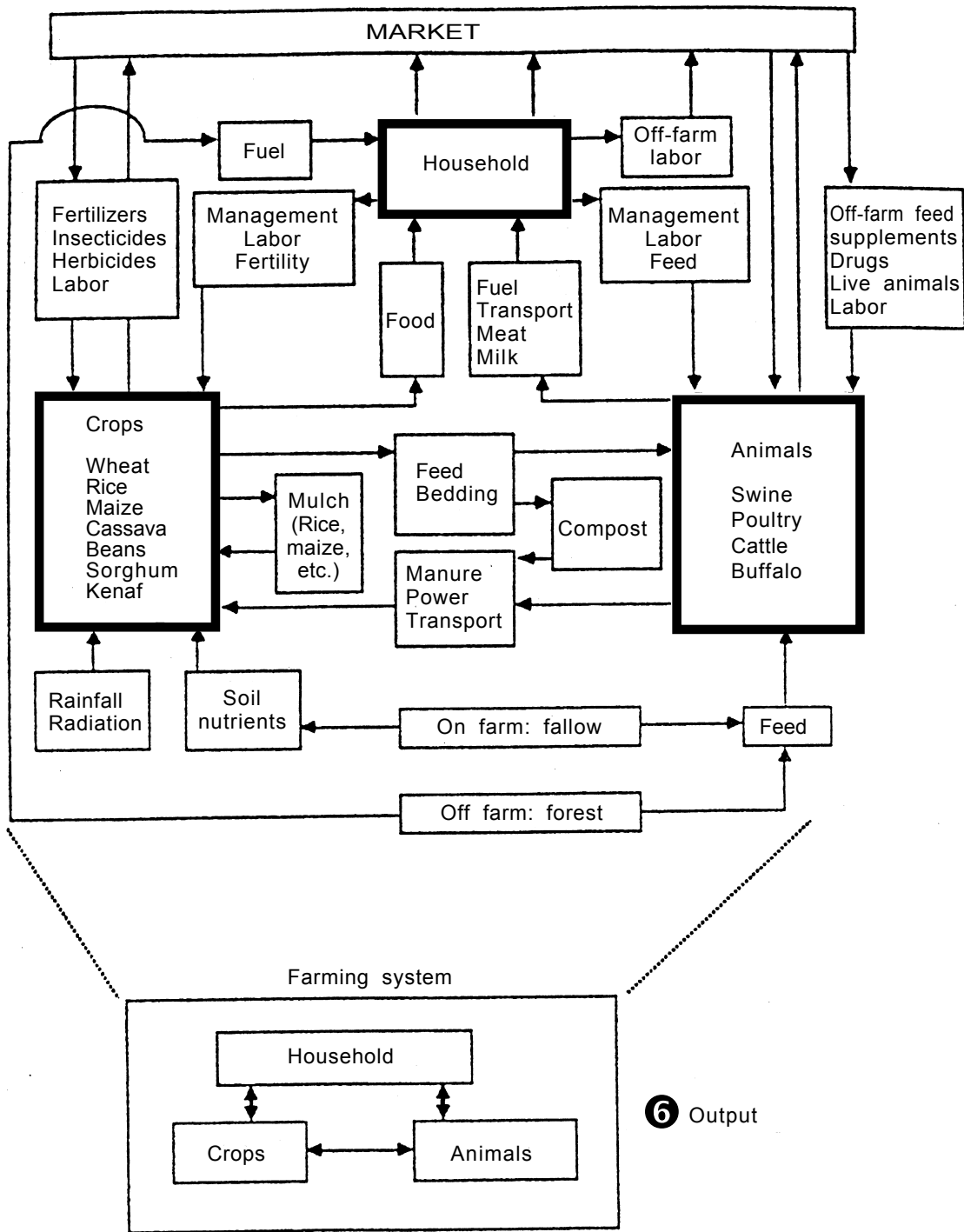


Fig. 4. The independent elements of a farming system and their connection with other elements within the agrosystem

Source: Amir P. and H. Knipscheer 1989



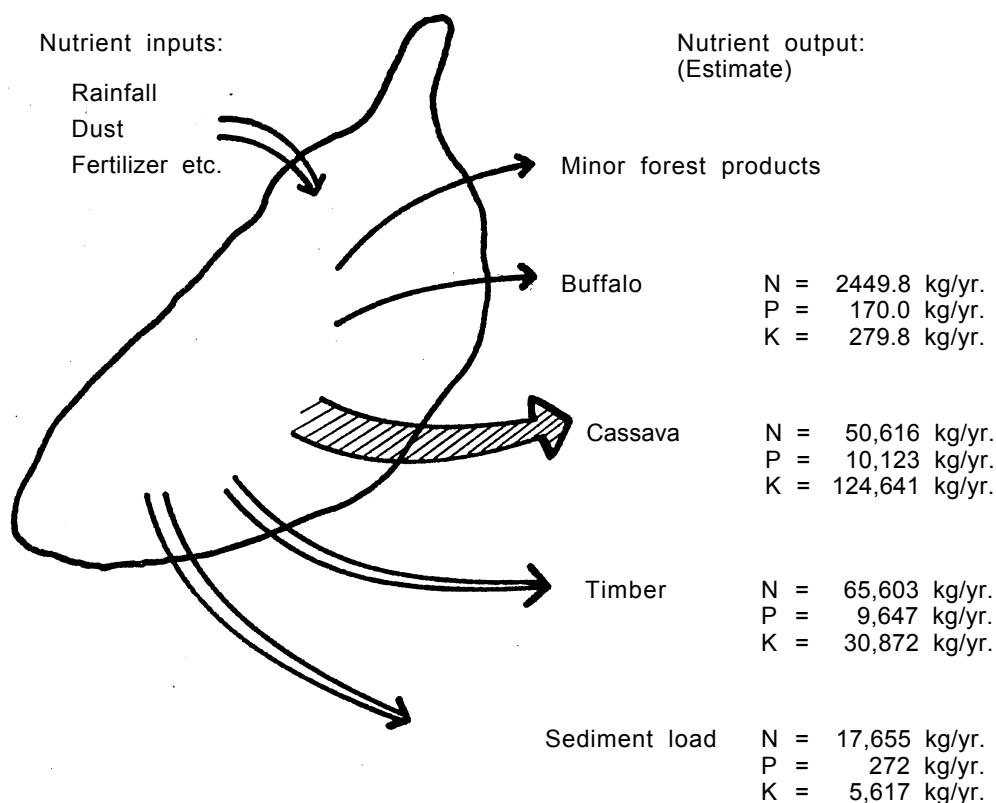


Fig. 5. Estimated outflow of some nutrients from the Phu Wiang watershed, Vietnam

Source: Suan-Eapi 1987

will accumulate in the lowlands while the uplands are continuously being depleted. This is going to cause a decline in upland productivity in the long run. Dumping of livestock wastes into the river, as is the case of crop-livestock integration in Central Java, causes water pollution. Landscape management should therefore be emphasized.

### Spread of Pests and Diseases

Free-ranging livestock, or even livestock kept in pens, may serve as biotic carriers of pests and diseases. For example, the manure of grazing livestock could serve as a carrier of upland weed species when applied as fertilizer to home gardens or lowland rice fields. Such weeds may become dominant on bunds, and get dispersed into other ecosystems. In the Phu Wiang Watershed in Northeast Thailand, water buffalo infected with liverfluke from Ubon Rat carried this parasite

to the Phu Wiang agroecosystem (Fig. 6).

### Emission of Globally-Important Gases

Methane emissions from livestock, especially ruminants, contribute to greenhouse gases, a probable cause of global warming. The level of methane emitted can be partially reduced by the use of certain chemicals which suppress the activity of anaerobic bacteria in the rumen of livestock, or by integrating non-ruminants into the farming system.

### CHANGES IN PATTERNS OF CROP-LIVESTOCK INTEGRATION IN SLOPELANDS

Crop-livestock integration in Southeast Asia, especially for smallholders, is changing rapidly. The factors responsible for these changes have long-term implications for slopeland productivity.

In the uplands of Vietnam, the policy of

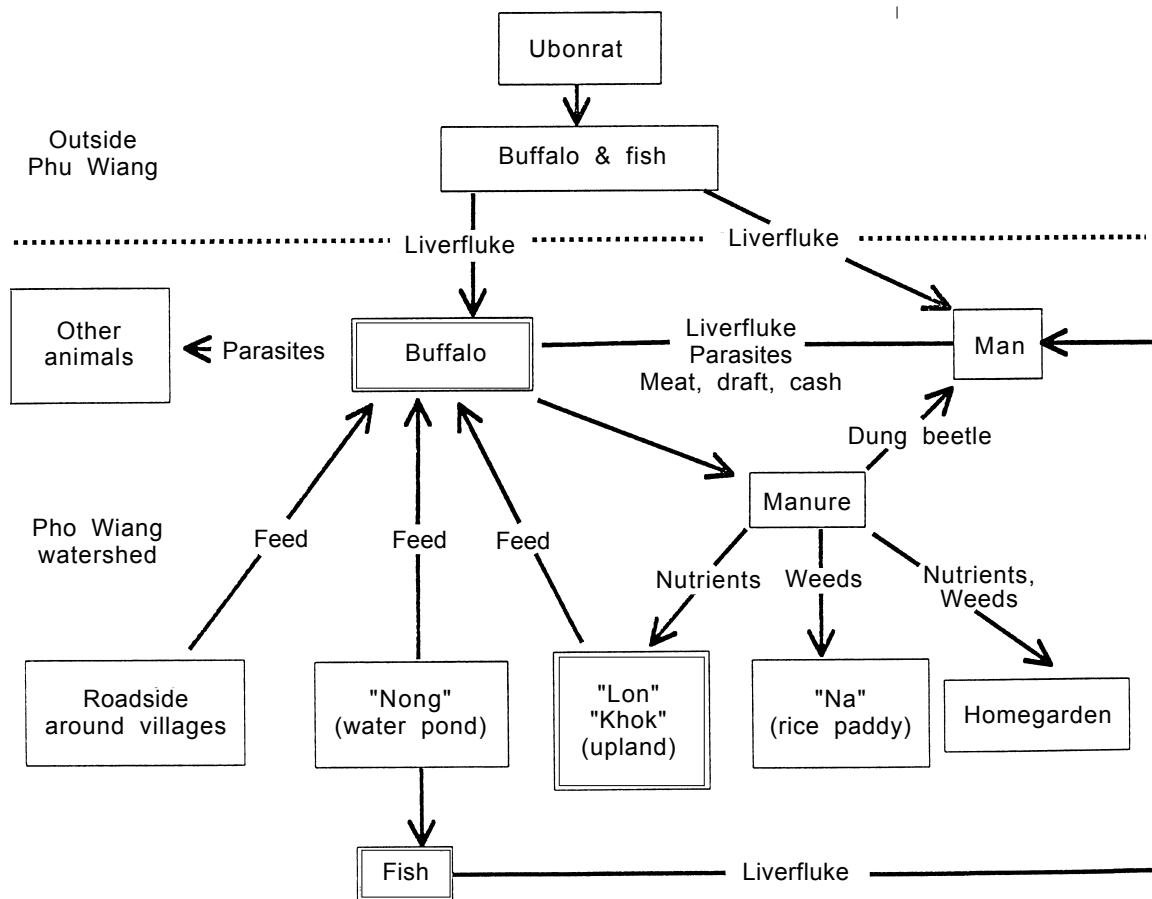
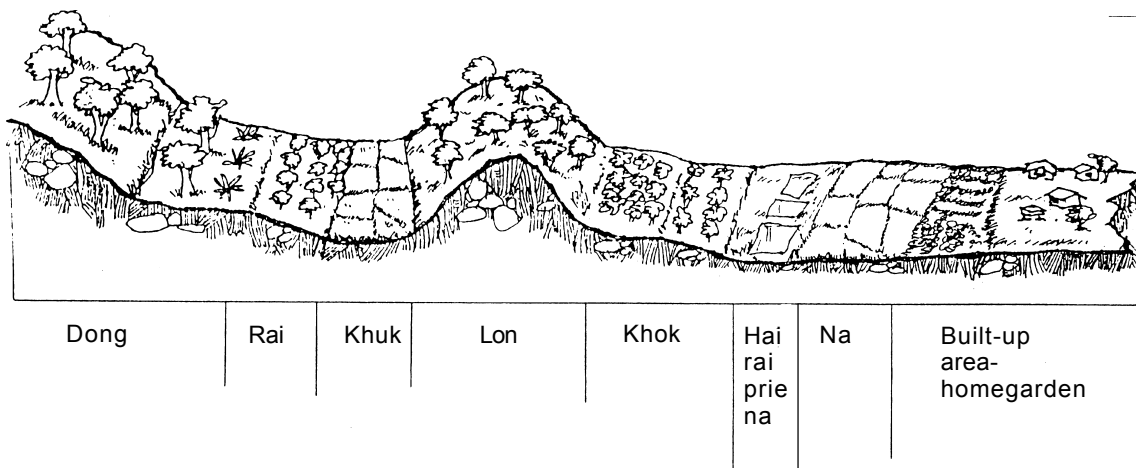


Fig. 6. Transfer of nutrients from upland to lowland in Phu Wiang Watershed, Northeast Thailand

Source: Suan 1987



the government is to promote a market economy, and allocate land to upland farmers. This has enhanced the greening of the uplands, because farmers have been encouraged to plant more fruit trees for the market (Cuc *et al.* 1996). This increase in vegetation cover in the hilly portion of the VAC has increased both productivity and soil conservation.

The introduction of electrical power into the Phu Wiang area of Northeast Thailand has allowed families to acquire appliances such as television. These give access to new information about commercial goods, including power tillers (locally known as “iron buffaloes”). This has resulted in the replacement of many water buffalo by power tillers, which means there is less buffalo manure available as fertilizer. Since water buffalo are usually tended by young children, this has meant an increase in the free time available to children. They tend to spend this extra free time watching TV or on their studies, depending on the values prevailing in the household.

These two cases illustrate how patterns of crop-livestock integration in slopelands can be changed by government policies, market forces and land tenure.

#### POINTS TO CONSIDER IN CROP-LIVESTOCK INTEGRATION

As discussed in this Bulletin, the pattern of crop-livestock integration has strong ecological implications for slopeland areas. It is therefore recommended that the following points should be considered in planning and management.

- The pattern of integration should make sure of crop-crop and crop-livestock ecological and economic compatibility, for optimum biomass production and environmental protection.
- The sustainability of crop-livestock integration should be assessed in view of the nutrient and material flow at the watershed level, and not only at the farm level.
- Crop-livestock integration should promote soil and water conservation, nutrient conservation, and minimize the emission

of greenhouse gases, especially methane.

- In developing crop-livestock integration, the possible spread of pests, diseases and polluting chemicals should be kept in mind, and their potential impact on human health and welfare.
- An appropriate Environmental Impact Assessment Framework should be developed for crop-livestock integration in slopelands, of a kind that smallholders can use in their farm planning. This framework should extend to monitoring and evaluation at both a farm and watershed level, to ensure the sustainability of the farming system.

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## DISCUSSION

Seminar participants discussed the problem of a net loss of soil nutrients from upland areas. One participant suggested that forest cover might help maintain a nutrient balance, since tree roots take up nutrients from low down in the soil profile. Dr. Sajise agreed, but pointed out that in the Phu Wiang watershed in northeast Thailand, some trees still remain but there is a decline in the amount of lower vegetation under the trees. This occurs because of soil erosion, and is an indicator of soil degradation.

Participants also discussed methane emissions from livestock production, and their effect on global warming. Dr. Sajise felt that this problem should not be addressed at a farm level, although intervention might be possible at a higher level. He suggested that slopeland agricultural systems cannot dispense with ruminants, since these are an indispensable component of the farming system. Furthermore, if farmers dispense with ruminants, they would be unable to make full use of primary production.

A Thai participant pointed out that ruminants can efficiently convert biomass in the rumen to more useful resources. If output from the rumen of gas etc. is compared with direct burning of the same materials, there is likely to be a lower production of carbon dioxide and methane if the materials are digested by ruminants than if they are burnt. He expressed concern that ruminants might be seen as building up gases that damage the environment. Dr. Sajise pointed out that according to a recent publication by Conway and Pretly (1991), animals contribute only about 15% of the world's total methane emissions. The greatest source of methane and carbon dioxide are rice paddies and industry, which together contribute around 80% of the world's methane and CO<sub>2</sub>.

