

AGRICULTURAL DEVELOPMENT AND LAND DEGRADATION? LAND USE CHANGES IN THE KUNDASANG HIGHLANDS OF SABAH

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Much of general literature suggests that land use changes following planned rural development programmes, and the desire among farmers to accumulate profits from cash cropping often lead to serious degradation of the environment. This paper examines land use changes, in terms of intensification and expansion of agriculture, that took place after a government programme to develop commercial agriculture among Dusun shifting cultivators in Kundasang highlands of Sabah, East Malaysia. The paper starts with an overview of the traditional land use system under shifting cultivation. A detailed discussion follows of land use changes adopted after the implementation of the agricultural development programme. Finally, the impact of these changes are analysed. The paper illustrates that, like many other places, the new crops, technologies and cultivation practices adopted in Kundasang have increased production but resulted in severe land degradation. To maintain production under such environmental conditions farmers were forced to adopt a new farming system based on high-energy and capital-intensive technology. However, unlike other places, some of the practices adopted under the new system of farming in Kundasang appear to be more sustainable than the previous practices and may lead to recovery of degraded land.

INTRODUCTION

Many geographers and anthropologists have shown that traditional agricultural systems are low-input, low technology, low-cost and relatively environmentally sound (Thiele, 1990:6-10; Slattery, 1979:196-208). Yet planned rural development programmes have been provided by governments to modernise and commercialise traditional agriculture. New crops, cultivation practices and yield enhancing technologies have been introduced. In the process much traditional agriculture has been transformed into high-input, high-technology, high-cost systems (Eastman, 1990:34; Morvaridi, 1990:303; Stonich and deWaltz, 1989:204-217; Hayami and Ruttan, 1985:16-20).

The introduction of new technologies and cultivation practices, and the desire among farmers to accumulate profits from cash cropping has led to intensification of cropping on existing farms and expansion of cultivation often onto marginal soils that are highly susceptible to erosion (Hardjono, 1991:133-

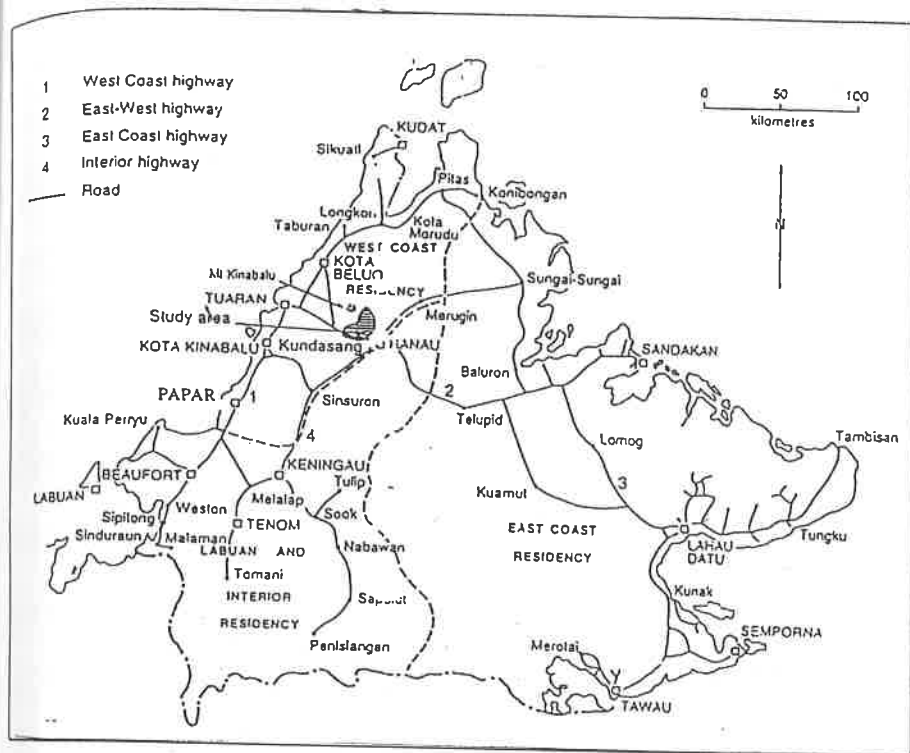
153; Morvaridi, 1990:305; Torres-Zorilla and Rausser, 1990:351). In addition to increasing productivity these land use changes can also result in serious degradation of the environment (Thiele, 1990:12-14; Blaikie and Brookfield, 1987:160-163, Brookfield, 1984:1544). Upland areas are degraded through removal of forest cover, accelerated soil erosion, and rapid leaching of soil nutrients resulting in depleted soils and poor yields. Lowland areas suffer from associated silting and severe flooding. The leaching and runoff of fertiliser and pesticides lead to concentration of toxic substances and eutrophication. Excessive and indiscriminate use of pesticides also results in pest resistance to pesticides (Brookfield, 1994:270-275; Lewis, 1992:161-170; Louloudis et al., 1989; Palte, 1989:7-89; Hardjono, 1983:54-55; Weir and Shapiro, 1981:6-10, Davies, 1981:242-255; Boserup, 1965:24-27).

The paper examines the case study of the Kundasang development project in Sabah and is based on findings of a nine-month long fieldwork conducted between December 1989 and August 1990 (Ali 1995). It starts with a review of land use prior to 1955 to illustrate the form of land use prevalent in Kundasang before government intervention. Then, land use changes and the impacts of these changes on the environment are considered over the three time periods, 1955-1971, 1972-1982 and 1983-1990 that match the changes in government policy and strategies in the Kundasang area. (*ibid*).

THE STUDY AREA

The area chosen for the study is the Kundasang Highland Vegetable Cultivation irrigation Project (KHVCIP) in the sub-district (mukim) of Kundasang and the administrative district of Ranau in the West Coast Residency of Sabah.(Fig. 1)¹

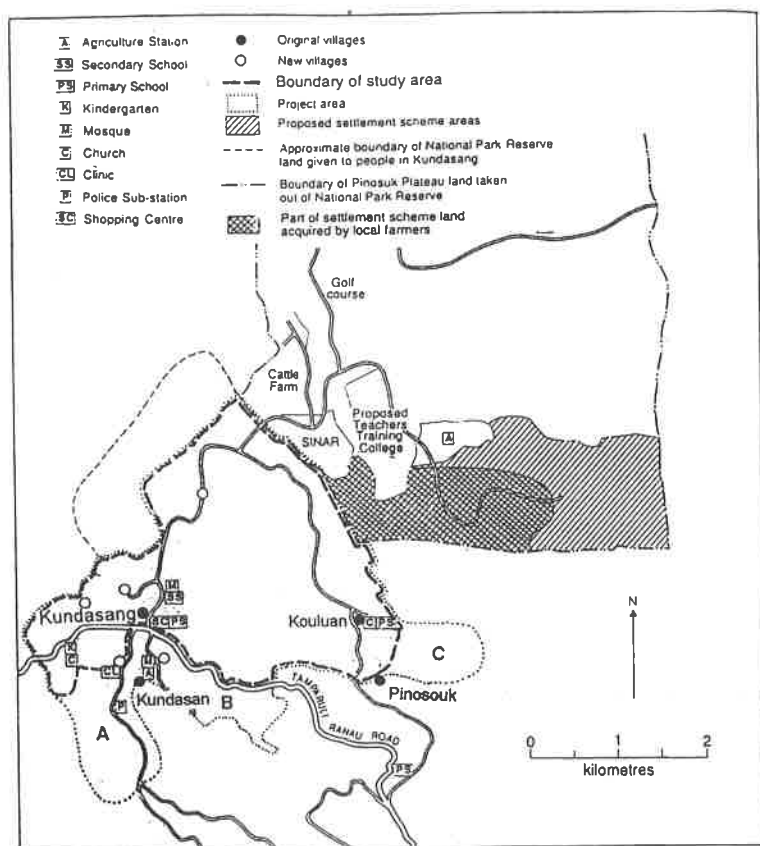
Figure 1: Location of the Kundasang study area in the West Coast Residency, Sabah.



Source: Mohamad, S. 1983:37

The project covers an area of approximately 1000 hectares. In-depth study was conducted in the core portion of the KHVCEP (Fig. 2)²

Figure 2: Location of Kundasang Highland Vegetation Cultivation Irrigation Project and the study area.



Source: Raja and Gabongan, 1986:32

It includes about 750 of the total of 1000 hectares under the project. Of these 750 hectares, approximately 565 hectares are taken up by 403 plots of agricultural land. The remaining 185 hectares are under rivers, streams, roads, settlements and other service structures. This particular portion was chosen for in depth study mainly because major government efforts were concentrated in this portion from the beginning of the development project, and it is possible here to trace some 35 years' of experience of agricultural development and land use changes.

PRE-1956 LAND USE SYSTEM

Until the mid-1950s the Kundasang Dusun were largely subsistence farmers. They produced crops to meet the dietary and social needs of their families. Shifting cultivation was the predominant form of land use whereby forested land was cleared, planted in crops for two to three years and then left in fallow under scrub and bush for five to ten years. A major portion of the cultivated land was planted in subsistence crops including hill padi, sweet potato, maize and vegetables, with small areas devoted to the production of tobacco for sale (Leng, 1965: 102; Baker, 1965: 111-117).

Cultivation practices on shifting agricultural plots showed a high degree of inter-cropping. Minimum tillage, presence of tree stumps and roots in the fields, following and burning were other common characteristics of shifting agriculture. Intercropping ensured a year-round supply of food, discouraged development of plant-specific insect pests and provided soil cover and green manure. Minimum tillage and presence of trees, stumps and roots in the ground helped to prevent soil erosion. Fallowing restored soil fertility while burning of debris after clearing the land destroyed weed seeds and also provided the soil with nutrients such as potash.

Thus, prior to 1955 Kundasang Dusun had a low-input system of production dependent on natural soil fertility and rainfall rather than on artificial fertiliser and irrigation. It was an extensive form of land use with low population densities over a wide area. Although yields were low, the system was not highly destructive, but generally sustainable.

1956 TO 1970: THE ADOPTION OF COMMERCIAL VEGETABLE FARMING

In 1955 the colonial administration sought to introduce commercial vegetable farming among the local Dusun shifting cultivators under its smallholder assisted scheme. The major strategies adopted under this scheme were provision of security of land tenure, trials and experiments, farmer education, extension services, incentives of cash grants and free high-yield inputs. Improvements in road infrastructure to facilitate marketing of vegetables formed an important part of government strategy.

To provide security of tenure, individual ownership of land with registered titles was also introduced. An agricultural research station was established at Kundasang in 1955 to conduct trials and experiments in different types of highland crops and to provide farmer training and extension services. Free

inputs such as hybrid seeds, chemical fertiliser and pesticides and cash grants were provided as incentives to farmers to adopt vegetable cash crops. Road improvements began with the construction and opening of the Tamparuli-Ranau main road in 1959. Within the study area several feeder roads connecting farming areas to the main road were constructed and work on Kundasang-Kouluuan feeder road was started in 1965. With provision of these services and incentives the adoption of vegetable cash crops gradually started.

Until 1958 very few changes in land use were adopted by the farmers despite the provision of various forms of incentives by the government. The traditional form of shifting cultivation remained the predominant form of land use. On the swidden plots major portions were planted in subsistence crops using traditional technology as was the practice prior to 1956. The only changes were the inclusion of vegetable cash crops and the use of chemical fertilisers and pesticides. A limited number of vegetable cash crops, such as English and Chinese cabbages, tomatoes, lettuce, carrots and leeks were planted on small portions of the swidden plots, with the chemical fertilisers and pesticides supplied by the Agriculture Department being used only on the vegetable cash crops.

After the opening of Tamparuli-Ranau trunk road at the end of 1959 the market for Kundasang vegetables expanded, boosting farmers' cash incomes. This provided them with both the incentives and the resources to produce larger quantities of vegetables using modern technologies while maintaining subsistence crop production under shifting cultivation. Subsequently, several changes in land use took place, most importantly, an expansion in land under cultivation, spatial specialisation of cash and subsistence crops, and adoption of new cultivation practices and technology.

The contemporaneous planting of both commercial and subsistence crops necessitated an expansion of the cultivated area, which consisted mainly of the clearing of forested land along the Kundasang-Kouluuan jeep track (Fig. 2), sometimes on steep slopes, as construction work on this track progressed. Consequently, by 1970, approximately 360 hectares (almost 50 per cent) of the 750 hectares of land in the study area had come under cultivation (Wong, 1973: Fig. 3). According to the estimates of the Agriculture Department staff this was an increase of over 100 per cent from the 1954-55 period (field interviews 1990). The remaining 50 per cent of the land remained under rotational grass, scrub fallow and forests.

In the early 1960s spatial specialisation of commercial and subsistence crop production began to emerge. Farmers who owned or occupied land close to the main road began to devote this land solely to commercial vegetable production

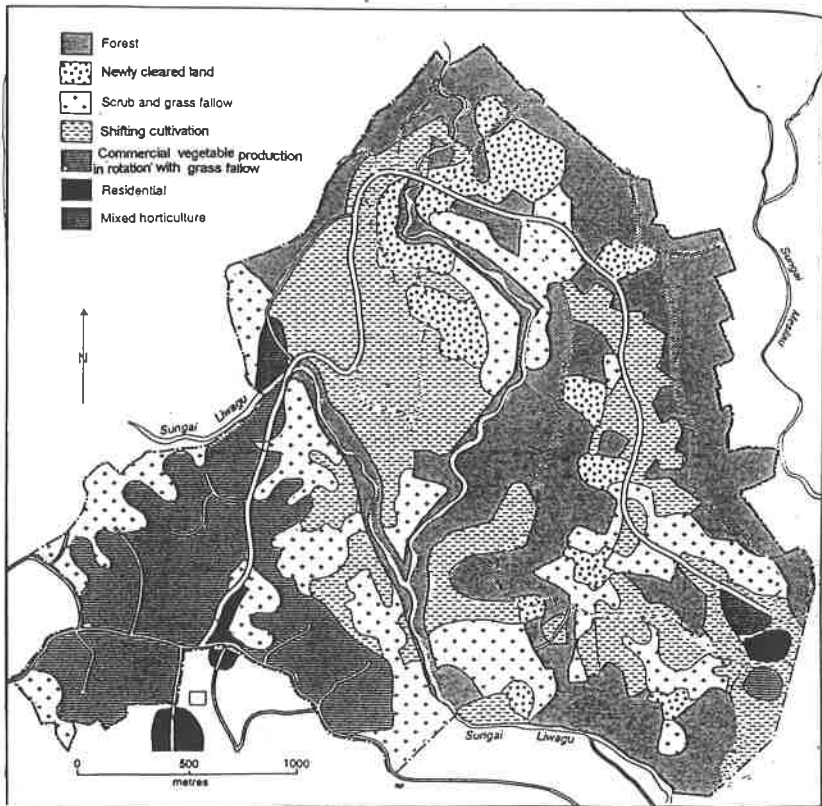
to facilitate marketing of vegetable cash crops. A survey conducted by the land use section of the Agriculture Department in 1970 showed that approximately 100 hectares close to the main road were devoted solely to commercial vegetable production (Fig. 3). The farmers who cultivated vegetables close to the main road also planted subsistence crops on additional plots located farther away from the main road. Other farmers in the study area who did not own land close to the trunk road continued to cultivate both commercial vegetables and subsistence crops on more distant plots (Fig. 3).

Cultivation practices began to change, especially on plots devoted exclusively to commercial vegetables close to the main road. On these plots a more intensive form of land use was adopted whereby commercial vegetables were planted in rotation with short-term grass fallow. Approximately one-third of the area (0.2 to 0.4 hectares per plot) was planted in vegetables for one cropping cycle of about four months while the rest of the land remained under grass flow. The second crop was planted on another one-third of the land, which was previously under grass fallow. During pre-planting land preparations weeds were dug out and burned to destroy rhizomes. The soil was tilled completely and crops were planted in rows to facilitate cultivation. The planted area was kept weed free until the crops matured.

This form of intensive cultivation increased the risks of soil erosion, loss of soil nutrients through leaching, and weed and insect pest infestations. To maintain soil fertility and crop yields, the use of chemical fertiliser and pesticides became a necessity. Dusun farmers had to use larger quantities of chemical fertiliser than they did previously on vegetable crops planted on shifting cultivation plots. Weeds that emerged after planting crops were controlled manually. Insect pests such as caterpillars, diamond-back moth and subterranean cutworm, which emerged as problems for production of cabbages, were controlled by the use of Endrin, Deldrin Malathion and DDT which were supplied by the Agriculture Department (State of Sabah 1963: 25-26).

To reduce soil erosion farmers were required to construct bench terraces on steeper slopes utilising cash grants from the Agriculture Department. However, a majority of the farmers did not construct bench terraces probably because they did not understand the importance of soil conservation. An agronomist based at Sandakan who visited Kundasang in 1966 noted that a large number of farmers cultivated steep slopes, but only a few had built bench terraces. Consequently, soil erosion had begun to emerge as a potential environmental problem (Department of Agriculture, 1966: File PT 18\4\ Volume 1).

Figure 3: Landuse types in the Kundasang study area in 1970



Source: Department of Agriculture, Sabah, 1971. Land use map of 1970

On plots planted in mixed subsistence-cash crops or subsistence crops only, relatively few changes were adopted in terms of cultivation practices and use of technology. On these plots about 0.1 to 0.2 hectares were planted in vegetable cash crops with the rest in subsistence crops (Raja and Gabongan, 1978a: 5-2). When a new plot was cleared the first crop of vegetables and subsistence crops was planted under minimum tillage, the seeds, seedlings and cuttings being transplanted into holes dibbled in the ground.

For the succeeding vegetable crops, the land was tilled completely to loosen the soil and remove weeds before planting. Chemical fertilisers and insecticides provided by the Agriculture Department were used only on vegetable cash crops. Soil erosion was not a problem on most plots, even if small areas under vegetable cash crops were cropped intensively for a period, because of minimum tillage and the presence of roots and stumps in the ground.

Thus, in the period between 1955 and 1970 a transition from a subsistence to cash cropping had started with all farmers adopting vegetable cash crops. However, production of subsistence crops was maintained. The cultivated area increased, resulting in the clearing of forested land. Moreover, a more sedentary system of cultivation in rotation with grass fallow had started on land close to the main road. Soil erosion and leaching of nutrients began to emerge as problems, particularly on plots cultivated more intensively because of changed techniques of cultivation without proper soil conservation measures. Insect and weed pests also became evident. To maintain vegetable cash crop production under a more sedentary system, the use of modern inputs had become necessary.

INTENSIFICATION OF LAND USE: 1971 TO 1982

Land use changes accelerated between 1971 and 1982 as government intensified its efforts to develop commercial agriculture. Specific strategies adopted by the government were the establishment of rural development institutions and improvements in physical infrastructure. The Farmers' Organisation (FO) and *Korporasi Pembangunan Desa* (KPD) were established in Kundasang. These institutions supplied the necessary farm inputs, provided vigorous extension services and trained farmers in the techniques of intensive commercial vegetable cultivation on a more sedentary basis (field interviews, 1990).

In terms of physical infrastructure, feeder roads were constructed and upgraded within the study area. These feeder roads facilitated regular visits by the extension officers and transportation of farm inputs and produce. The opening of the East-West highway in 1976 helped to establish better marketing links between Kundasang and other urban centres in Sabah (Campbell, n.d: 73-79).

As the marketing network expanded, and farm inputs became readily available at subsidised prices and on credit, commercial vegetable farming became highly profitable. This provided the Kundasang farmers incentives to expand vegetable cash crop production. Consequently, rapid transformations in land use took place between 1971 and 1982. The most significant changes were a virtual

cessation of subsistence crop production, an expansion in the area cultivated in commercial vegetables under a more sedentary grass-fallow rotation system and more intensive use of modern technology.

To take advantage of high profits, Dusun farmers began to devote more of their land and labour resources to production of vegetable cash crops. Production of subsistence crops under the shifting cultivation system of farming received less attention and began to decline from 1976 and finally ceased in 1981-1982. With the cessation of subsistence crop production the shifting cultivation system of farming also stopped. All farmers became specialised producers of commercial vegetables and adopted a more intensive form of cultivation in rotation with grass fallow. As a result, the area planted in commercial vegetables under more intensive grass-fallow rotation increased from 100 hectares in 1970 to about 250 hectares in 1982. About one third of this was under cultivation at any one time of the year (field interviews, 1990).

All land under commercial vegetable cultivation became concentrated close to the main road and other feeder roads because of greater access to marketing facilities. Land farther away was fallowed. Figure 4 is a thematic map showing the approximate distribution of land under different uses in 1982. Although the figure may not be accurate in terms of the actual area under cultivation, it does show the overall pattern of the spatial distribution of land under different uses.

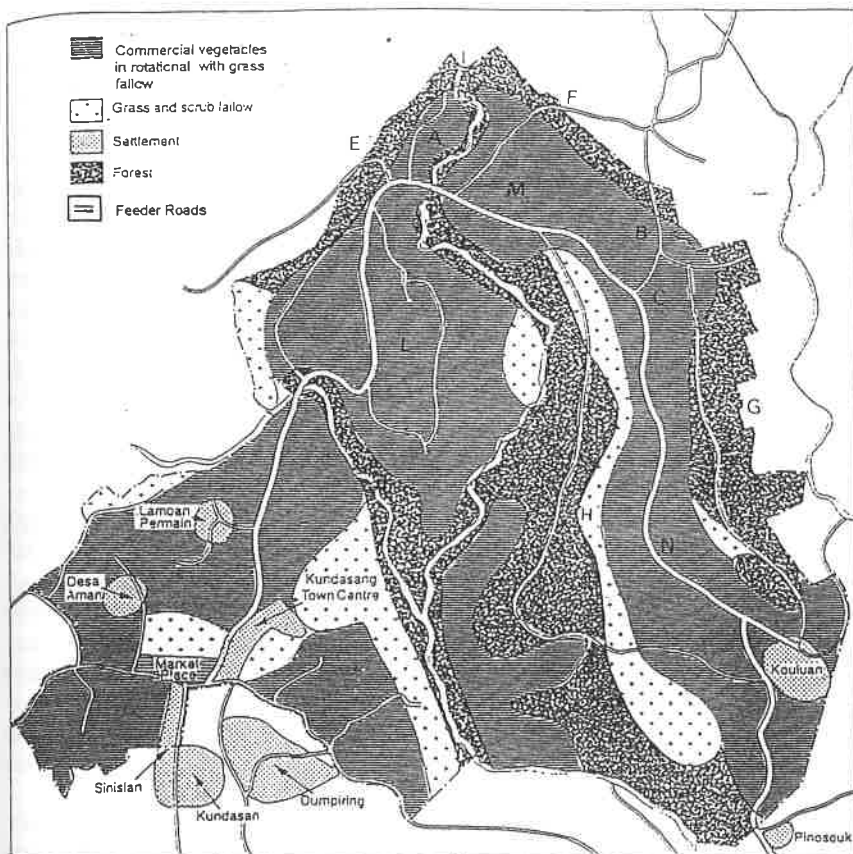
With the expansion of cultivation along the feeder roads in the early 1980s, destruction of forests proceeded at a rapid rate on very steep land (particularly in areas marked A, B, and C on Fig. 4). Moreover, some very steep land, which was previously cultivated under a regime of shifting cultivation, were brought under permanent cultivation (Fig. 4: L, M and N).

The removal of forest cover and cultivation of steep land confronted the farmers with problems of accelerated soil erosion and leaching of nutrients. The adoption of a more intensive form of land use, with vegetable monoculture, led to rapid loss of soil fertility. Weed and insect pests also began to pose more serious problems to crop production than they did in the 1960s. To control soil erosion and maintain soil fertility and crop yields under deteriorating environmental conditions, the FO and KPD emphasised soil conservation and use of larger quantities of chemical fertiliser and pesticides.

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Figure 4: Approximate distribution of land under different forms of uses in 1982 in the Kundasang study area.



Source: i) Field interviews 1990; ii) Field Survey 1990

Most farmers increased the use of chemical fertiliser such as NPK, urea, lime, Hi-Pod Calcium and Wuxal on their land. These fertilisers made up for the depletion of soil nutrients and maintained crop yields. Weed and insect pest control also became increasingly dependent on chemical pesticides. At the start of land preparations tracts under fallow were sprayed with herbicides such as Grammaxone or Lasol. When the grass dried up it was burned. On cropped land, weeds were removed manually, which became a more labour intensive and time consuming task than it had been under shifting cultivation.

To control insect damage farmers continued to use insecticides, as they had used prior to 1970, but the variety of insecticides used had increased with the introduction of Methamidophos, Bacillus Thuringiensis and Phenthoate. The use of insecticides also increased in quantity and frequency. According to estimates of the FO officials and Raja and Gabongan (1978b: 4-6), most farmers doubled the use of the chemical pesticides, with some farmers using the cocktail method of applying indiscriminate mixtures of the chemicals.

To prevent accelerated soil erosion the development institutions advised farmers to use techniques such as bench terraces, contour drains and placing logs across steep slopes. According to FO and KPD only 50 per cent of the farmers made some efforts to control soil erosion (field interviews 1990). The other 50 per cent did not adopt any soil conservation measures. Of these, 10 per cent did not cultivate steep slopes. The other 40 per cent did not see soil erosion as a major problem despite cultivating steep slopes.

Similar observations were made by soil conservation experts from West Malaysia who visited the area in 1980. They noted that soil erosion in the area had become worse with the expansion of commercial vegetable cultivation on steeper lands (Government of Malaysia, 1981a: 1-21). This was because some farmers were not aware of the extent of soil erosion on their land and so did not adopt any conservation measures. As a result, slopes up to 45 degrees were cultivated without any terracing or other soil conservation measures. Also, there was a lack of technical skills among the field staff of various institutions who advised farmers to construct bench terraces on their land. Consequently, most terraces lacked the right amount of inward slope or failed to follow the contour, and therefore did little to prevent soil loss (*ibid*).

INTENSIFICATION AND LAND DEGRADATION: 1983 TO 1990

In 1983 the Sabah State Government introduced irrigation (through the KHVCIP) to facilitate year-round cultivation of commercial vegetables. During the establishment of the irrigation project feeder roads that were constructed earlier were upgraded and new ones were constructed. These improvements provided farmers further opportunities to increase their cash incomes. Following the news about the irrigation project there was an influx of immigrant farmers and farm workers in the study area who came to take advantage of new economic opportunities that became available.

Irrigation water made possible year-round cultivation of vegetables without the risk of crop failures during the dry seasons. This provided farmers opportunities to increase their cash incomes by expanding the area cultivated in

vegetable cash crops using irrigation facilities. The upgrading and construction of feeder roads made nearly all land in the study area easily accessible. The arrival of immigrants increased the number of farmers in the study area and also provided the labour force to farmers to expand the cultivated area and adopt more intensive forms of land use.

These infrastructure and demographic changes led to drastic changes in land use in the following six to seven years. The most important among these were a rapid expansion of the cultivated area and changes in agricultural practices and technology. Within two years of the implementation of the irrigation project, all land within the vicinity of the feeder roads was brought under cultivation, thus increasing the cultivated area considerably. According to the estimates of FO and KPD officials some 350 hectares of land in the study area came under continuous year-round cultivation by 1985-86 (field interviews, 1990). Of these about 65 per cent was cultivated by the Dusun owner-occupiers and the rest by relatives of land owners and non-Dusun tenants. The increased area came from clearing some of the remaining forests (Fig. 4: E, F, G and H) and bringing previously fallowed land into cultivation.

Cultivation practices also underwent considerable transformation. Irrigation had not only eliminated the risk of crop failures during the dry seasons, but also resulted in increased yields from continuously cultivated irrigated land. Given such advantages it was logical for farmers to cultivate the land with irrigation facilities on a year-round basis. Within a short period of time a uniform system of cultivation was adopted throughout the study area whereby all cultivated land was planted with commercial vegetables throughout the year using irrigation water. Under this system land was tilled completely and crops were planted in rows as was the practice on grass-fallow rotation system of cultivation.

The availability of irrigation water also facilitated the introduction and expansion of high value crops such as asparagus, capsicum, broccoli, cauliflower, celery and sweet peas. These crops were generally planted by immigrant farmers, particularly Chinese and Timorese lessees, with more capital and higher levels of technical and managerial skills than those possessed by local Dusun.

The new cultivation practices adopted by the farmers, particularly the use of sprinkler irrigation continuous cultivation of land in vegetable monoculture, complete tillage and planting in rows, accelerated leaching of nutrients and exacerbated the problems of weed and insect pest infestation on all types of cultivated land. Moreover, these cultivation practices worsened the soil erosion problems on land with moderate to steep slopes.

The maintenance of crop yields under a permanent system of cultivation using sprinkler irrigation necessitated considerable technological changes. The use of chemical fertiliser and pesticides intensified and increased by 50 to 100 per cent per unit area of land cultivated after the implementation of the irrigation project. About 90 per cent of the farmers also supplemented the use of chemical fertilisers with large quantities of chicken manure (interviews with FO officials, 1990).

With continuous use over a long period of time, most insect pests seemed to have built resistance to commonly used pesticides. Therefore, a majority of farmers used a cocktail of two or three insecticides. In the mid-1980 farmers reported using a mixture of Methamidophos, *Bacillus Thuringiensis* and Phenthoate to kill insect pests. Observations in 1990 showed that a mixture of atrazine, diuron and malathion was very commonly used by most farmers.

Methods of weed control also became heavily dependent on chemicals. A majority of Dusun farmers and Timorese and Bugis share-croppers generally sprayed weedicides such as Grammoxone, Lasol weedkiller and 'Clean Up 80' to kill weeds at the start of land preparation. Before planting, about 60 per cent of Dusun farmers blanket sprayed the land with Devrinol 2-E (a pre-emergent herbicide). During the growing period, hand weeding was commonly done on vegetable plots. However, to avoid labour expenses involved in hand weeding, some farmers adopted another system of weed control by covering some crops, such as English cabbages and tomatoes with plastic bags or containers and sprayed weedicide around them.

Other lessees were less dependent on weedicide, keeping the cropped land carefully weeded and planted immediately after harvesting, thus allowing no time for weeds to grow. The weeds from cultivated plots were removed manually. Most lessees, especially the Chinese, believed that weedicide hindered the growth of vegetables.

A more sophisticated yield-enhancing technology introduced after 1983 was polythene sheds. These were introduced by a few well-off lessees. Following the implementation of the irrigation project Chinese and Timorese lessees had started planting high value crops. To enhance the production of high value crops the lessees who could afford the costs established polythene sheds on their farms. Polythene sheds protect more sensitive high-value crops such as celery and capsicum from the direct impacts of hot sun and heavy rain during the early growing season. They also help prolong the bearing life of capsicum, tomato and sweet peas, and facilitate intercropping of these crops with short term crops such as Chinese cabbage and lettuce. Plastic sheds also helped reduce soil erosion and leaching of nutrients. In 1990, 24 plots in the study area

had polythene sheds. Of these 17 belonged to Chinese lessees, one to a Timorese lessee and six to Dusun land owners. Of the latter all were built by lessees who had since left.

While all farmers intensified their use of modern technology to enhance crop yields and control pests, soil conservation measures were neglected, particularly by Dusun land owners. Whereas in 1982 about 50 per cent of the land owners maintained bench terraces or other soil conservation measures, field observations in 1990 showed that a majority of Dusun farmers totally neglected conservation measures. About 90 per cent of Dusun farmers cultivated land at least part of which was susceptible to erosion. Of these only 10 per cent maintained bench terraces and contour drains in good repair. These included the relatives of land owners who started cultivating the land more recently. The remaining 80 per cent who cultivated some slopes ranging between 10 and 43 degrees, either had no terraces or had terraces which were in a poor state of repair due to neglect for some years and often had collapsed on sections of the plots.

The main reasons given for this neglect were high costs of construction and maintenance of terraces, the perceived ineffectiveness of the terraces in retaining soil and availability of other land to move on to when one plot became degraded (field interviews, 1990). Dusun farmers claimed that construction of new terraces cost them over RM500 per hectare and maintenance another that construction of new terraces cost them over RM120 per hectare per year. A majority of Dusun farmers felt these expenses were too high, given the falling profits from vegetable farming.

Some farmers reported that they tried to build and maintain terraces after the implementation of the irrigation project but these collapsed repeatedly during irrigation and heavy rainfall. Frustrated with repeated damage, they stopped putting in further efforts to build new terraces or repair old ones. About 30 per cent of the landowners explained that they did not want to waste time and money in trying to conserve soil. Instead they planned to farm the land while it remained productive and then move on to other plots they owned elsewhere, leaving the degraded plot in fallow or leasing or share-cropping it with non-Dusun tenants.

However, all the non-Dusun farmers who cultivated slopes susceptible to erosion made concerted efforts to maintain bench terraces in spite of repeated collapses. They did this because the conditions of tenancy required them to use appropriate cultivation practices including proper soil conservation. Moreover, it was in the tenants' interest to conserve soil as much as they could in order to get the maximum yields from the land during the tenancy. They also had no

guarantee of other land to which they might move if severe erosion did occur.

The neglect of soil conservation by Dusun farmers has had serious long-term degrading effect on land. Most of the steep land cultivated by Dusun farmers suffered massive soil erosion and land degradation. Some land had been rendered unsuitable for cultivation without adoption of expensive and laborious innovations to increase yield and restore fertility. The land that Dusun owner occupiers continued to cultivate within the study area, both on steep and gentler slopes required heavy application of chemical fertiliser and chicken manure and raised their cost of production considerably.

By 1986-87 rising costs of production due to land degradation became major disincentives for Dusun landowners in commercial vegetable farming and maintenance of cultivation within the study area. About 20 per cent of the landowners, most of whose household labour was occupied in off-farm employment or businesses, stopped farming and began to concentrate full-time on non-farm economic activities. The remaining 80 per cent, both with and without off-farm economic activities, continued to farm. However, in order to reduce the cost of production many of these landowners moved outside the study area to land that was considered more fertile than the land they cultivated inside. Although most of the land vacated by these landowners was cultivated by tenants and relatives of landowners, some lay under fallow because of excessive degradation (Fig. 5). Field measurements showed that 290 hectares of land in the study area remained under cultivation in 1990 compared to 350 hectares in 1985-86 period.

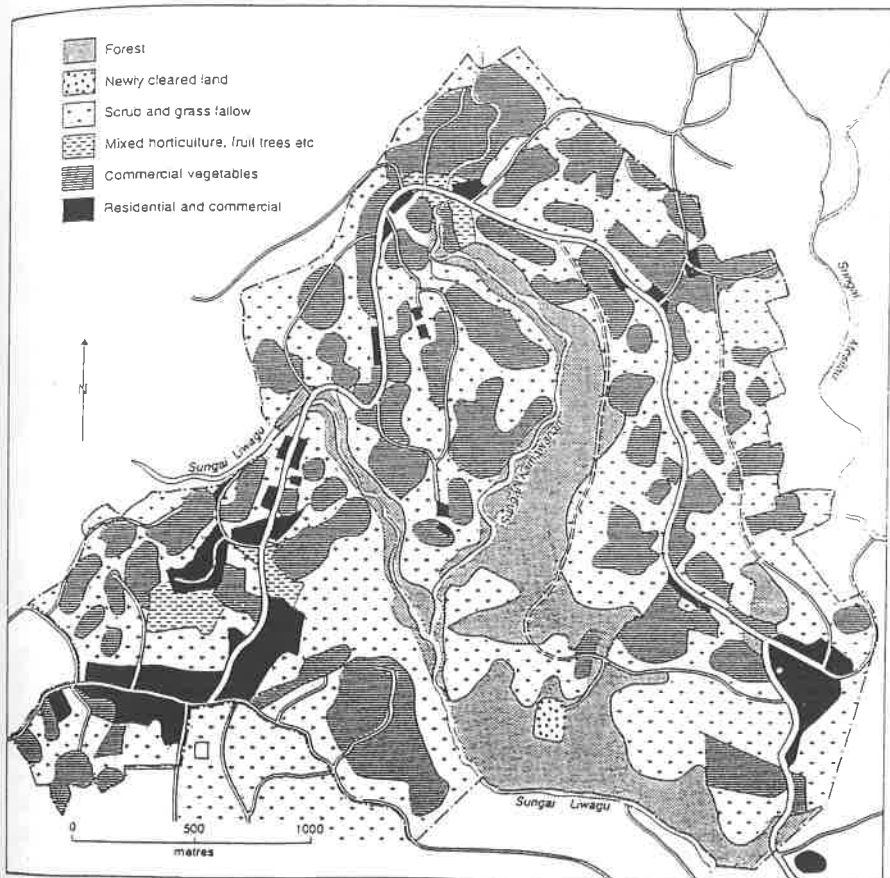
IMPACTS OF LAND USE CHANGES

The changes in land use initiated by the rural development programme have seriously degraded the land. The adoption of new cultivation practices, use of sprinkler irrigation, cultivation on steep slopes and neglect of soil conservation measures led to rapid land degradation through loss of soil nutrients and accelerated soil erosion. Moreover, weed and insect pests became major problems due to monocultural cultivation of vegetables on a sedentary basis. Consequently, the maintenance of crop yields became heavily dependent on the application of large quantities of chemical inputs and chicken manure.

The heavy dependence on chemical inputs has had considerable ecological impacts, principally pollution of soil and water. The farmers used a wide variety of pesticides to control weed and insect pests, some of which (atrazine and diuron) are persistent. The use of irrigation and frequent rain storms during the wet seasons produced ideal conditions for the pesticides to be washed into

ground water reserves, rivers and streams through leaching and surface runoff. The effects of water contamination on human health were not observed because farm households did not utilise water from wells and nearby streams and rivers for domestic use.

Figure 5: Land under different categories of use in the Kundasang study area in 1990



Source: Land use survey conducted with the assistance of land use section of the Department of Agriculture, 1990

However, the impacts of pesticide and fertiliser use on aquatic life were more evident. Pesticide contamination appeared to have destroyed most of the aquatic life that formed an important part of local diet in the past. The older residents reported that eels, fish and prawns, which had been in abundance and formed an important source of protein in local diets in the 1940s and 1950s, were rarely seen in the rivers and streams at the time of study. They blamed the excessive use of poisonous pesticides and chemical fertilisers on nearby fields for this (field interviews, 1990). Field observations showed that most of the streams within the study area were filled with weeds of various kinds. It was clear that the influx of nutrients in runoff was a contributor to greater weed growth in streams.

The spiraling costs of production and land tenure changes were the main socio-economic consequences of land degradation and increasing use of pesticides and fertilisers. To avoid the high costs of production many Dusun land owners moved to land outside the study area where infrastructure was less developed but soil fertility was higher. Some of the degraded lands within the study area abandoned by these farmers were then cultivated by non-Dusun lessees and share-croppers. These tenants used more sustainable cultivation practices such as proper soil conservation measures, a combination of chemical fertiliser and chicken manure to increase soil fertility and both chemical and manual control of pests. By doing this they gradually improved the quality of degraded land within the study area.

CONCLUSION

Rural development in Kundasang has led to increased production but it has also led to accelerated environmental degradation. There has been intensification of production on existing farmland and extension of cultivation on previously uncultivated marginal land. The new cultivation practices resulted in severe land degradation. To maintain production under such environmental conditions farmers were forced to adopt new yield-enhancing inputs and technology such as chemical fertilisers, chicken manure, polythene sheds and sprinkle irrigation. By adopting such inputs and technologies, Kundasang farmers, like farmers in many other areas, have become locked into a system of production based on high-energy and capital-intensive technology. However, unlike other places, many practices adopted under the emerging new system of farming in the study area show signs of a more sustainable and permanent system than the previous practices. Polythene sheds and drip irrigation reduce the risk of soil erosion and leaching while enabling highly intensive forms of land use. The use of chemical fertilisers and chicken manure may lead to recovery of degraded land. This system of farming appears to be the only alternative available to the

NOTES:

- ¹ Hereafter the KHVCIP is referred to as the project area and Kundasang sub-district as Kundasang District.
- ² This portion is referred to as the study area in the paper.

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