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SUFFICIENT HARVEST-YIELDS DESPITE LOW SOIL FERTILITY— The Special Strategy of Nepalese Mountain Farmers

With Comments by

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SUFFICIENT HARVEST-YIELDS DESPITE LOW SOIL FERTILITY – THE SPECIAL STRATEGY OF NEPALESE MOUNTAIN FARMERS

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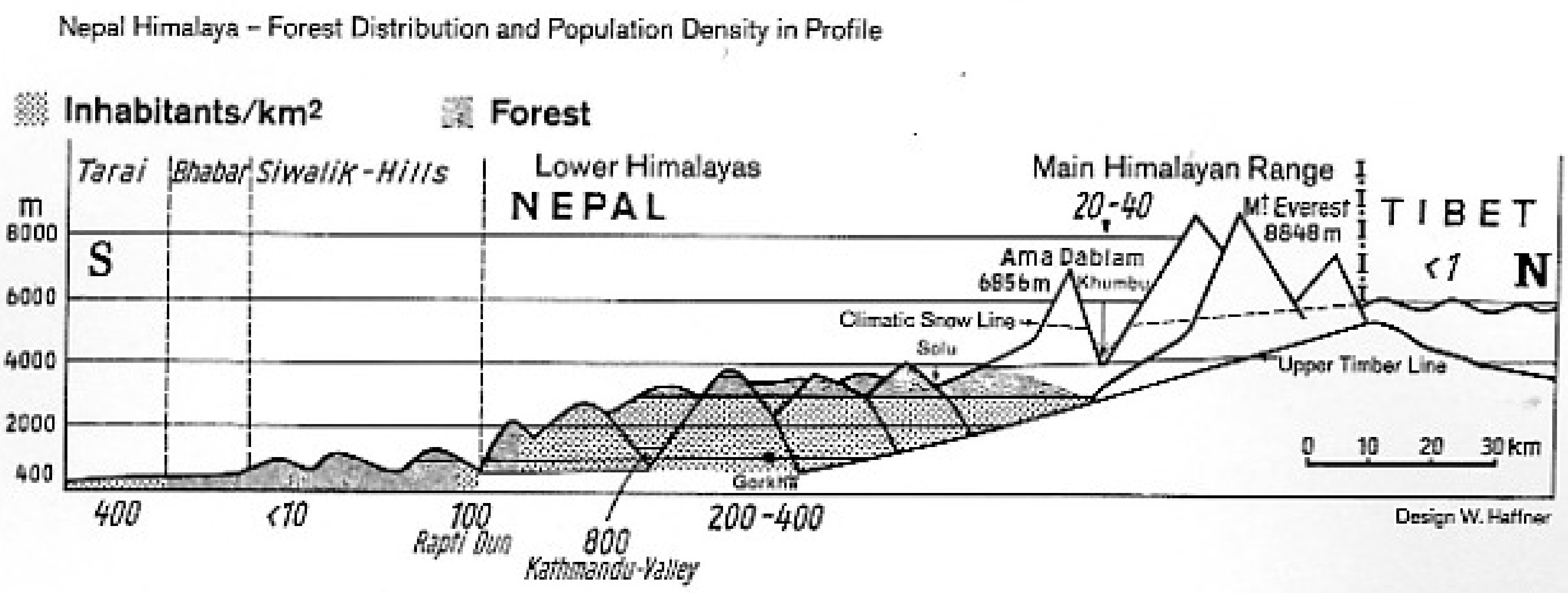
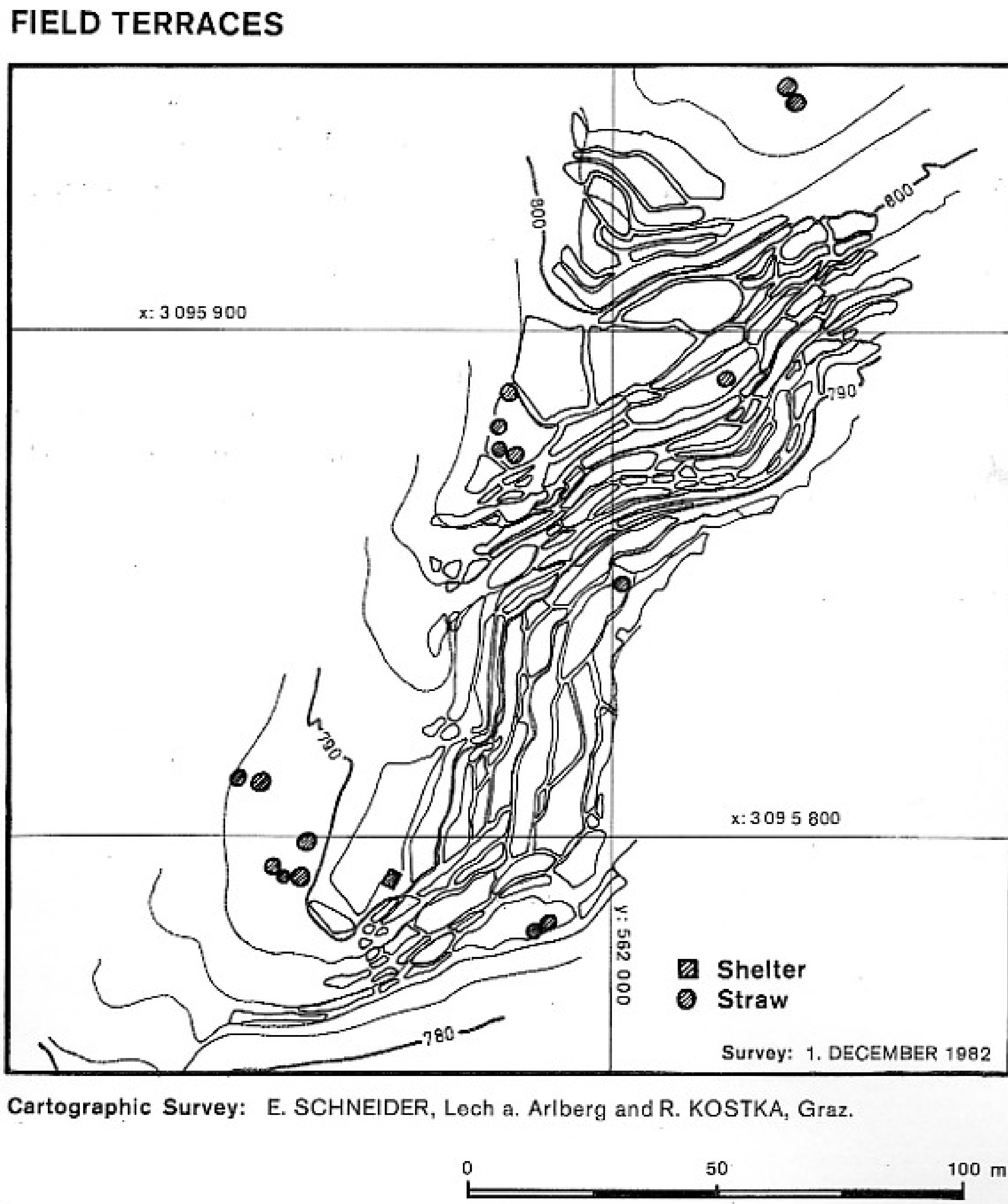
In the Nepalese Himalayas, the difference in elevation between the Gangetic Lowlands (100 m above sea-level) and the main Himalayan range with its 8000 m summits is enormous (Fig. 1). The upper limit for permanent settlements is

Fig. 1: The Nepal-Himalaya in profile.



4000 m, for forests 4200 m, and the climatic snow line is 5700m. All these values, it will be noted, are about twice as high as in the Alps, which is of course due to climatic conditions and the southerly position of ±27°N. The plentiful summer rains and freedom from frost up to a height of ±1500 m characterize the Nepalese Himalayas as a monsoon-tropical high-mountain area. This climatic-ecologically favourable position is reflected, among other things, in the high population density; in the Lower Himalayas it reaches 400 inhabitants per km^2 and — as in other developing nations — is still steadily increasing. However, in mountainous regions, such high population densities are only possible with especially labour-intensive forms of agriculture. The terraced fields of Nepal (Fig. 2), which

Fig. 2: A detailed sketch map of irrigated terraced fields.



stretch several hundred meters upward from the bottoms of valleys up to heights of 1500 m and give the landscape its typical character, are well known and admired throughout the world.

A slope of this kind, characterized by its intensive, terraced agriculture, is the site of the old residence and bazaar city of Gorkhā (cf. land-use map). One of the reasons why we chose the surroundings of Gorkhā for our geographical studies was because there are stone inscriptions preserved not far from the palace of the Gorkhā kings (G. Unbescheid, 1986) which testify to this region's having been settled for at least 1500 years: to put it another way, the mountain farmers of Gorkhā have known for centuries how to live and farm on this mountain slope in an adequately successful way. This is still true today. In support, the current system of land use can be mentioned. One can gauge their success by the following figures which give the agricultural yields per hectare:

Tab. 1: Harvest Yield in Gorkhā and Jelung	
Gorkhā (1000 m above sea level)	
Upland rice	750 kg/ha
Wet rice	2800-6500 kg/ha
Maize	1730-3400 kg/ha
Finger-millet	up to 5000 kg/ha
(Survey: MÜLLER-BÖKER, POHLE)	
Gorkhā-District	
Wet rice	2180 kg/ha
Maize	1520 kg/ha
(HMG, 1983: Agricultural Statistics of Nepal)	
Jelung (2000 m above sea level)	
Amount of seed	Harvest yields 1 pāthi = 4.5 l
1 pāthi barley	7-8 pāthi
1 pāthi wheat	5 pāthi
1 pāthi black potatoes	8-10 pāthi
1 pāthi white potatoes	12-13 pāthi
1 pāthi red potatoes	17-18 pāthi
1 pāthi maize	20 pāthi
1 pāthi finger-millet	30-35 pāthi
(Survey: POHLE)	

Although the agricultural yields mentioned for Gorkhā are indeed considerably lower than in Germany or in the Punjab in India, the yields for crops which are grown in the monsoon period (wet rice, maize, finger millet) are considerable. The same is also true for the area of Jelung (±2000 m above sea level) in eastern Nepal which is settled by Sherpa farmers. Eight to ten times the seed amount for potatoes is harvested there, for maize twenty times the seed amount. The high yields for finger millet (*Eleusine coracana*) are especially surprising. However, these can be understood as soon as one considers the high amounts of compost and natural dung which are typical in the cultivation of millet. Agricultural yields on the order of those listed in Table 1, i.e., yields which could guarantee the self-sufficiency of the population with basic provisions, are therefore unexpectedly high, especially because of the unfavourable relief and soil conditions which are typical of the Lower Himalayas.

Rocks and Soils and their Ecological Value for Agriculture

The parent rocks which are typical of the soil formation in the region of Gorkhā and on the whole for the Lower Himalayas are relatively uniform mica-schists rich in quartz and silicat, fine phyllites and gneisses. These metamorphic rocks are the basic material of the so-called Nuwakot nappes (T. Hagen, 1959), that most important tectonic unit in the Lower Himalayas. The soil formation on acid phyllite and mica-schists as the parent rock material, both of which are rich in quartz, produces acid soils with a high percentage of sand and fine sand and low content of clay, that is, soils which are relatively easy to cultivate but have the disadvantage of a low soil fertility (Tab. 2) (W. Haffner, 1986).

On the rocky silicate outcrops in the Gorkhā region, two main types of soil can be found: lateritic red clays (ferric luvisols) and brown soils low in alkali (dystric cambisols) (cf. soil map).

The red clays are relics of earlier soil formation in a warmer climate, possibly before the rising of the Himalayan mountains. The distribution of these soils on old, ridge-like land surfaces also seems to confirm this. The uniform elevation of these denudated surfaces in the region of Gorkhā is noteworthy. In all the places where the relics of red clay have been eroded and worn away (i.e. in areas of sloping valleys interspersed with ridges), brown soils (dystric cambisols) low in alkali and, as a proto-stage, ranker, have developed under the recent conditions of a monsoonal mountain climate. Ranker of extremely varied thickness shows a relatively wide distribution (cf. soil map) on recent to subrecent rock fall or slide material. Above all, in forest land, for example in Rāniban, the humus horizon is clearly developed and well preserved. Deforestation and the resulting erosion,

Tab. 2: Selected Soil Data from Gorkhā

	cm	pH	clay	org.C	humus	mg P_2O_5	mg K_2O	C:N
			in %			in 100g soil		
Ferric Luvisol (bāri eroded)	0-10 10-30	3.9 3.9	39.5 42.8	0.8 0.5	1.4 0.9	5.9 8.1	1.0 0.8	11.4 8.3
Rice Gleysol (khet)	0-20 30 65	4.6 5.5 5.5	7.9 9.6 17.4	0.9 0.4 0.5	1.6 0.7 0.9	4.9 2.7 4.3	2.3 1.8 2.0	15.0 10.0 12.5
Dystric Cambiosol (forest)	0-7 10-20 100 >200	5.4 5.2 4.9 4.8	19.1 11.5 36.8 35.2	7.0 3.2 1.1 1.7	12.0 5.5 1.8 2.9	8.1 2.7 8.1 2.7	10.3 5.3 1.8 5.0	17.1 11.4 14.1 14.2
Dystric Cambiosol (bāri)	0-20	4.2	17.9	1.1	1.9	2.7	1.3	11.0

through centuries of terraced cultivation, but especially through the cultivation of wet rice, has changed and transformed the natural top-soil to a large extent. Therefore, it was not possible to find undisturbed, fully-developed soil profiles in the region of Gorkhā. Even forest soils are either young ranker (i.e. Rāniban, Kāliban) or disturbed top-soils. There is a long historical tradition of carefully working the soil through, which led to successful retention of soil within the scope of terraced agriculture, and which fully justifies speaking of perfect soil management. The decisive factors in present-day soil thickness, as well as in the physical and chemical characteristics of these anthropomorphic soils, are the form and intensity of agricultural usage. Although forest soils show the highest observed humus content (up to 12%), the larger uninterrupted areas of forest are in fact all located on coarse block fields of relatively recent landslide debris, which means soil formation has not yet developed to a very advanced stage. The fact that this layer of stony soil (rankers on rockfall debris) is so thin explains why these tracts of forest have been preserved and did not become part of the cultivated and terraced slopes long ago. Although severe weathering of the parent substratum occurs in this rainy, monsoon-tropical climate, many of the nutrients are washed away and the organic matter rapidly decomposes, especially when the land is being farmed (see Tab. 2). An X-ray-graph determination of clay minerals[1] did show illite and alluminium chloride (along with kaolinite) as the main components in three profiles of the soil. The high acidity of the soil, however, causes a limited availability of plant nutrients. Finally, the low cation-exchange capacity, which would be expected with low clay and humus content of soils, is the reason for the limited fertility potential of the soil in the region under investigation (cf. Tab. 3).

Tab. 3: The Effect of the Humid Monsoon-Tropical Climate and of Acid Phyllite and Mica-Schist on Soil Formation

Humid Monsoon-Tropical Climate

+

Phyllite and Mica-Schist

↓

(1)	Weathering several metres deep (favourable for the construction of terraces)
(2)	Low content of clay of the soil (±20%)
(3)	Low content of humus especially on arable land (±20%)
(4)	Low pH value: pH 3.8 — 4 Wet rice cultivation: pH 4.6 — 5.5
(5)	Low cation-exchange capacity (s-value between 5.4 — 6.2)
(6)	Reduced availability of nutrients

↓

Reduced ecological potential of the soils

If, in spite of this, the Lower Himalayas of Nepal give the impression of an abundant, green farming area — which is so striking a feature of the landscape

[1] For the X-ray determination of the clay minerals I would like to thank Dr. H. Tributh (Institute for the Science of Soils of the JLU), for the determination of the soil-chemical data Mr Adam Lapp (Geographical Institute of the JLU).

especially during the monsoon; if adequate yields for self-sufficiency of a slowly but steadily increasing mountain population have been guaranteed for centuries, one reason for that is that the population is very knowledgeable about using its natural environment successfully: Nepalese mountain farmers have developed and handed down special forms of agrarian technology which mitigate the unfavourable ecological factors, if not entirely, then at least to a considerable extent:

1) A stabilization of soil fertility is achieved through crop rotation and through intermittent periods of leaving the land fallow (cf. P. Pohle, 1986).

2) Attempts are made to counteract the depletion of nutrients in the soil through application of natural manure. As the fodder is to a considerable extent composed of slopping fodder, a continual transfer of organic matter from forest and fallow lands to the fields takes place via the manure. The cultivation of trees for use as fodder has a similar effect (cf. Fig. 3). Only the rice fields are not generally manured.

3) The farmers try to compensate for the low humus content of the soil (especially where no animal dung is spread) by raking the plants which have grown during the previous rainy season down from the terrace walls. The organic matter obtained in this way is then worked into the soil with a plough.

4) In addition, the annual carving-out of the terraces, i.e. the gradual diminution of the mountain side, has the effect of steadily feeding fresh mineral matter from the crumbling, decaying rock back into the soil. This process counteracts washing-out. Finally, the channelling of irrigation water also has the effect of compensating for nutrient depletion.

Only because of these measures which compensate for nutrient depletion has it been possible to keep the yields in irrigated agriculture sufficiently stable for centuries, even without regular organic fertilization.

5) Artificial irrigation is a further important means of increasing the ecological potential of naturally poor soils. The highest pH (KCl) readings were recorded in soil samples taken from areas where wet rice was grown. Although pH readings of between 4.1 and 5.5 are still definitely within the acid range, an increasing amount of nutrients vital for plant growth (nitrogen, phosphates, potassium) and important trace elements can be found in those types of soil where pH readings are distinctly higher than 4. In the case of paddy gleys, the pH values evidently increase during the flooding of the fields, which takes place in the summer months. For soil types which are naturally high in acid content, the importance of such a process cannot be overemphasized.

Fig. 3: Ecologically adapted land use during the agricultural year.

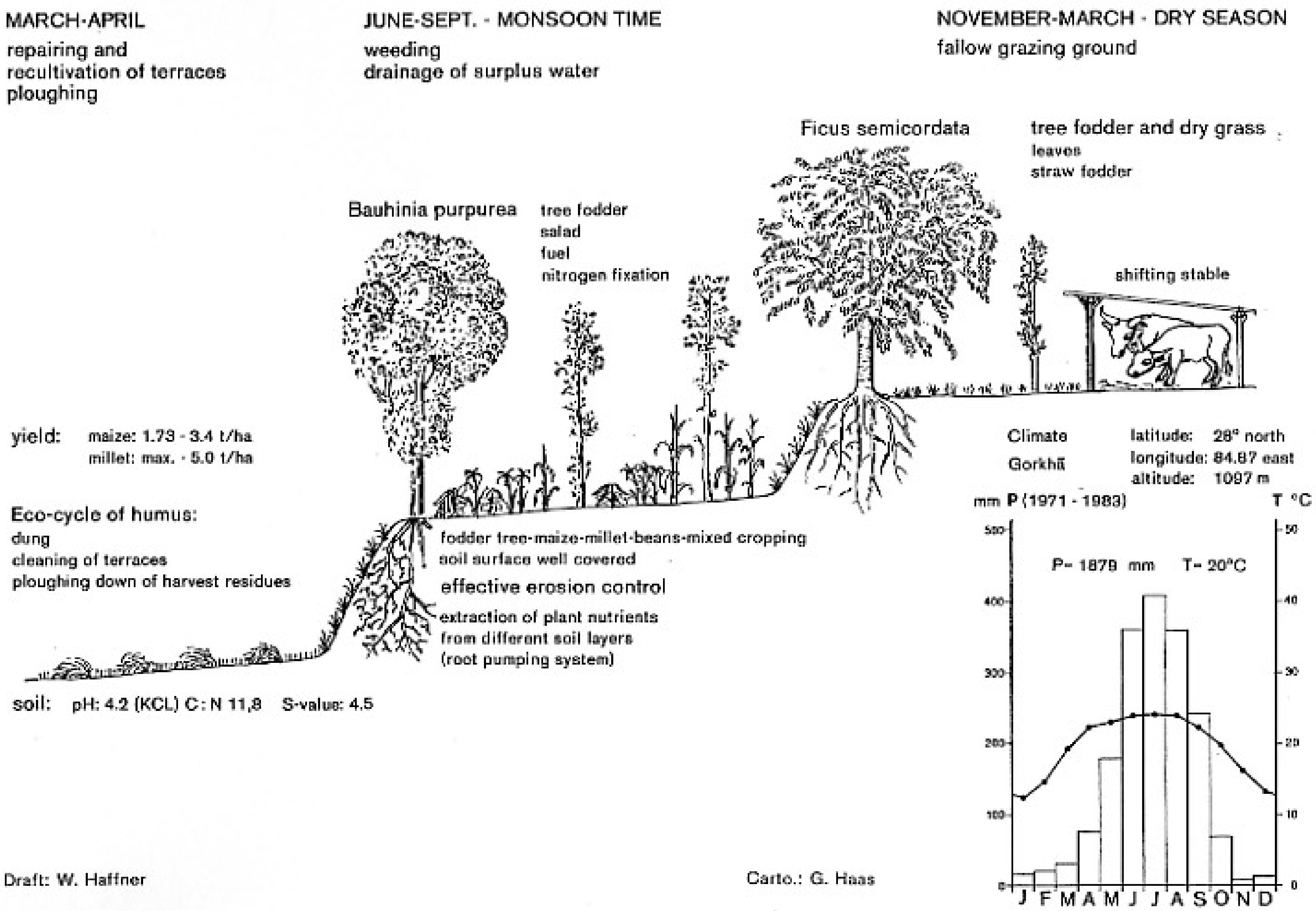


Figure 3 again shows, in the form of the seasonal cycle, the perfect type of land-use in Gorkhā. Both the leaves from fodder trees and the constant transportation of organic substance (straw, leaves, wild hay) from the forests onto the intensively used, terraced dry fields (bāri) play a key role within the framework of the regulated humus-farming which is common for this region as well as in the attentive care of the soil. Fodder trees (i.e. *Bauhinia variegata* and *B. purpurea*) provide foliage fodder; their stronger branches provide firewood; their blossoms are used for salads; in addition, the Bauhinia species, as leguminous trees, serve as collectors of nitrogen. Fodder trees with their deep-reaching root system are also important as protection against erosion. There is good reason to believe that, in a combined agriculture of deep-rooting trees and shallow-rooting annual plants (for example maize), soil horizons of different depths can be brought into the circulation of nutrients. Trees in this system are used to "pump" nutrients and water out of deeper soil layers (root-pumping system) and, via defoliation, supply the top-soil layers with organic substance which, when mineralized, serves as nutrient for annual plants.

The climatic diagram included in the outline is meant to point out the tropical-monsoonal climate during the growing season. The low soil-fertility in agro-ecological systems of the Nepalese Himalayas is apparently at least partially balanced by the especially favourable monsoonal climate. This is demonstrated by the climatic diagram included in the outline, and there are the following supplementary observations to be added: With the beginning of the moist-warm monsoonal vegetation period a "growth spurt" occurs which never fails to amaze the European. After just a few days the land becomes green; freshly sown fields are covered by vegetation in a short time. Even ligneous, stick-like "cuttings" which are often planted on the sides of paths — examples of the *Ficus* species, of the *Poinsettia* (*Euphorbia*) and others which can reach a length of one and a half metres — shoot out in next to no time and — something that is unthinkable under European climatic conditions — even the wooden posts planted by Swiss development helpers as pasture-fences begin to bud and sprout leaves.

Traditional agricultural techniques and traditional systems of cultivation and pasture-farming are undoubtedly adapted to the natural potential in the densely settled Nepalese area. One should not, however, confuse adaptability with environmental and ecological stability or, even worse, with an ecological balance between the natural potential of the environment and the demands made upon it by the people who settle and farm the land there. Slow but relentless forest and soil degradation have proved unavoidable and are by no means a modern development, even in old, cultivated landscapes. The continual transfer of organic matter from forest and scrub areas, from roadsides and patches of wasteland to the sloping terraces used for upland farming has inevitably led to the gradual degradation of both trees and soil.

Even wet rice cultivation, which is generally regarded as being a most suitable form of ecological farming, has always been responsible for erosion damage. Heavy monsoon rain or even the smallest weak spot in the canalization of water, especially in drains, have repeatedly entailed sudden landslides in the larger terraced complexes. As a result, continual repair and perfect recultivation of the areas damaged by landslides are two of the traditional technical skills mastered by Nepalese mountain farmers.

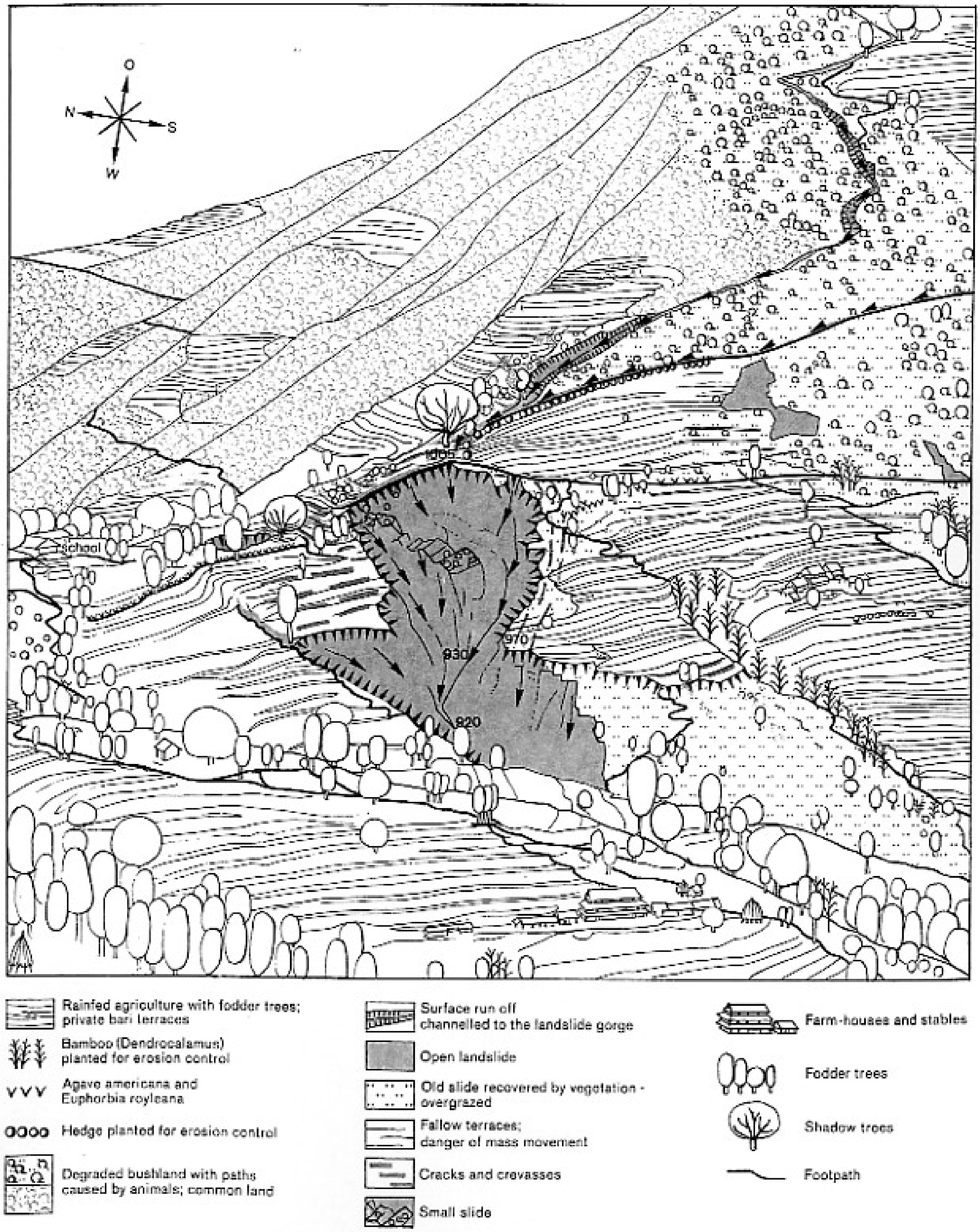
The agricultural landscape of the Lower Himalayas today is therefore characterized not only by carefully tended terrace complexes which are interspersed with fodder trees but also by degraded, overused forest areas and erosion phenomena which can assume catastrophic proportions. A good example is the upper Ludi Kholā basin not far from Gorkhā (Fig. 4).

As the sketch shows, the farmers living on the upper part of this mountain brook perfectly master the art of terracing even in steep inclines; the fields, which are interspersed with fodder trees, give the impression of an intact, ecologically stable environment. However, on the upper slope the continual overuse of the forests has led to the typical gradual degradation of forest and soil. In the last few decades the branches of the upper Ludi Kholā have widened to the point where they now resemble ravines, terraced field complexes are in danger of sliding away, and houses, even the school, are endangered by the possibility of a landslide. After torrential monsoon rains the heavy regressive river erosion in deeply weathered bedrocks and thick colluvial slope sediments (albeit a natural phenomenon) also accelerated the formation of a valley; moreover the slope was increasingly destabilized through the diversion of the excess surface water from a neighbouring village uphill into the erosion ravine of the Ludi Kholā.

As can be expected, there are serious conflicts between the population of the immediate, endangered vicinity of the erosion-ravine and the inhabitants of the village above.

To sum up: A highly developed art of changing the relief through terracing, the careful tending of the soil, an ingenious form of humus-farming: all these laborious techniques and strategies have until now enabled Nepalese mountain farmers to balance the disadvantages of the relief and the handicap of soils low in nutrients — at least to some extent. Therefore, an adequate self-sufficiency of

Fig. 4: Nepalese agro-cultural landscape along the upper Ludi Kholā. Typical the contrast between carefully tended terrace complexes with fodder trees, overused forest areas and erosion phenomena.



Draft: W. Haffner

Carto.: G. Haas

the mountain population was assured over the centuries. But by now there is another question to be faced: Which strategy should be followed, what should be done in the future if the present population growth-rate continues. It will lead to a doubling of the population in 25 to 30 years. Have the boundaries of the carrying capacity not long been crossed, has the land not reached the limits of growth?

One could draw up a long list of possible solutions for this basic theme; it is not only typical for Nepal but assumes general validity for poorer developing nations:

- The reduction of the population growth through birth control and family planning. In traditional agrarian societies this is a very doubtful attempt, at best, it will be a long-term success.
- Seasonal or permanent migration to the Nepalese Lowlands or abroad. Even in the last century there were colonies of Nepalese immigrants in Burma, Sikkim, and India. The Terai, the Himalayan forelands of Nepal, has become a desirable settlement area of Nepalese mountain farmers since the eradication of malaria in the sixties. Even the seasonal migration of labourers and the hiring of men as "Gorkhas" in the Nepalese or Indian Army has a long tradition. Nevertheless, the mountain population continues to grow.
- Agro-economically, an increase in productivity through the introduction of improved agricultural technologies is conceivable: that is, mineral fertilizer, improved seed, etc., as much as possible combined with irrigation and humus farming.
- Another recommended measure is the change from a policy of self-sufficiency to a market economy, for example from the cultivation of grains to vegetables. It has enjoyed a certain success in the mountain valleys which are accessible by road (cf. land-use map).

There is a final point which has to be raised. From a strict economic point of view, suggestions which could increase the productivity of farming in the Nepal Himalayas are open to a fundamental objection. Experienced agricultural economists of international organizations (cf. Report of the Special Programming Mission to Nepal of IFAD 1989) deny any benefit of agricultural investments in the mountainous regions of Nepal especially because of the very limited natural resources, the size of the farms, which are often too small (U. Müller[-Böker], 1986), the deficiency or lack of accessibility to roads and other infrastructural disadvantages. But is it really appropriate to judge concepts and suggestions for developmental planning of the mountain regions of Nepal only according to economic criteria?

In Nepal itself, completely different planning concepts are being put forward. These have their roots in the self-perception of the Nepalese as a mountain people who consider the mountainous areas the traditional political and cultural centre of their country. Thus, it is not economic profitability and feasibility which play such a central role in Nepalese development planning. Rather, the aim is to maintain the cultural identity of the Nepalese farmers and also the typical Nepalese agrarian and cultural landscapes which they have taken centuries to create and which they have so admirably adapted to the environment. Parallels to the alpine farmer's uncertainties and problems are obvious. Despite the decreasing profitability of alpine mountain farming, the traditional life-style so well adapted to the environment, should be retained as much as possible in the Alps. The development programmes for mountain farmers in Germany or Austria pursue this goal, as does the so-called "Winter Help" which reaches back into the last century in Switzerland, all of which in effect are something like "developmental aid". It therefore seems appropriate to consider similar programmes of assistance or aid for the Nepalese mountain people and their economy. Industrial countries will definitely have to sponsor and to subsidize the basically unprofitable rural economies in the Nepalese Himalayas if they want people to stay there and if they want the Nepalese specialists of high-mountain agriculture to survive economically by continuing to farm "sufficient harvest-yields in spite of low soil fertility" and other on-site disadvantages so typical of the Nepalese Himalayas.

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Comment on Haffner's Contribution

Harka Gurung

We are familiar with Dr Haffner's earlier studies on the ecology of parts of Nepal. The area studies by Dr Haffner and his colleagues from Giessen are well-designed to represent different geographical areas in Central Nepal. The case study of Gorkhā represents an area with a comparatively long history of human settlement. Another reason for the choice of the site was the availability of large-scale maps for the area.

The enquiry into the use of resources yields two basic conclusions. The first is the poor quality of the soil in terms of agricultural productivity. The second conclusion relates to the farming methods which are highly adapted to the local ecological system.

Other relevant observations in the paper include susceptibility of the land to landslides even in forested areas and the need for the constant repair of the fields. These points deserve some further explanation. Generally, soil erosion and landslides are attributed to a lack of vegetation cover or deforestation. Although vegetation cover does minimize the impact of rainfall on the removal of soil, the slope factor is a still more important cause of erosion. In areas of high relief such as the Nepalese hills, soil erosion as an expression of mass wasting takes place whether there is vegetation cover or not. As to the need the for the continual repairing of the fields as the basic feature of traditional farming, there could be no better expression of the dynamic nature of the landscape. Indeed such labour is the basis of survival and sustainability of the hill-farming system.

The traditional farming system has evolved through generations of trial and error. This holds good for the Gorkhā region just as for any other. However, the area has had a road connection since 1981. Assessing the impact of the road on farm technology would be a pertinent question. I am raising it in the context of the long experience of the Khairenitar Agriculture Extension Programme served by Prithvi Rajmarg in which the Federal Republic of Germany has been involved. Has the road to Gorkhā affected or facilitated innovations in farming technology, such as the use of chemical fertilizers and improved varieties of seeds? Or is the poverty so pervasive as to preclude these outside interventions and thus perpetuate the old practices with increasing stress on local resources and the natural environment? [...]