ECOLOGICAL-ECONOMIC CONSIDERATIONS IN RESOURCE USE IMPACT ASSESSMENT AND MANAGEMENT AT THE LOCAL LEVEL

A CASE STUDY OF NAKKHU KHOLA WATERSHED, MIDDLE MOUNTAINS, NEPAL

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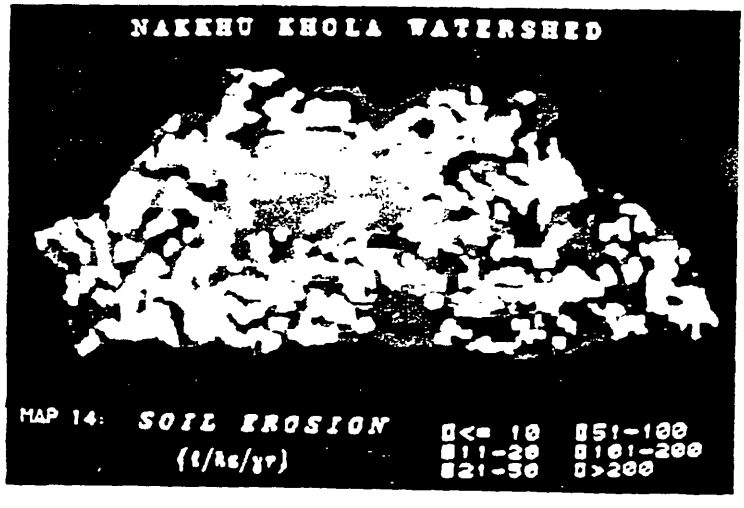

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Abstract

Integration of ecology and economics has increasingly been a major concern towards environmental assessment and management of natural resources for a sustainable future. This paper attempts to adopt the concept of institutional economists on integration of ecology and economics by presenting a case study of Nakkhu watershed in the Middle Mountains of Nepal. The impacts of change in resource use patterns on the physical environments (e.g. change in surface runoff, soil erosion rates) are estimated with application of empirical models using Geographical Information System techniques. Local peoples' perceptions on the changing environment and the effectiveness of government conservation policy and management actions are presented. A cause and effect loop diagram is developed, to determine whether the cause is ecological or economic in nature. Inappropriate government policies and programs lacking a clear definition of property rights and enforcement of the formulated policies, rather than the ignorance of the local people, were found to be the major causes of resource degradation. Carrying capacity of the watershed is estimated, policy challenges are presented and resource management actions are outlined. The carrying capacity analysis indicated a relative and absolute scarcity of the natural resources. The scale of the problem identified is very large in comparison to the government's present management efforts. Therefore, a farmer-based solution with the involvement of the local communities and the required administrative and legal processes to share the power and resources with them are suggested.

Environmental Problems : Nature and General Concerns

The depletion of natural resources and its impact on the overall environment has been a growing concern in Nepal. Nepal's natural resources - land, water, and forests have made significant contribution to the economic growth of the country. Though the massive exploitation of these resources have helped in temporary gains in GDP in the past, the continuing degradation of the resources has a major on both the functioning of the ecosystem and the development process as a whole. An equally important effect has also occured on the socio-cultural integrity as well as on legal and political environments. As the rate of exploitation has been in a scale greater than the regenerative capacity of the natural resources, the impact on the overall economy can be expected to be more severe in the years to come. Because the natural succession period is very long and natural shocks can often take place, such impacts can be more severe in the short run. It further emphasizes that the socio-economic development process requires a compromise between economic developmental activities and ecological constraints. The major concerns thus lie on i) the depletion and degradation of natural resources and preventing them from further degradation, ii) improvement of the local environmental conditions, iii) improvement of the economic conditions of the people, and iv) the building of the local capability in managing the resources.

Sustainable development at the local level means that planned economic activities do not

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result in over exploitation of natural resources e.g; forests, shrubs, grazing fields and soils and livestock and human population and that the related human activities are within the defined level of the carrying capacity of the ecosystems. In adopting ecological-economic integration for natural resources planning at the local level one of the most important question is thus to estimate how close we are in reaching the ultimate limits in exploiting our natural environment and how long we can continue without seriously endangering the reproductive capacity of the resources. The assessment of the state of resources and environmental conditions and the carrying out the decisions accordingly are the most important tasks at the local level.

This paper attempts to present a ecological-economic framework for environmental assessment and management at the local level. The paper is divided into four main parts: the ecological-environmental characteristics are discussed; the changing environmental conditions and processes of producing environmental degradation are presented; resource use limits are identified with the estimation of physical carrying capacity of the watershed and property right issues and the role of government and private sectors are dealt to develop a basis for the sustainable use and management of the resources at the local level.

The Approach

Considerations of both ecological and economic aspects requires a multi-stage approach i.e; i) identification of the changing environmental conditions, ii) examination of the socio-economic and political causes of resource degradation to identify the policy challenges; iv) carrying capacity estimation to identify the limits for economic use of the resources and v) a holistic analysis to develop the appropriate mechanism for management of the resources at the local level. Methodological approaches devised to measure the impact of environmental degradation have been debate for years. Traditional cost-benefit analysis (CBA) which still dominates as a major tool in making the investment decisions has been revised to measure and include the costs/benefits of environmental degradation. CBA is based upon the idea that there exist "correct" social values or prices for each impact and that such prices can be used in a summation procedure (Soderbaum; 1987). CBA is also mainly designed to determine the project feasibility rather than to identify the resource use impacts and limits. As the neoclassical approach based on cost-benefit analysis is severely attacked for its shortcomings for including all the environmental costs and benefits (Broomely, 1985; Swaney, 1987, Soderbaum, 1990), the concept of positional analysis based on the view of institutional economists has been partially adopted in this study. This study does not attempt to quantify the effects on monetary terms.

This study has used the field survey method for questionnaire administration, crop and forest resources survey, soil tests and ground feature identification for aerial photograph interpretations. The aerial photographs for two different time periods (1954 and 1986) were interpreted and land use maps of three time periods (1954, 1978 and 1986); soil, vegetation, geological, stream network and cropping systems maps were prepared and digitized. The soil erosion rates and surface runoff at different time periods were estimated using empirical models with application of GIS (ARC/INFO) program. Likewise, change in land use patterns, ecosystem susceptibility to landslide hazards and physical carrying capacity were analyzed with help of the GIS.

Environmental Conditions in the Mountain Watersheds

Mountain regions in Nepal occupy a prominent place in the geographical and economic setting of the country. They account for 68% of the total area and serve as a homelands for 60% of the total population. Natural resources provided by the mountain watershed ecosystems are the main sources of livelihood of the majority of the rural population. More than 90% of the population living in these watersheds are dependent on primary resources.

Many factors combined influence the physical environmental conditions in the mountains e.g. physiography, geology, vegetation, soil, climate, and the degree and nature of human interventions. The overall environmental conditions of the middle mountains based on the watershed classification (Nelson et.al, 1983) are categorized into five classes: excellent, good, fair, poor and very poor. In the middle mountain zone, 14% of the watersheds are ranked as excellent, 65% good, 15% and 6% poor. The overall condition of a watershed is indicated by the intricate, extensive terrace system (beneficial) and by a large number of landslide scars, eroded soil areas, and loss of forest land (detrimental).

Case Study: Nakkhu Khola Watershed

An Overview of Ecological-Economic Characteristics

The watershed is located in the middle mountains on the southern part of Kathmandu valley. It constitutes a small part of the Bagmati watershed. and comprises the catchment areas of Nallu and Lele Khola which are the main tributaries of Nakkhu Khola. The area above the point where the two branches meet is 42.20 sq.km. This upper watershed area is divided into three village units namely; Bhardeo, Nallu, and Lele. The area is accessible by fair weather road and can be reached within one and half hours drive from Kathmandu.

Physical Features and Climate : The elevation of the watershed varies from 1417 m to 2378 m. Slopes rise more than 75%. The area is situated in the warm temperate zone with humid moisture regime and the elevated area are characterized by a cool temperate pre-humid climatic conditions. The monthly mean temperature varies from (-)2.2^{0}C in the winter to 34^{0}C in the summer. The average annual rainfall is 1925mm.

Geology and Soil Characteristics : The rock formation of the Nakkhu watershed area consists of quartenary fluvio-lacustrine sediments, limestone, argillaceous formation and Tistung meta-sandstone formation (GEOCE, 1990 after Stocklin and Bhattarai, 1977). The soil type in the area varies from silty loam to sandy loam. The lower plain of the Lele valley has sandy loam and the rest of the study area have silty loam with varying percentage of silt, sand and clay. The pH value range from 4.4 to 5.3 (Field Test, July,1990).

Vegetation Characteristics and Species Diversity : The main dominant species found in the area are ; *Chir pine,* hardwood species like; *Gurans Rhododendron, Angeri Lynolia species, Ghangaru Prykantha* and other fodder trees like; *Chuletro Brassaiopsis hainla, Gogan Saurauria*

napaulensis, Anjir Ficus nemoralis etc. (Pandey, 1990). There is significant decline in original species and original species are replaced by *Chir pine.* In government protected forest areas efforts are being made for afforestation with *Chir pine* plantation than to reestablish original species. However, protection of these forests have helped to the regeneration of original species in about 100 ha of land at the upper catchment of Nallu Khola. In Lele village unit nos. 4 and 5, farmers are managing a small forest area as the only one example of the community managed forest in the area.

Hydrology : The observed run-off in the stream varies as low as to cubic meter per sec. The sedimentation load estimated in the Nakkhu Khola measured at Tikabhairab range from 280 to 484 t/sq.km. based on mean annual flow (GEOCE, 1990).

Land use, Cropping patterns and Cropping Intensity : The land use category in the watershed area considered are; forests (24%), shrubs (32%), cultivated land (28%) and the rest grazing and others (16%). The net cultivated area in the three village units is estimated to 876.60 ha (21%), New Era 1986). The climate being constraint in the upper slopes, farmers in the upper slopes grow maize mixed with potato. In the middle slopes, farmers produce two crops maize followed by mustard or wheat. In the valley bottoms rice is followed by wheat cultivation in winter. The cropping intensity varies from 100 % in upper slopes to 200 % in the valleys.

Population and Land holding Size : The total population of the area is estimated to 10,886 with a population density of 259 persons per sq.km.(New Era, 1986). The average family size is 5.6 persons per household. The area originally was inhabited by Tamangs in Bhardeo and in Nallu. But in Lele area the dominant group is Chhetri. The average land holding size is 0.7ha.

Living Standard and Income Generation Pattern : Majority of people in the area were found living below subsistence level. About 60% of the total household face food deficiency for more than 6 months and by 29% for 3 to 6 months. Only 11% of the total population enjoy food balance from their farm. The average annual off-farm income is estimated to 160$ (1990 price). The sources of off-farm income generation are livestock, charcoal making and labor and official employment in Kathmandu valley.

Changing Environmental Conditions

Change in Surface Runoff conditions : Figure below presents the summary of results of the surface runoff estimation by using SCS Curve Number Model. The change in total runoff volume from 1954 to 1986 by 18mm. Comparison of the distribution of CN values also indicate that the percentage of the area with high runoff potential has increased in 1986 compared to the 1954. It can be concluded that the change in land use pattern, especially the change in forest and shrub cover density has resulted in the increase of surface runoff in the area.

Soil Erosion Rates : The estimation of soil erosion rates were performed using Universal Soil Loss Equation. The estimated average potential soil erosion rates in the Nakkhu watershed vary from 5.56 t ha/yr in forest areas to as high as 173.11 t/ha/yr for the grazing fields. The

Table : Results of Estimation of Surface Runoff

Variables	1954	1978	1986
Rainfall (mm)	2084.0	2210.0	1809.0
CN (Normal)	44.9	50.8	54.0
CN (Dry)	25.5	30.3	32.8
CN (Wet)	65.2	70.4	72.4
Estimated Runoff (m^3/sec/yr)	537.0	586.3	624.7
Rainfall Loss(mm)	983.2	753.4	627.2

Table : Estimated Soil Erosion by Land Use /Land Types (t/ha/yr)

Land Use Types	Average rate	Area (Ha)	Top Soil Loss(mm)
Forest	5.6	1019	0.3
Shrubs	42.6	1366	2.7
Grazing	73.1	221	10.8
Valley Plain	15.0	227	1.0
Foothills	20.5	835	1.4
Steep slope	74.0	550	4.6

average value for the whole watershed is estimated to be 44.13 t/ha/yr (Map 2). Table below gives potential erosion rates by land use types.

Annual Sedimentation Load in the streams : The sediment yield downstream in the Nakkhu Khola using a sediment delivery ratio of 0.169 is estimated to 744t/km/yr excluding the mass contribution and 8596.71t/km^2/yr including the mass contribution which is very high in comparison to other areas of Nepal.

Processes of Producing Environmental Degradation

Population Increases and Land Use Changes : Estimated average population in the area increased from an average density of 48 persons per sq.km in 1954 (Gurung; 1987, average figure for the middle hills) to 259 persons per sq.km in 1986 (New Era; 1986). As a result the resource use pattern has been changed. Tables below indicate the percentage change in land use and gain or loss figures from 1954 to 1986. Comparison of 1954 and 1986 figures indicate a decrease in the forest area by 48% and increase in the cultivated area by 25%. The major forest area has been converted into shrub land and the rest into grazing and agricultural lands.

The introduction of Road : This has two fold impacts: i) direct physical degradation due to hill slope cutting, and ii) transportation of fuelwood to Kathmandu. As complementary programs to increase the local level production were not introduced, the introduction of the road has only been towards more exploitation of the local resources and local labor for the benefit of the outsiders as in other parts of the mountain areas (Blakie et.al, 1978; Tiwari, 1983).

Table Changes in Land Use Pattern (1954-1986)

Land Use	1954	1978	1986	% Change
Forest (ha)	1916	1825	1019	48%
Shrub (ha)	1018	821	1366	34
Grazing (ha)	-	221	221	0
Cultivated Area (ha)	1285	1573	1611	25%
Total (ha)	4219	4219	4219	

Susceptibility of Mountain Ecosystem to Landslide Hazards : Based on the slope class, coverage and soil type scenario was developed to help in explaining the natural susceptibility to the mass wasting process in the study area. The map was developed assigning ranking values within the subclasses of land use and soil type and giving weights according to their nature of susceptibility to the mass

Table Estimated Gain or Loss in Land use Changes (1954-1 86) (Ha)

Gain or Loss	Forest Area	Shrub Area	Cultivated Area
No Change	703	480	1154
Loss	1213	539	131
Gain	316	886	308
Others	1987	2314	2626

wasting process. The analysis indicates that more than 50% of the total area are highly susceptible zones and 12% of this area has been already brought under cultivation.

Geological Features : The number of landslide scars in the area were mostly identified in limestone and meta-sandstone areas. The potential for instability is greater in areas with extensive faulting than in areas with discontinuities. Likewise, higher rock bedding slopes (65°) in the area is another major structural factor in causing landslides. Both the large area under high susceptibility to landslide hazards and geological features indicate that the natural phenomenon in the area is subject to more vulnerability or the possible natural shocks and

may create discontinuity in the in the ecosystem succession process. One of the event was noticed in September, 1981, when there was extensive damage due to massive landslides and flood together with heavy rainfall.

Local People's Response to the Problem : Of the total households interviewed (69 numbers, 5% of total population), 33 % replied that the main cause of the flood was massive deforestation that took place due to increased consumption of fuelwood, fodder, making of charcoal and the forestry act of 1957. 16% replied high intensity of rainfall as the cause of flood, 16 % replied deforestation and landslides, 4% replied deforestation and rainfall, and the rest 8% replied rainfall and landslides. Their response to the causes of the landslides itself were deforestation, rainfall and increased use of stone quarries. Of the total respondents, 72% felt that their land is not as productive as it was 20 years ago. Of those who complained of decreased yields, 47% believe that the main cause was top soil loss, 14 % to siltation, 19 % due to lack of fertilizers, 6 % lack of improved seeds, and the rest 14 % complained that the reason was the decrease in fertilizer input due to increased deforestation. On the condition of the soil in the cultivated terraces, 90 % complained that the top soil is getting harder than before, while others said it is rather stony. The change in the quality of the soil according to the farmers, was due to the increased use of chemical fertilizer to maintain the level of declining soil fertility from the year 1970 when chemical fertilizers were first introduced in the area.

It seems that most of the farmers have clear ideas on the causes of the flood, increased soil erosion and declining productivity levels. They expressed the need for terrace improvement but added that the slope percentage of the present terraces is difficult to reduce because, of the possible failure of the bunds. They need bunds constructed with stones walls is a costly job. The conservation practices they are following was the continuation of their ancestors.

Government Conservation Policy and Property Right Structure : Before 1950 forest were fully exploited for both economic and political benefits by then Rana rulers. After the transfer of power to the Royal family, a Forest Act (1957) was introduced which nationalized all the forests. Farmers of the area mentioned that the introduction of this act was the starting of misuse and mismanagement of forest resources by the government. Farmers complained that the government took control of the forests they were managing before, but failed to control the logging activities by local contractors/ elites who had contacts with top government officials. The government control on forest resources were further reinforced with the introduction of Forest Acts 1967 and 1970 which further strengthened the power of the local forestry officials over the local people. The Local people had to take permission from the forestry guards, employed by forestry department for the collection of fuelwood and fodder from the nationalized forests. To some extent, this helped to control of the over use of the forest resources by the local people. But on the contrary, the politicians and bureaucrats concerned with the management of forest resources seized the opportunity to export forest products in a massive scale. In the absence of corrective measures and from the continuous support of the ruling class to this "easy-money-making" process the level of bureaucratic

corruption and misuse of the forest resources increased. In the Lele and Bhardeo areas, besides logging activities, the charcoal making was illegally permitted. Complaints of the local people were neglected, because, both the forestry guards and officials would benefit from such activities. This weakened the position of local communities in managing the resources so as to use them for household consumptions.

The Panchayat Forestry Act (1975), the Community Forestry Act (1977) and the Decentralization Act of 1982 provided some power to the local leaders. These series of Act were introduced to give the management responsibility to the local political units to start the "bottom up" planning approach and initiate peoples participation. In practice however, the crated rules were not strongly enforced and the dense forest covers of mountain watersheds were disappearing. The move to change in the forest control policy was more political oriented and were done due to the demonstrated successful examples of forest protection and management by local communities (in most of the cases non-political units) in areas where they had control over the forests. The next and most obvious reason was that external agencies started to warn the government on the growing environmental degradation and so a change in policy was necessary to draw more foreign aid.

The recent conservation policy (IUCN; 1988) only outlines the conservation strategy and has not been reflected in the implementation of the plans and programs related to watershed managements. The structure of recently established central level environmental secretariat is also not clear.

Bagmati Watershed Management Project (BWP) and Farmers Response : A clear discrepancy existed between the scale of the problem, need of local people, objectives of the program itself and the scale of project achievement in the area. The main aim of the project was to bring about changes in land use and management within the Bagmati watershed area to sustain land productivity and reduce soil erosion. The strategy adopted was to launch a series of programs like nursery establishment, conservation plantation trail and terrace improvement, stream bank protection, gully control, construction of catchment ponds, irrigation network and water supply through peoples' participation (BWP, 1989). As seen from the soil erosion estimates, about 1044ha under cultivation in the watershed have erosion rate more than 64 t/ha/yr, which needs immediate rehabilitation. Likewise, grazing areas in Lele and Nallu produce high erosion rates. Most of the forest and shrub areas are degraded. People are now approaching Phulchoki area for fuelwood and fodder collection. The watershed management program has covered only 2.0 ha of land for terrace improvement. There is no production oriented or employment generating activities. In comparison to the degree of these problems, the targets and efforts of BWP in solving the problems are almost negligible.

About 31% of the household interviewed replied that they even did not know what BWP is doing in that area and why it is there. Some of them replied that they know only some government vehicles running up and down and expect some activities in the area. About 33% replied that the program in itself is not sufficient. 29% hoped that the program may benefit

them but the rest 7% replied that the program was beneficial only to the local village leaders and not to the poor people. Some of them replied that with the changing political system the situation might be better but they themselves do not know how it will be better. Most of them expressed the need for loan provision for livestock and small business purposes, provision of nurseries, distribution of fertilizer in time, more contribution from the project in terrace improvement and in a large scale transfer of forest management to the people etc.

Carrying Capacity Analysis

The concepts of carrying capacity and environmental limits can, at a minimum, provide some descriptive idea of what is happening or what might likely to happen. The carrying capacity analysis can also be used as a standard against which we could evaluate and reshape developmental schemes (Ross,1981?). The physical carrying capacity is estimated with fixed minimum soil erosion rates (soil loss tolerance value) that is inevitable considering the nature of the topography and geological features as well as land use and management conditions. The population carrying capacity is based on the food demand and sustainable supply of food with consideration of physical carrying capacity.

Physical Carrying Capacity : The analysis based at allowable soil erosion rate (15 t/ha/yr, Joshi, 1989) and maximum rate (64t/ha/yr) that can be reduced to minimum allowable rate with improvement in land management conditions, indicated that about 860 ha forest, 498 ha shrubs, 23 ha grazing field and 416 ha of cultivated land can be used with the continuation of present management practices. 160 ha forest area, 389 ha shrub area and 431 ha of cultivated area can then be brought under resource use activities with intensive management practices. The remaining 482 ha shrub area, 166 ha grazing field and 769 ha of cultivated land cannot be used for the resource generating activities at present, because of the critical soil erosion rates.

Population Carrying Capacity considering food demand and supply : Comparison of food supply and per capita demand at present (129 kg/person) indicates that the watershed is sustaining 6117 people and can accommodate 4940 people at the subsistence density. The remaining population numbers of 4769 are in excess of carrying capacity. The present scenario II is based on the estimation of total food supply available at present, including all the agricultural land without excluding areas highly prone to erosion. The latter scenario indicates the size of the population being feed by the present level of food production within the watershed.

Scenarios (I and II) consider population increase from 1986 to 1991. The cultivated area under highly erodible category has not been included in scenario I. However, in developing scenario II it is assumed that this area under highly erodible category will be able to generate income through other crop practices in supplying food in the amount that is being produced with maize cultivation in 1986. The excess population under Scenarios I and II is estimated to be 8267 and 7213 respectively, if off-farm income is not considered, and 4513 and 3459

Table Land Use Area Distribution by Land Capability Classification (Ha)

Land use	on-erodible	Erodible	Highly Erodible
Forest	864	160	0
Shrub	498	389	482
Grazing	23	32	166
Valley	163	52	14
Foothills	180	288	369
Steep Terrace	75	91	386
Total (Ha)	1795	1012	1417

respectively if off-farm income is considered. This situation indicates that even with off-farm income ($160/family), the food requirement at the subsistence level cannot be met by the resources within the watershed.

Livestock Carrying Capacity : The comparison between average TDN requirements per livestock unit and total TDN available from different sources indicates that the watershed at present can sustain only a total of 6530 numbers of livestock. With the assumptions that i) total forest area can be brought for use with good management practices, and ii) the present livestock remains constant, the total demand of TDN can be met in the future. The future scenario based on these assumptions also indicated a surplus of total TDN available that can sustain an additional 1,955 livestock.

Fuelwood Demand and Supply : The estimated sustainable supply of fuelwood at present of 1,402 MT meets only 28% of the total demand. The analysis indicates that at present the watershed carrying capacity for sustaining fuelwood requirements meets only the demand of 2,676 population. With assumption that all the forest and part of the shrub areas can produce sustainable yield of fuelwood under good management conditions increases to a total of 4826 people. For 1991 assuming population increase by 2.06% (national average), the excess population will be 6,060.

The comparison of supply and demand of resources as well as specification of the population size that the sustainable supply of resources can sustain, indicates that there exist an acute deficiency of natural resources. Even at the optimum management level, a large size of the population (60%) has to be externally supported. If the present level of off-farm income generating activities is not increased the goal of meeting basic needs in terms of food requirements cannot be achieved. Likewise, the demand and supply comparison of fuelwood indicated a worsening situation with large deficits of fuelwood in the years to come. Even under good management conditions, existing forest and shrub areas cannot meet the growing

demands of fuelwood. The demand and supply of TDN for livestock indicate that if the resources are well managed, the present level of livestock can be well sustained. Hildreth (1986) estimated that around 5 ha of forests under the present degraded state is required for each hectare of agricultural land in the middle mountains for sustainable farming systems. A scenario developed based on this assumption also indicates a deficiency of forest area by 3,447 ha. However, if the cultivated land under highly erodible conditions is changed to forest the total cultivated area will be 847 ha and the total forest area will be 3,207 ha. This situation also indicates a deficiency of 1,046 ha of forest lands.

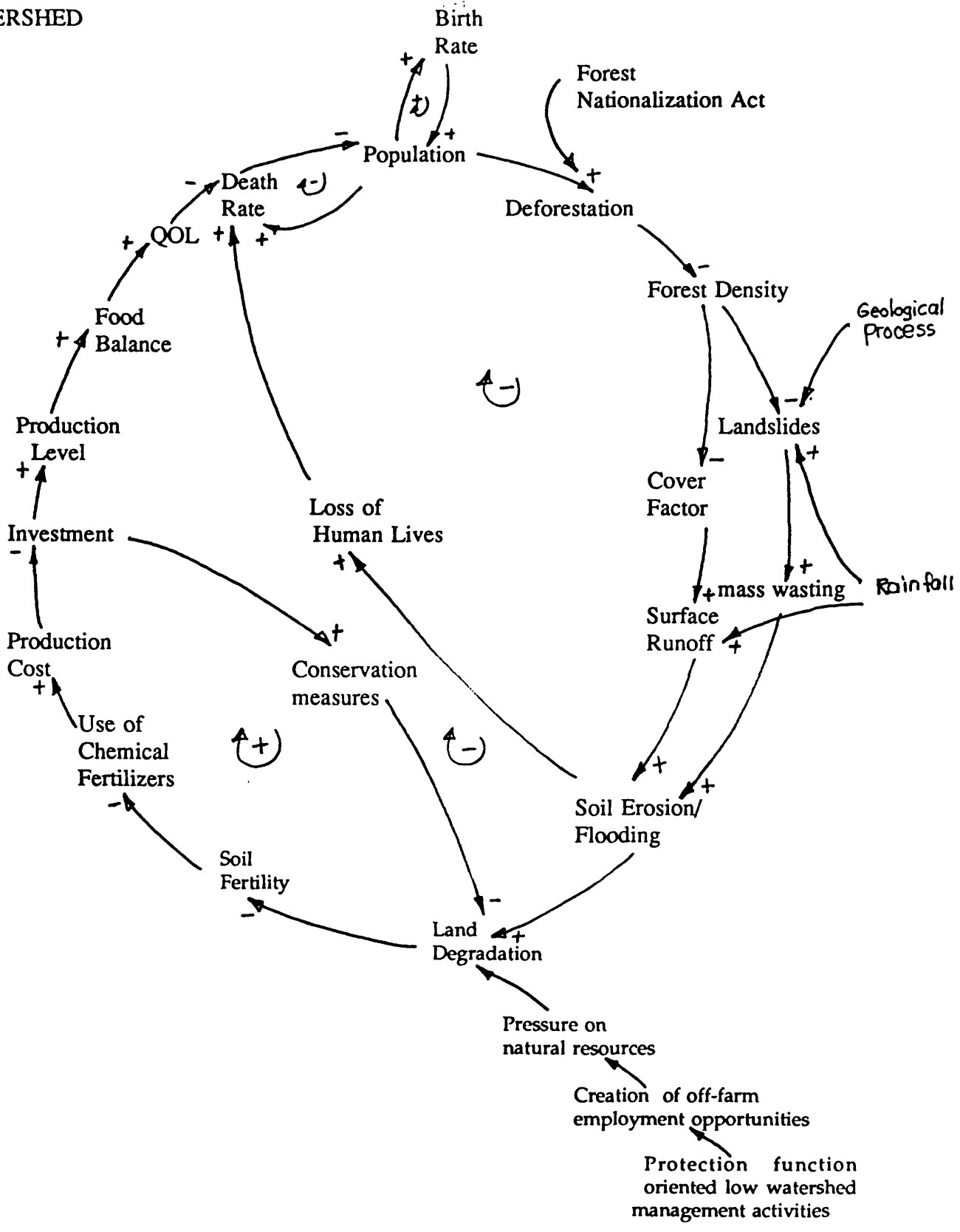
Cause and Effect Linkages and Challenges for Watershed Resources Management

Changing environmental conditions and processes of producing environmental degradation in the foregoing sections can be viewed as both natural given and a resource scarcity and the failure to maintain a balance between the consumption and re-production of the resources. In the watershed ecosystem the demand variable (population) and supply variable (resources) form an interacting relation as forcing and resulting components of the model. Combination of these variables functioning in the watershed ecosystem form the casual loop diagram which shows the cause and effect relationships. The forming loops are characterized by both negative and positive loops. Negative feedback loops are referred to loops that negate changes. Such loops are described as stabilizing, equlibrating, self-correcting or regulating. On the contrary, positive feedback loops are described as destabilizing, deequilibrating, run-away, growth or collapse producing.

The figure below establishes an interlink among physical and socio-economic factors in the watershed which are frequently linked together into a cause and effect loop. The figure shows that the relationships in the cause and effect loop are quite complicated. The birth-population forms a positive loop and the death-population forms a negative loop. There is another positive loop which reinforce a decline in conservation measures and increased land degradation over time. The two major loops are negative feedback loops which indicate that the system is self-correcting in the long run. But in the short run it cannot attain equillibrium as there is a long time involved for the regeneration of the natural resources and that is why policies either aimed at reducing the environmental degradation or increasing food production have to be introduced. Planners should think on how to increase the investment capacity of the farmers in the short run. It needs policy interventions such as — population control, increased soil fertility by increasing the use of traditional fertilizers, supply of food from outside, improved forest cover and density and other preventive and rehabilitative measures for soil conservation and water management. However, adoption and implementation of these location specific policies and programs in the short run are limited by physical and socio-economic as well as political constraints.

The Challenges : Although some major differences such as socio-economic conditions of the people may exist, the changing environmental scenario described in this case study is applicable throughout the middle mountains of Nepal. As economic activities in the Nakkhu watershed area and similar degraded watersheds in other parts of the mountains can't yet be

CAUSE AND EFFECT LOOP OF ENVIRONMENTAL DEGRADATION IN NAKKHU WATERSHED



carried out without natures' resources, economic policies and decisions aimed at sustainable use of the resources may face a number of challenges constrained by the limit of the use of the resources. As discussed in the foregoing sections, the major challenges confronting sustainable development in the mountain environment include;

i) *High natural susceptibility to landslides* may present difficulties for the planned conservation programs and can nullify the impact of human initiated actions such as preventive or rehabilitative measures.

ii) *Primary resource based subsistence level economy with increasing population pressure* may put increasing pressure on natural resources as other alternative means for livelihood both inside and outside the watershed are limited.

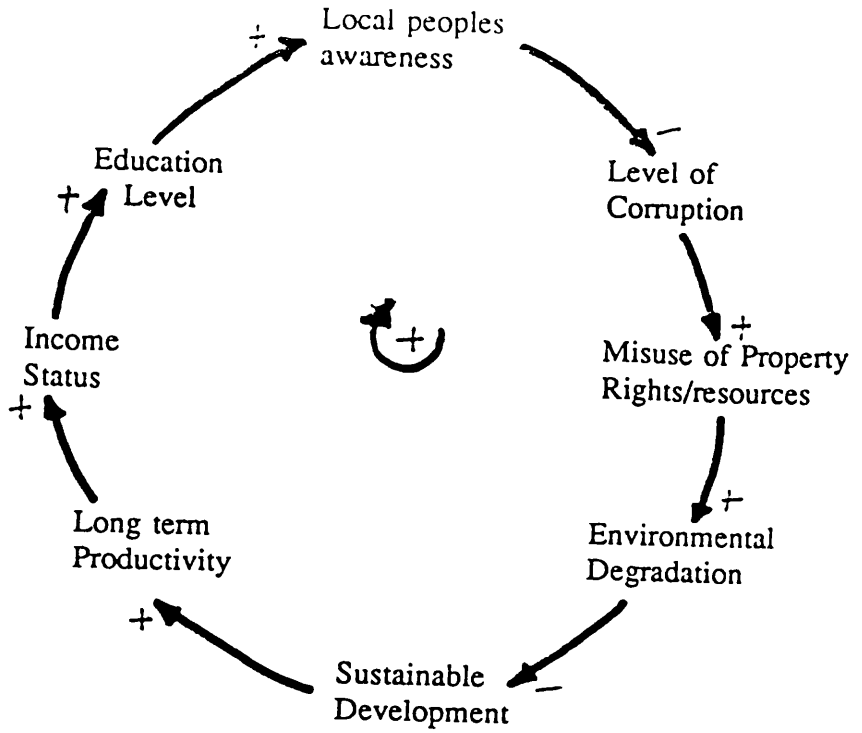
iii) *Increasing cost of cultivation and decreasing productivity of land* may provide little incentive to the farmers to invest on conservation measures. It becomes very difficult to assess the direct benefits of the farmers investment to improve the terraced conditions.

iv) *Discrepancy between the scale of the preventive, maintenance and rehabilitative measures required, the interest of the watershed inhabitants and the planned watershed management measures of the government* indicate a low performance of the measures undertaken so far. The limited financial capability of the government has little chance to address the problems timely and adequately.

v) *A series of existing decisive Government Forest and Conservation policies* favoring the implementors than the beneficiaries help to centralize the power and interventions in a way so as not to encourage people participation but to increase the level of corruption.

vi) *Low income and low education status of the people prevent conscious voting thus encouraging vote buying*. The advantages politicians can take may not be easily avertable within a short time period. Instead chain reaction of poverty-vote buying-centralized control-easy money making-ineffective of government measures-widespread poverty and low education status may continue making it difficult to break this chain reaction. Figure below shows the cause and effect loops of this chain reaction which is not self-stabilizing.

vii) *Resource demand in excess of carrying capacity in the mountains* requiring equitable distribution of resources between and among regions not politically desirable as it is risky for securing votes. The resettlement of the mountain population in excess of the carrying capacity either in industrialized areas to supply labor or in the virgin areas clearing forests do not pave the solution. The industrial sector is not strong enough to accommodate such a large segment of the population and forest clearance is not a long term solution.



viii) *Single discipline oriented development activities, less powerful central environmental organization, undefined linkages among and between concerned ministries and departments both for information flow* provide little optimism for a fast adaptation of environmental-cum-economic planning for sustainable development. Policy mechanisms allowing the market to control the use of the resources and fixing the institutional structure can provide only little optimism for reorienting the bureaucratic set up in line with the emerging challenges of environmental problems.

Measures for Watershed Resources Management

The cause and effect analysis of environmental degradation and a series of outlined policy challenges indicate that the environmental degradation problem and the measures for resource management are linked to various disciplines and are very complex in nature. A search for a single solution would be a myopia. A series of resource management activities based on the analysis can be listed to improve the environmental conditions and resource management actions in the future. But the basic question is who will be responsible to implement the suggested programs and efficient utilization of the allocated resources. The government's failure to improve the watershed conditions in the past demands alternative measures for the management of the resources in the future.

There has been a wide debate in the past for changing the institutional set up as an alternative measure to watershed resources management. The first dilemma is related to the transfer of property rights. A series of programs aimed at to give authority to the local

political units have not proved successful. Wallace (1987) concludes that community forestry projects (Panchayat forestry projects) cannot by themselves be a solution to manage the resources. He favored complementary programs to encourage leasehold and private forestry on a wide scale. Though this is not an impossible solution, at least at present, there are major limitations for privatization and leasehold of common property resources. The existence of the subsistence level economy, absence of alternative means for income generation and fuelwood, non-monetized nature of remote area economy, socio-cultural background as well as a low level of awareness to developmental activities. There is also major fear of allocative inefficiency, fragmentation of land and involvement of high transaction costs. Runge (1985) also maintains that low levels of income imply that formalized private property institutions which involve high transaction and enforcement costs are often outside the budget of village-level responses to resource management. The case of degradation and failure to improve the steep terraces and the enforcement of rules and regulation by the government in the area support this hypothesis. Another problem is associated with the enforcement of rules for the protection of private property. In case of common property rules, they are generally enforced locally; abuses of authority, if they occur, may be less widespread than under a centralized program of privatization (Runge, 1985). The study on Farmer Managed Irrigation Systems (Tiwari and Thapa, 1989) clearly shows that abuse of power is less in these systems than in government managed systems and the conflicts in resource use are managed through mutual understanding in case of common property. Thus, the search for appropriate institutional responses has to respect both the traditions and constrains of local needs in specific choice environments (Runge, 1985). In case of Panchayat managed forest projects the transfer of rights and responsibility was never carried out effectively. The whole aim of decentralization was aimed at mobilizing voluntary labor for physical works and the ownership still belonged to the government. This case can be compared with the government's attempts to form water user groups in many government managed irrigation systems in an attempt to transfer the responsibility to the local farmers. But the government authorities exercised power and control over the resources. On the contrary, the FMIS shows successful examples of irrigation management in many cases. The sense of ownership, the needs, formulation and strict follow up of the rules and regulations and the established traditional organization have helped much in managing these irrigation systems for centuries. However, the lessons from successful management of irrigation systems cannot be directly transferred to the management of the forests, shrubs and grazing lands. The time involved in the regeneration of the resources once it is consumed takes a long time than the acquisition of irrigation water from its source. But the traditional institution, its organizational structure and the decision making processes can be equally applied in case of other common property resources.

Institutional theory suggests that changing institutions to accommodate environmental interests is necessary to social equity. Political or market forces simply serve as vehicles or impediments in reaching a particular instrumentally grounded outcome (Livingston; 1987). In the context of rural areas of Nepal, change in the present institutional set up is necessary and the involvement of the traditional community and transfer of power, responsibility and resources to the local people appear to be one of the immediate solutions for the management of watershed resources at the local level.

Another important concern is to create awareness among the farmers on environmental degradation and its increased costs and to develop moral values among bureaucrats involved in the planning and management processes. To achieve this end, there is a need of the recognition of the rights, duties, obligations, rules and needs of others outside the organizations. This can only be achieved if the moral values among politicians, bureaucrats and other concerned mass are improved. To improve the moral values or follow environmental ethics, politicians have to be honest and really motivated towards protecting the environment. Only then can they control the bureaucrats and technicians. This needs a tremendous effort from the government's side.

Creating awareness among the local people is one of the solution to improve the moral values among the bureaucrats and politicians and this can be done only through NGOs. Because, people from the government mostly hesitate to consult the local people and transfer or share the power they hold for resource management activities. To create awareness among the people, the watershed management program should be first launched as a social package program to improve or strengthen the traditional institutions.

Farmer-based Solutions

i) Changing of existing legislation and financial procedures to give local communities appropriate power to manage and use the natural and financial resources directly from the project.

ii) Introduce land use planning guidelines for local farmers based on the physical carrying capacity of the ecosystem.

iii) Let the people themselves organize and demand assistance.

iv) Employ catalysts or NGOs to strengthen the local communities and to train the people. Employ field supervisors from among these trained people and local teachers.

v) Introduce technical programs after setting up of local institutional infrastructures and provide financial and technical support with least interventions.

vi) Provide incentives for the improvement and protection of highly degraded areas.

vii) Establish clear demarcation of forest, shrub and grazing areas for each organized community according to the traditional rights.

viii) Establish resource accounting system at the local level and inform people on the resource supply conditions as well as on necessary management steps to be taken;

ix) Carry out timely monitoring and evaluation with people participation and suggest for improvement in conservation practices.

x) Carry out farmer to farmer training to initiate people in conservation management.

Other issues to the resource management actions at the local level are related to the planning approach, development priorities, scale and duration of the programs, type of technology and way of evaluating the management programs. Each issue needs a separate look for suggesting some measures.

Planning Approach : For successful implementation of conservation measures the planning of the watershed projects should be guided by local specific needs by enhancing people participation. To enhance people participation, the farmers should be involved right from the beginning of the project planning stage. The planning process BWP now adopted is neither decentralized planning nor is it utilizing the concept of people participation. A project document claims (BWP 1989) that it has followed the both approaches. It is rather politics than real facts in such claims. The present planning, design and implementation approaches should be changed towards systematic development of planning guidelines at micro-watershed basis and carry out monitoring and evaluation works of the farmers'community.

Scale and Duration of the Program : For a micro watershed like Nakkhu the total responsibility and right should be transferred to the people and for a macro watershed composed of many micro-watersheds like Bagmati, the program should be launched for a fixed duration of 5 to 6 years. After this project period, the project should be able to generate the capacity of the local communities in managing and implementing conservation programs by themselves. The present coverage under the project can help to show the increase (in government documents) in total area under the watershed management project but may hardly have an effect on the present environmental quality.

Technological Choice : Ecological characteristics always do not allow the adoption of a technology such as cropping practices that is only preferred by the farmers. Depending upon the physical carrying capacity of the soil or land, the cropping pattern or cultivation technology should be developed; attempts should be made to match with local practices such as plantations of suitable fruit crop trees. An agreement must be made with the farmers as to who should accept the technology after demonstrating it effectively. In steep terraces, present practices of maize farming cannot be allowed to continue. To enhance people participation in this case, subsidy for certain years should be given during which suitable fruit crops in these agro-climatic conditions do not start to provide returns. Other employment opportunities or incentives, if possible can be provided to this section of the population. If not provided, the cost of upper slopes degradation will also have to be borne by others living in the lower slopes. The second point to be considered is that the type of technology adopted should decrease the soil loss within the limits of the physical carrying capacity. The evaluation criteria for measuring soil loss against soil loss tolerance values and for productivity measures (before and after the project) must be developed and carried out for the selection of appropriate technologies in the future.

Structural Measures : The structural measures followed by BWP sound quite appropriate,

though not sufficient. Agronomic measures should follow along with structural measures. An experimental surface run-off plot should be established and research on developing agronomic packages suitable for steep slopes should be conducted in one watershed and the results extended to similar locations. Other structural measures such as construction of ponds, runoff diversion structures, land reclamation, terrace improvements etc. should be continued but with the involvement of the local people.

The success of a watershed management program, thus, lies on the commitment of the government to change the present strategies. A major political commitment is required to manage the natural resources to meet the requirements of the mountain people. With the recent change to a multi-party political system, Nepal will be able to launch for such commitments and solve the growing environmental and resource scarcity problems.

Future Research Directions

Several conclusions regarding future directions emerge from this case study in the ecological-economic considerations at the local level;

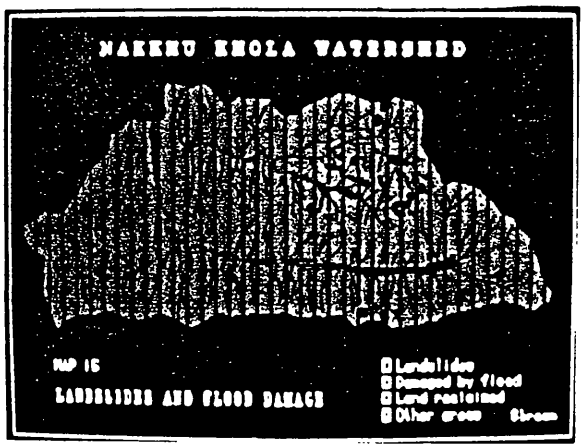
i) There is still deficiency of data on the characteristics of the ecosystems that can be used to predict the long term behavior and irreversibilities of the ecosystem and their possible impact to human behavior;

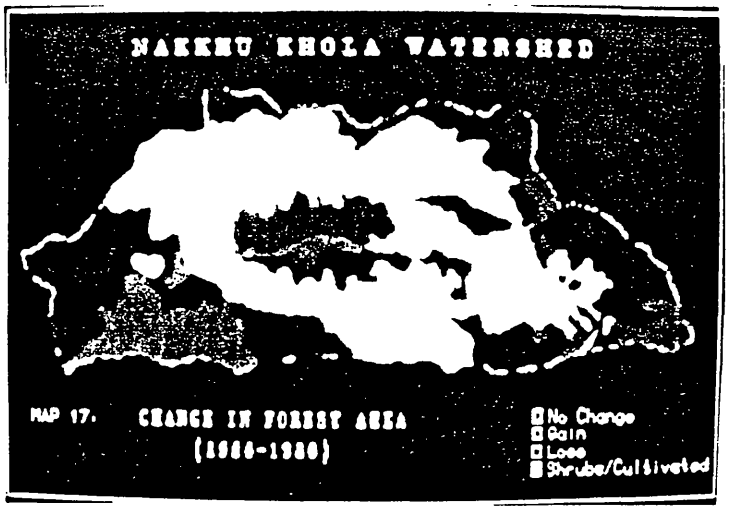
ii) The measurement of carrying capacity requires more systematic and scientific database on biophysical aspects. Resource accounting system can be helpful and a meso watershed level accounting system needs to be developed;

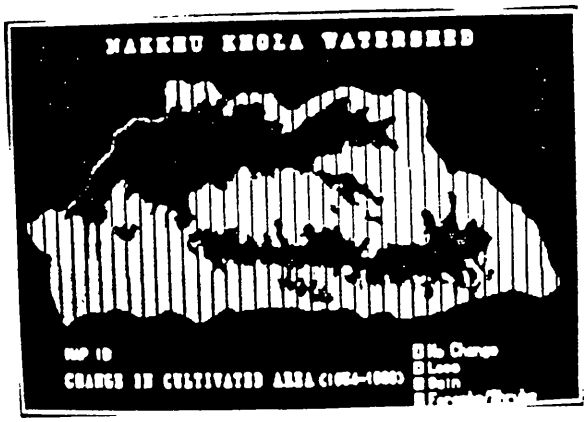
iii) How to relate theoretical concepts and emerging problems in environmental management depend on how much we can recognize the importance and borrow the concepts from other disciplines for our analysis. Theories provide a basic framework for the field level research study and our efforts should be more toward such studies;

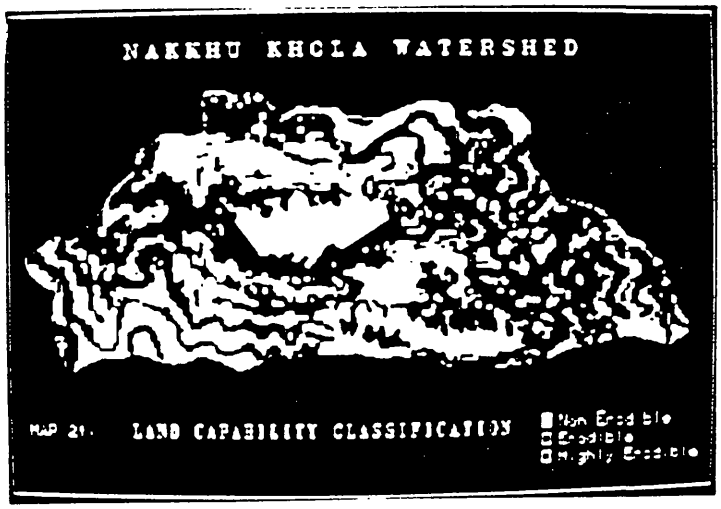
iv) The models and tools used in this study can be extended to analysis of problem to of other mountain watersheds. The use of Geographical Information System (GIS) can prove to be a useful tool.

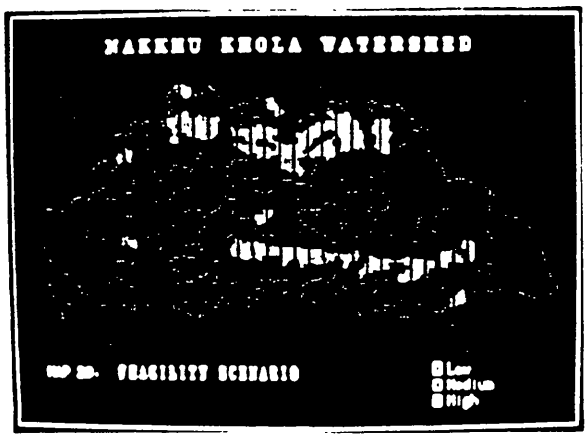
v) Field studies should not be only directed to test both the theories and the degree of the problem of the local people. The ecosystem is always subject to change and the studies should always be able to identify the changes for immediate and long term solutions.

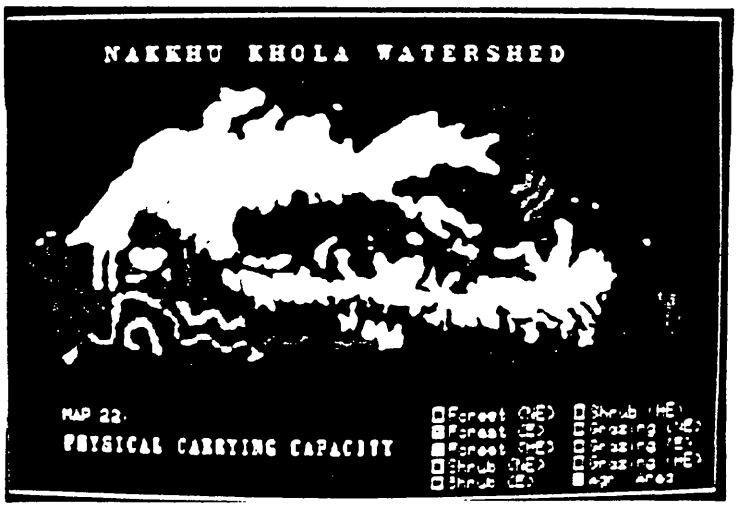

NAKKHU KHOLA WATERSHED
MAP 16
LANDSLIDES AND FLOOD DAMAGE
Landslides
Damaged by flood
Land reclaimed
Other areas
Stream


NAKKHU KHOLA WATERSHED
MAP 17.
CHANGE IN FOREST AREA
(1966-1986)
No Change
Gain
Loss
Shrubs/Cultivated

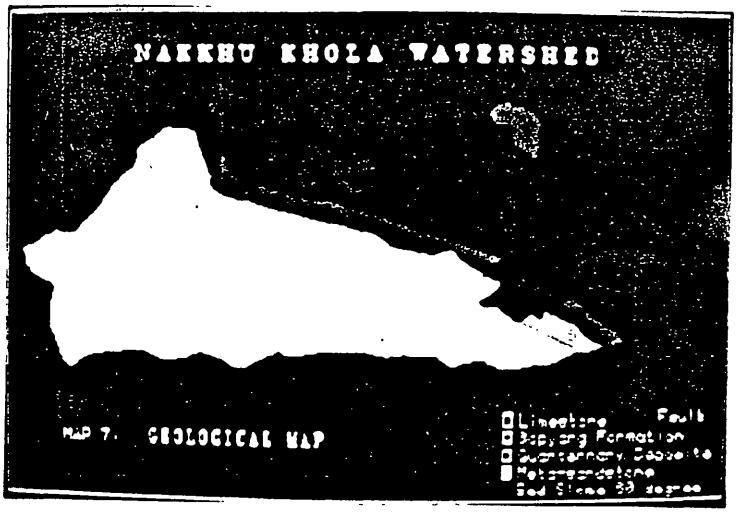

NAKKHU KHOLA WATERSHED
MAP 19
No Change
Loss
Gain

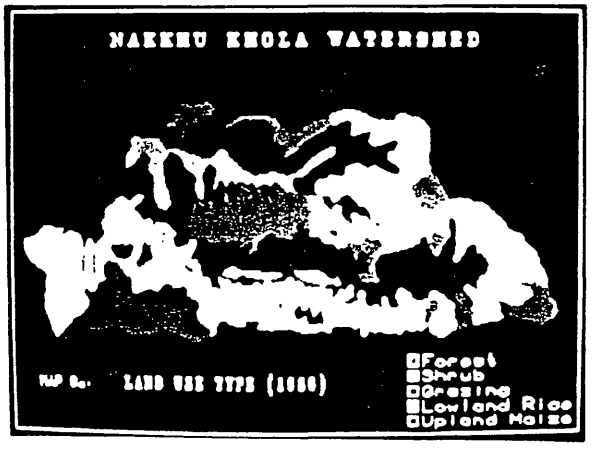

NAKKHU KHOLA WATERSHED
MAP 21.
LAND CAPABILITY CLASSIFICATION
Non Erodible
Erodible
Highly Erodible

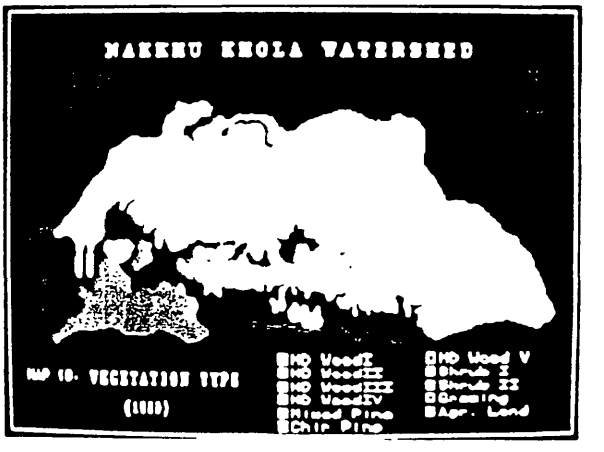

NAKKHU KHOLA WATERSHED
Low
Medium
High

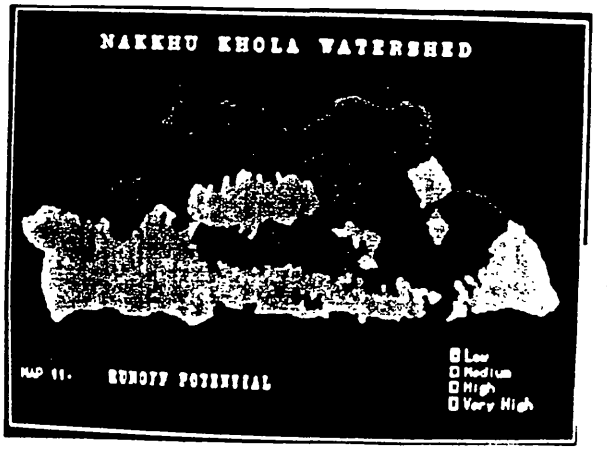

NAKKHU KHOLA WATERSHED
MAP 22.
PHYSICAL CARRYING CAPACITY

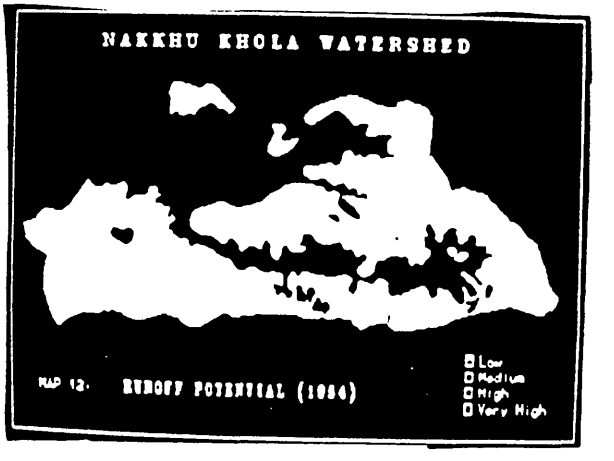

NAKKHU KHOLA WATERSHED
MAP 6. SOIL TYPE
Sandy Loam(SL)
Silty to SL
Silty Loam
Sil(red color)
Sil with Clay


NAKKHU KHOLA WATERSHED
MAP 7. GEOLOGICAL MAP
Limestone
Fault
Bajura Formation
Quaternary Deposits
Metamorphites
Dip Slope 30 degree


NAKKHU KHOLA WATERSHED
MAP 8. LAND USE TYPE (1988)
Forest
Shrub
Grazing
Lowland Rice
Upland Maize


NAKKHU KHOLA WATERSHED
MAP 10. VEGETATION TYPE
(1988)
Mixed Pine
Chir Pine
Agr. Land


NAKKHU KHOLA WATERSHED
MAP 11. RUNOFF POTENTIAL
Low
Medium
High
Very High


NAKKHU KHOLA WATERSHED
MAP 12. RUNOFF POTENTIAL (1984)
Low
Medium
High
Very High