SUSTAINABILITY, COMMONS AND CO-EVOLUTIONARY VIEW

Environmental Change and Traditional Organizations in Nepal*

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Abstract

Sustainable use and management of the *commons* requires a co-evolutionary understanding of the traditional resource management regimes. Capital theory lacks in explaining such a view and measuring *equity* and *sustainability*. Institutional theory attempts to examine from co-evolutionary perspective but, majority of case studies carried out in Nepal present the sociosystem in a narrow framework. This paper adopts the concept of ecological economics and institutional economics to examine the links between ecosystem and sociosystem in a wider perspective. First, the distribution and degradation of *commons* and their effects on the traditional organizations in both the hills and plains of Nepal is presented in spatial framework using GIS techniques. Second, a case study of the traditional irrigation system (3500 ha) is presented with agro-ecological analysis, change in technical and property right structure and functioning of the sociosystem based on one years' action research.

The paper argues that misuse of *commons* in the upper watersheds have contributed to the degradation of the resources and in some cases, failure of the traditional systems. The case study included, however, shows successful adaptation of the changing environment by the organization over period through; crop diversification, physical realignment, adaptations of appropriate technology, decentralization of power, equity in water distribution according to water allocation and resource mobilization. The relative O&M cost shows a increasing trend over period, as a result of growing forest resource degradation, flooding and siltation. The paper concludes that accounting of ecological-economic system and sociosystem is needed to explain fully from co-evolutionary perspective. Some policy measures are suggested to empower local-level resource management regimes for sustainable use and management of the commons.

Environmental Change and Degradation of Natural Capital

Many factors combined influence environmental change in Nepal e.g; physiography, geology, vegetation, soil, climate, and the degree and nature of human interventions. There are three major issues related to environmental degradation in Nepal. Firstly, the usual focus of the issue has been on the population growth-deforestation-environmental degradation linkages and secondly, to the geomorphological process-mass wasting-environmental degradation linkages. The third issue is based on the cause of deforestation

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itself and is related to the first issue. The major change in environmental conditions important in the context of Nepal are briefly mentioned below.

Decreasing Bio-diversity and Ecosystem Stability: Due to increased deforestation (3.9% per anum after 1978; APROSC,1986), the bio-diversity and the capability of the mountain ecosystem (68% of the total land) to cope with the external shocks and perturbations are decreasing. The losses of flora and fauna have been major issues. About 10 species of highly valuable timber, 6 of fibers, 6 of edible fruit trees, 4 of traditional herbs, and some 50 species of little known trees and shrubs are expected to be extinct within a few years. Likewise, about 200 species of birds, 40 species of mammals and 20 species of reptiles are expected to be severely altered if the present rate of deforestation occurs. Presently though it has been estimated about 40% of the total area covered by forests (LRMP, 1985), are expected to be only 20% of the total area. These contrasting figures indicate that though the total area has increased due to i)inclusion of private forest land, ii) about 168 kilometer square of forest land in northern boarder from China (to be confirmed), the quality of forest lands have been seriously degraded over periods. The frequency of landslides, flooding and damage of land and other properties is reported to be increasing.

Increasing Soil Erosion: Various studies have shown increases in soil erosion rates in Nepal. The approximate soil erosion rate varies from less than 10 ton/ha from forest and shrub lands to as high as 173 t/ha in case of grazing lands (Tiwari, 1991). The poor terraced lands in the high slopes produce almost the same amount of soil erosion to that of grazing lands. The established rainfall-runoff plots in some areas however, show relatively low erosion rates as low as 1.78t/ha in 1985 to 7.15t/ha in 1988 for hill side ditching (Upadhaya et.al, 1991). The increased deforestation and resulting soil erosion has degraded numerous upper watersheds which are the homelands of about 60% of the population.

Water Pollution: Increased soil erosion and the increased use of chemical fertilizers have decreased the water quality in the rivers and streams. The annual sediment load is estimated at the rate of 0.98 to 1.43 gm/l in major rivers. The drinking water supply in urban areas is highly polluted and in rural areas only 20% of the total population have access to potable water supply. The contamination level in drinking water supply is reported to be up to 4,800 coliform per 100 ml in urban areas. A large numbers of patients suffering from water related disease are reported every year (HMG/MOF&E, 1992).

Air Pollution: There has not been a systematic study on the level of air pollution in major urban cities of Nepal. Sampling of particulate showed the level to be up to 3000 U/m^3 in

Kathmandu valley. Likewise a theoretical estimate showed that the load of carbon monoxide, hydrocarbons, nitric oxide and sulphur dioxide would be at around 18,400, 3300, 1660, and 275 tons/yr in Kathmandu valley from about 2500 vehicles only (HMG/MOE&F, 1992). The increased numbers of cement and other industries in urban areas are contributing towards traffic congestion and air pollution. The burning of fuelwood is the major source of indoor air pollution in the rural areas of Nepal. However, air pollution is not regarded as a major pollution problem compared to others.

Hazardous Wastes generation and Land Pollution: Increased hazardous wastes from hospitals, residential and industrial areas have been major problems in urban centers. In the Kathmandu valley, the wastes derived from hospitals has increased from 1.5 in 1986 to 1.86 tons/day in 1990. Hazardous pests and fertilizer wastes are among other problems though not severe in decreasing the water quality, but the concentration of DDT residue was found to be the highest in milk at about 1.2 ppm (HMG/MOF&E, 1992).

Natural Capital Degradation and Quality of Life: The degradation of forest and land resources, increased uncertainty in rainfall and water availability in the streams have increased the hardship of the rural communities. Due to the environmental problems mentioned above and other geo-political factors, the level of poverty has increased from 42% of the people living below the poverty line in 1975 (NPC, 1976) to 43% of the population below the poverty line in 1985 (NRB, 1988). Due to increased soil erosion, use of chemical fertilizer has increased to maintain the agricultural productivity over the past few years. However, the food and fuelwood deficit is increasing over the past few years. The main problem in the hills and mountains have been seen for the collection of fuelwood. The time required for the collection of fuelwood has increased to six hours for the collection of one *bhari* (approximately 40kg). The increased landslides and soil erosion have affected as much as 50% of the lands in the degraded watersheds.

Sustainability Criteria and Cultural Capital

The concept of sustainable development in Nepal is then closely related to the issues of degradation of natural capital. At what level the total capital should be maintained to achieve sustainability is another question. As most of the people are still below poverty line, the criteria for sustainability should reflect to these sector of the population and maintaining the basic needs of this group of people without further environmental degradation. The level of poverty in Nepal can be explained in terms of i) poverty line and ii) income gap. The poverty line defines the minimum acceptable standard of living for the society. In Nepal this has been defined in terms of 2250 calories required per day just to maintain life (NPC, 1982). Based on this approach, whereas 42 percent of the total population were identified below the poverty line in 1976, it has increased to 43% in rural Nepal in 1985. Moreover, the rate is as high as 52.7% in the hills where there is high pressure on natural resources and more environmental degradation.This shows a increasing trend of the population below the poverty line mainly in the environmentally unsustainable areas.

The next approach of measuring level of poverty is the income gap approach. The comparison of the survey on income distribution pattern in Nepal by the National Planning Commission (NPC, 1976) and Nepal Rastra Bank (NRB, 1988) indicates that the income inequality gap has not reduced so much in the 1976/77 to 1986/87 period. Though gini-coefficient is high, the NRB survey pointed out that on per capita basis the income inequality is not so much high because of a large size family among the top 10% income holders. With the expansion of population which is assumed to double by the year 2010 at the 1981 level, the per capita land holding size will be below 0.5ha which is the main source of production and income generation.

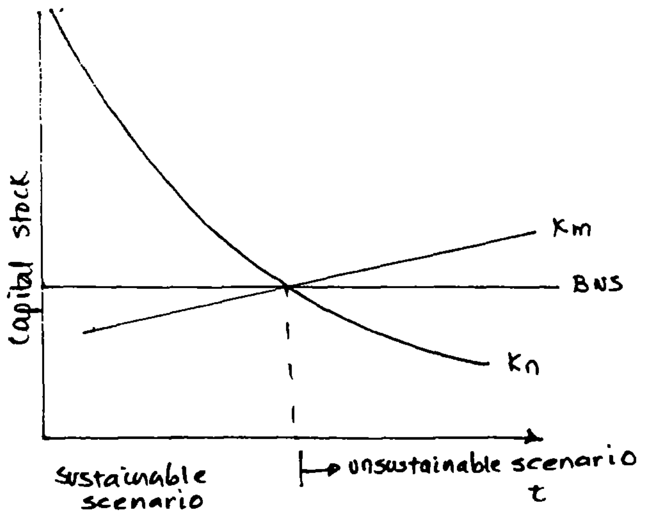
Poverty and Intergenerational Equity : Intergenerational equity refers to justice to the people among generations. Achieving sustainability is to secure the livelihood of future generations. If the present generation is in misery due to the deprivation of minimum physical needs, the objective of saving and managing the resources to provide justice to future generations remains questionable. The operational concept of intergenerational equity is to try to maintain both the man made and natural capital intact to provide the opportunity for future generations to sustain their quality of life at least at the level enjoyed by the present generation (Pearce, 1989). In this context, the poverty scenario in Nepal indicates that the present generation has less resources left for consumption compared to the resources per capita before 1976. Though this is a very short time horizon to provide such an example, yet it shows that the consumption and investment patterns in the past have not contributed to the regeneration of resources to feed the growing population in the future enough.

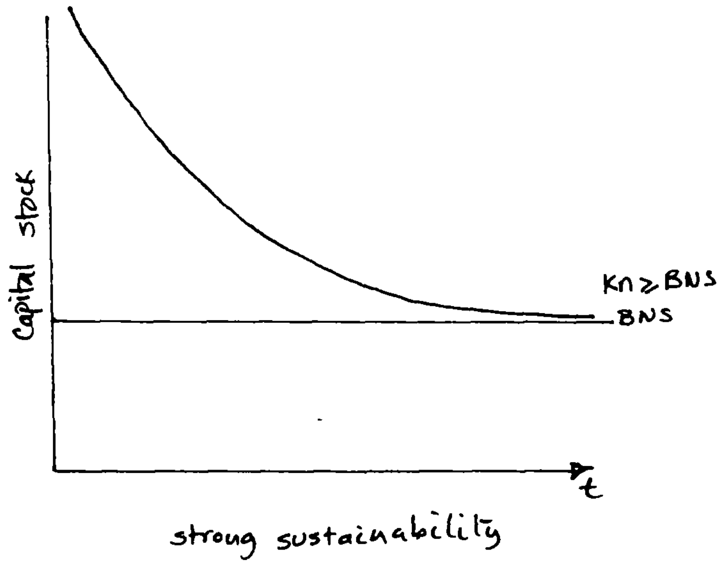
Let us fix some basic criteria for sustainability based on this intergenerational equity. the operational definition of intergenerational equity as mentioned above implies the constancy of natural capital at the present level. This implies that the total capital ($K_m + K_n$) where K_m = man-made capital and K_n = natural capital at present should at least be equal or greater than in the future. In the context of Nepal if our aim is to achieve basic needs of the people then this constancy implies;

$(K_m + K_n) >= $ (BNP * Population Size) i.e, the total capital should not be below the basic needs level.

where BNP = basic needs per capita to be measured in physical or monetary units.

The present resource supply and demand scenario (Tiwari, 1992) indicate that the level of consumption of natural capital already exceeds the sustainable level. Though man-made capital in terms of per year GNP is increasing, the natural capital is decreasing over period. The sustainability criteria implies that the natural capital curve should be shifted atleast up to the basic needs level to alleviate both poverty and reduce the environmental degradation. since the environmental degradation problems are closely associated with the *commons* the property right structure and management systems and success or failure of the traditional organizations play important role in managing commons in Nepal. In the rest part of this





paper I will try to present a co-evolutionary view on how the traditional organizations mainly related with the water use systems are functioning.

Commons and Co-evolutionary View: A General Framework for Analysis

Bromely (1991) outlined four kinds of possible resource management regimes namely; i) open access regimes, ii) private property regimes, iii) state property regimes, and iv) common property regimes. In Nepal, before 1957 state has little control over the communal forest resources and water resources. Many indigenous organization were in existence for managing local commons. In this respect, the access to outsiders were denied and they were likely communal property regimes rather than common property regimes which is the case after the state intervention in 1957. In 1978 and 1981 attempts were made to transfer the property rights to the local people but they were mostly local political units different than original communal groups. At present there is no defined property rights related to commons in Nepal. However, in case of water use systems, many traditional organizations are functioning well without state intervention. The focus of this paper is mainly on this aspect of property regimes associated with water use systems for agricultural purposes in the Terai plains of Nepal.

The growing environmental problems have added new dimensions in dealing with the problems of these property regimes. Environmental problems are always associated with the exploitation of natural resources both- renewal and non-renewal. The associated facts are due to the function and use of the resources such as; i) primary resource sources, ii) secondary sources and their use, iii) produce wastes in the production processes and assimilate them by natural process, iv) impacts of both resource depletion and pollution in the regenerative capacity of the ecosystem, v) ecological life support systems and vi) balancing of the natural system within the biological tolerance of the human bodies.

The first three aspects are related to the first and second law of thermodynamics. The fourth aspect is that due to the law of entropy, 100% recycling is not possible and all wastes cannot be converted for reuse. It presents a problem due to a high time lag in regeneration after the breakdown due to external shocks or use of the ecosystem resources and the increased level of pollution in the environment decreases the recovering capacity of the ecosystem in the short run. Man can survive only under a balanced condition and the resource depletion can have a direct impact not only in the economic processes but also in the biological and social processes.

Norgaard (1985) called it a co-evolutionary perspective as both the ecological and social systems coevolve together. The neglect of one or the breakdown in one can have an effect on the other. This model provides interesting insights into how social systems evolve, the role of property rights and the effect of stock resource use on this evolution. Environmental and resource economics should provide evolutionary explanations of biological system behavior and physical science explanation of atmospheric, hydrological and geological phenomenon (Norgaard, 1985). In the rest of the paper we will focus on co-evolution of agriculture and water use systems in Terai belts of Nepal.

Co-evolution of Agricultural Systems in Terai

Regmi (1981) reported that the entire Terai region located on the fringe of northern Indian plains was relatively undeveloped at the middle of nineteenth century. the evolution of agricultural systems in this area were brought by the rulers after this period by granting *birta* to service men and others in order to increase the state revenue from agriculture. Regmi (1988) further reports that the development of Indian railroads systems after the third quarter of the nineteenth century opened up unlimited prospects of the for the export of agricultural and other commodities from the terai regions of Nepal. This led to the large immigration of people from India and the development of the agricultural system started in the regions. Due to fear of malaria, people from the hill were still reluctant to migrate in this region and it was only after 1950 they started to migrate in this area. both the original settlers and the migrants contributed to develop their own indigenous irrigation systems for rice cultivation in the Terai belts.

Upper Watershed Degradation and Traditional Water Use Systems in Terai

People in the Terai plain reported that the major river and streams had a narrow and deep channel when they started to divert the irrigation water from these sources by making brush dams. However, over periods the river course changed and the bed width has extended and the bed level has raised creating a lot of problems to FMIS. Examples are Tedhi-Gurgi Ssytems and Karnali Irrigation Systems in the Far Western Nepal (Yoder et al., 1987, Pradhan et al., 1987). This environmental change in the plains is closely related with the increasing watershed degradation particularly in the middle hills. A reconnaissance study on the watershed conditions of Nepal (Nelson et.al, 1983) is the only source available that describes the overall watershed conditions in Nepal. The overall watershed conditions are categorized into five classes: excellent, good, fair, poor and very poor (Map 3). In the middle mountain zone, 14% of the watersheds are ranked as excellent, 65% good, 15% fair 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). The water use systems located down stream of degraded watersheds have experienced a serious problems due to i) scarcity of forest resources, ii) increased flood frequency and siltation of the canals resulting in increased maintain of brush dams and canals, iii) collapse of some traditional systems due to both increasing necessity of resource mobilization and increased conflicts (Appendix 1).

Failure of some Traditional Systems to cope with Changing Environment : The summary of Water Use Inventory Study (WECS, 1987) indicated that there are about 1820 locally developed canal irrigation systems in the Terai belts of Nepal. The size of such systems range from less than 5ha to as large as 15,000 ha. But over periods such indigenous systems have lost their identities due to growing environmental problems and social conflicts (Tiwari, 1988). A reconnaissance survey was carried out in 1987 to know the status of such systems with irrigated area larger than the 1000ha as recorded in the inventory study. The findings of the reconnaissance survey indicated that:

Among total systems studied (14nos.) only eight systems Babai, Deukhuri, Panch and Saat Mauja, Chattis and Sorha systems were found having system command area over 1000 ha with perennial source of water. In most of the systems all the land area command is already irrigated through the system network.

Irrigation systems in the east terai were found now irrigating less area than in the past due to increase in conflicts among villagers. Expansion in irrigation area through the use of better water management practices are possible in these systems during rainy seasons. In some cases, farmers are not making strong efforts as they hope their area will come within government projects.

Tree branches and stones are the main materials enabling farmers to divert the water flow and regulate water flow among the distributors by making check structures. In the absence of these materials in the eastern terai compared to west systems farmers have to pile either sand or mud to make diversion structures. This has led to difficulty in controlling the flow of water in the canal and every year their field are damaged by floods.

All systems cropping pattern, follows with rice as the main crop. Cropping of early paddy was found only in small area in each irrigation systems. While systems fed by Babai and West Rapti have sufficient water for early paddy, in other systems water is sufficient only for wheat in winter season. In the Babai and West Rapti systems, the low cropping intensity was because of i) low price of products, ii) household consumption oriented production rather than market oriented, iii) lack of agricultural demonstration activities within the area. In other systems lack of water and strong organization was found as the main constraints in increasing cropping intensity.

Systems in the western parts are functioning better in comparison to those in the eastern

ORGANIZATIONAL STRUCTURE AND STATUS OF THE SYSTEMS

Name of System and Location	Level of Orgn.	Nos. of Comm. Mem	Separate or LPU Comm.	Basis of Res. Mobilization	Status of System/Orgn	Upper watershed Condition
1. Raj Kulo, Bardia	2	19	Separate	Land & Household	Very strong	Very Poor
2. Padnah Kulo ,,	2	15	Separate	Land & Household	Very Strong	Very Poor
3. Baniyabhar Kulo	2	8	Separate	Land & Household	Very Strong	Very Poor
4. Kalapani Kulo Deukhuri valley	3	15	Mixed	Land & Household	Very Strong	Marginal to Very Poor
5. Panch/Saat Mauja Rupendehi	3	42	Mixed	Land & Household	Very Strong	Poor to Very Poor
5. Pahila Bandh, ,,	2	not defined	Mixed	Household	Medium	,,
7. Amaltari Ko Kulo Nawalparasi	1	1	Separate	No Defined Basis	Poor	Fairly Good to marginal
8. Badgaon Paini Bara	2	7	VP's Control	Household	Strong	Very Poor
9. Enerwa Mal, Bara	1	not defined	VP control		Poor	,,
10. Pokharvinda Kulo Rautahat	2	6	Mixed	Household	Poor	,,
11. Sanatpur Kulo ,,	2	5	Mixed	Household	Strong	,,
12. Damhi Nahar Mahottari	1	2	Mixed	Landholding	Medium	Fairly Good to Poor

parts. The organization pattern also differs among these systems. While in western systems there are separate canal committees, in the eastern systems the whole management of the canal systems are done by village panchayat members. The organizational patterns and the success or failure of the system to cope with the changing physical environment is given in Appendix 1.

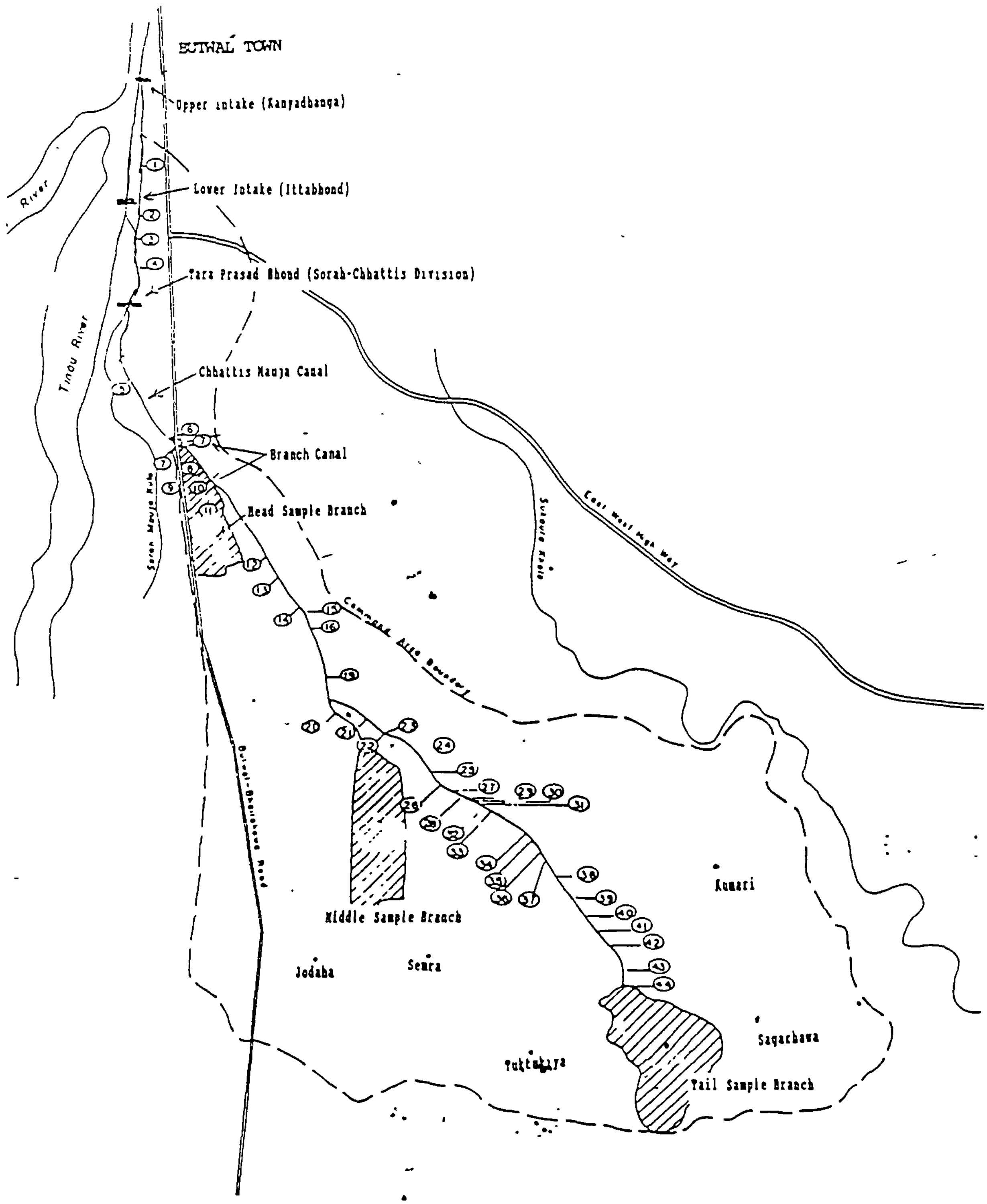
However, some of these FMIS in Nepal have presented an excellent example of success of traditional organizations to cope with both changing physical and social environments. A case study of Chhattis Mauja Irrigation System (CMIS) based on one years field research (Tiwari et al., 1989) is presented here as an example.

Coevolution of Agriculture and Water Use Systems in Chhattis Mauja

The Chhattis Mauja farmer-managed irrigation system is one of the largest irrigations systems in Nepal. Despite its size, its historical development is difficult to trace because its origins go back more than 180 years. Also many of the original settlers' families, who are primary sources of information, have migrated out of the area. Elderly farmers resident in the area have to be relied upon for information concerning the development of the system. They say that early settlement of the area concentrated near the town of Bhairahawa for security reasons. These settlements gradually spread toward the north. A road linked Butwal and Bhairahawa along the eastern side of the Tinao river. Most of the area presently included in the system's command area was densely forested until 1940. In the forested area, the Tharus, a hardworking and carefree people, lived in the settlements now in the tail end section of the present system. However, most of these villages do not use the canal water now because they receive water from the Bhairahawa Lumbini Ground Water project and from drainage water collected from the CMIS command area.

The elderly local farmers say that the Chhattis Mauja irrigation system was built by the Tharus during the regime of Junga Bahadur (1846-63). At that time it served only village in the tail end part. Some migrated people in this village received a tax-free land grant from the Rana ruler then in power, Chandra Shamshere, between 1901-29. likewise, in the east part of the present command area, Chandra Shamshere also granted approximately 1,200 hectares of tax-free land to other family. Another ruler later confisticated this land, but it was returned to Ram Mani during the rule of Judha Shamshere (1933-45). This all led to the successful expansion of the irrigation system over the area. Furthermore the struggle over the control of the irrigation system led to the realignment of the physical network and reorientation in the organizational structure. The original Tharus slowly lost their control

Figure 2.2. Chhattis Mauja irrigation system.



over the system but it produced more hierarchial organization system which presents a model to other irrigation systems in Nepal.

The command area continued to expand from 1940 to 1960 due to immigration of hill people to the Tarai. At one point during this period the system served 36 villages, and came to be known as the Chhattis Mauja (meaning "36 villages" in the Nepalese language) irrigation system, by which it continues to be identified as today despite continued expansion. Regarding the history of the settlement in the study branches 12 farmers were settled before 1950, 12 farmers in between 1950-1960, 23 farmers in between 1960-1970, 44 between 1970-1980 and 10 farmers from 1980 till now among the sample farmers. On the other hand, the number of settlers who settled during 1970-80 period are 14, 18 and 12 in head, middle and tail respectively. It is therefore believed that the CMFMIS command area was expanded from tail to head (i.e., from south to north).

Table 1.0 Periodic settlement in CMIS

Period	Head (no.of settlers)	Middle (no.of settlers)	Tail (no.of settlers)	Total (sample systems)
Before 1950	0	0	12	12
1950-60	6	6	0	12
1960-70	6	11	6	23
1970-80	14	18	12	44
1980-over	1	5	4	10
Total (Sample size 60%)	27	40	34	101

Source: Field Survey, 1989

The total command area of the present Chhattis Mauja irrigation system is estimated to be 3,500 ha(source:air-photo maps of 1964 and 1978/ground checking.), which includes 54 villages. There is a joint operation system for water acquisition as well as for water sharing with the Sorah Mauja system (which presently covers 33 villages).

The source of water for the system is the perennial Tinao river whose flow fluctuates greatly from monsoon to dry season. At the head of the town of Butwal the river changes from narrow to wide banks and enters the lowland plain, depositing large boulders and heavy silt, making water acquisition for irrigation extremely difficult. The Chhattis Mauja irrigation system is run-off-river gravity flow using a temporary brush diversion approximately 792 m in length. The alignment of the brush diversion along the upstream portion (563 m) is changed and reconstructed each year according to fluctuations in the flow. In the winter when flow in the Tinao is low, the brush diversion is extended upstream as far as the farmers think necessary to capture sufficient water. The length of the brush diversion is reduced and shifted downstream in the rainy season due to the high flow of water. The last 228 m of the dam is constructed with stone crates. This section is more stable and requires less repair. The width of the canal near the intake is approximately 70 m. The height of the dam above the river bed is one meter.

Agro-ecological Characteristics of the System

The topography of Rupandehi District where the CMIS is located is flat, or nearly flat plain, sloping in a general northwest to southeast direction with an average gradient of 0.1 to 0.2 percent. Elevations range from about 120 m in the northeast to about 90 m in the southwest. The soils in the district are alluvial, moderately finely-textured silty loams, silty clay loams and silty clays. They are neutral to moderately alkaline in pH value. Nitrogen deficiency is a common feature whereas availability of phosphorous and potash is relatively better. Organic matter content is very low, ranging between 0.99 and 2.48 percent. The physical characteristics and nutrient levels of the soils in the study areas are shown in Appendix 2.

Three secondary canals were selected at the head, middle and tailend of the system for detailed study on agro-ecological characteristics and other socio-technical aspects. Field interviews and action research was carried out between May 1988- March 1989. The results of farmers interview showed that in the head branch all the sample farmers (27) are found to have agriculture as the main occupation whereas in middle (out of sample 40 farmers) and in tail (out of sample 34 farmers), 38 and 27 farmers are found to have agriculture as the main profession. However, 95, 60 and 50 per cent of the sample farmers in head, middle and tail branches respectively have reported to have other occupations in addition to agriculture. Farmers deriving income from secondary sources other than agriculture are

40 per cent in head, 66 per cent in middle and 60 per cent in tail. In head branch out of total sample farmers (27) nearly 50 per cent are engaged in agriculture. In middle branch out of sample farmers (40) representing 306 people, nearly 40 per cent are engaged in agriculture. In tail branch out of sample farmers (34) representing 260 people nearly 45 per cent are engaged in agriculture. Likewise, in head branch out of total sample farmers (27), nearly 30 percent hired labor for agriculture purposes. In middle branch (40 farmers) nearly 30 percent and in tail branch (34 farmers) nearly 10 per cent hired labor for agriculture purposes.

In the head branch, no farmers rented in land for the main crop rice whereas, in the middle branch, nearly 11 per cent farmers rented in land and in the tail branch, 10 per cent farmers rented in land for rice crop. Similarly, in the head branch, 14 per cent farmers rented-out land, in the middle branch 4 per cent farmers and in the tail branch, nearly 5 per cent farmers rented-out land for rice crop.

Organizational Structure

The main activity of the CMIS is concentrated on intake maintenance and canal desiltation because of the large seasonal floods on the Tinao river which frequently damage or wash away the temporary intake brush dams and cause a large amount of silt to flow into the canal. In seasons other than the rainy season the discharge in the Tinao river is below four cumecs, and Chhattis Mauja must also share water with other FMIS. Therefore, there is a limited availability of water except in the rainy season, causing water allocation and distribution and conflict management activities to be other very important activities of the irrigators. To perform all of these activities a well-defined five tier organization exists. The daily management at different levels of the system is controlled by functionaries who are elected at the respective level or tier in the system. Meetings are held at each tier to direct the functionaries, resolve conflicts, discuss financial matters, and adjust rules and operational policy. Table 2.0 shows the relationship between the type of activities and the jurisdiction of the different tiers or organization.

Resource Mobilization

Four types of irrigation activities were observed to occur: 1) the mobilization of external resources, 2) mobilization to accomplish main canal desiltation, 3) mobilization for branch canal desiltation, and 4) mobilization for emergency maintenance. The main task of the organization is to mobilize labor for the repair of main canal brush dam. farmers reported that due to increased degradation of upper watersheds the frequency of maintenance has increased over period. During the 1988 rainy season the intake required major repairs 34 times and the farmers worked on 24 other occasions to affect minor repairs. About 15,000 bunches or 75 tons of brush (one bunch = 5 kg) were consumed during one year to repair the intake. Locally available brush and tree branches were used for this purpose. Due to increased unavailability of these materials farmers seek external helps to construct permanent structures wherever, they found appropriate to make such structures. Most of the secondary canal intakes and the main water distribution structure between Sorah and Chhattis mauja are now have permanent weirs. The resource mobilization patterns in three selected branches is given in Table 3.0. As seen from the table while the cost per culara is high in tail end branch the cost per ha is low compared to head and middle branches. this is due to the additional length of the individual branch which adds more costs to the desilting works.

Table 3.0 Labor Mobilization from Three Sample Branches

Description	Head	Middle	Tail
Water Allocation Share (Kulara)	5	4	2
Land Area (Ha)	50	70	92
labor Mobilised			
Regular canal desilting	186	174	74
Emergy maintenance	469	364	174
Total	655	538	248
Labor per Water Allocation (Persons-days/kulara)	131	135	124
labor per ha	13	8	3
Cash Equavalent of labor	16375	13450	6200
Cash paid in lieu of labor	4600	9800	6200
Total Cost	20975	23250	12400
Cost per Kulara	4200	5800	6200
Cost per ha	420	340	135

Water Allocation and Distribution

Chhattis Mauja receives 60 per cent of the total flow in the canal at this point for its use, leaving 40 per cent for Sorah Mauja. This water allocation proportion was determ ied by the zonal commissioner at the time that the Sorah Mauja system began sharing the same intake with Chhattis Mauja in 1965.

The CMIS has specified entitlement of each branch canal and established rules and procedures to fulfillment of that entitlement. Allocated discharge per Kulara (l/sec/ku) as per the measured discharges at Tara Prasad Bhond (Sorah and Chhattis Mauja divide) for the seeding and transplanting of rice in 1988 season are presented for head, middle and the tail branch.

The head branch had the highest average allocation of 73 l/sec/ku against actually received average of 23 l/sec/ku for the whole period of seeding and transplanting. The middle branch had the average allocation of 63 l/sec/ku against actually received average of 12 l/sec/ku. This was followed by the tail branch which had the average allocation of 38 l/sec/ku against actually received average of 12 l/sec/ku. Discrepancy was found on allocated discharge than on actual received. Ratio distribution of allocated discharge is 1.9 for head, 1.6 for middle, and 1.00 for tail branch. In other words, for every one 1 l/sec per kulara allocated to tail branch, correspondingly head branch was allocated nearly twice as much and the middle branch about half with respect to the allocation of discharge made to tail branch. Where as, ratio of distribution of actual received discharge is 2 for head, 2 for middle, and 1 for tail branch. Allocation and distribution seemed consistent with the distribution of kulara entitlement of respective study branches. However, plentiful amount of rainfall within seeding and transplanting period precluded the need to effect systematic water-distribution rotation on system basis. It was observed that CMIS effected water distribution on rotation basis for seeding to 28 tail branches which did last for more than 10 days. For transplanting also it was not necessary for the CMIS management to distribute water to branches on rotation basis. In head branch, it was observed that farmers resorted to within-branch rotation distribution for about nearly 21 days, where whole command area of the branch was divided into two halves and water alternated from one half to another in 24 hrs. The rotational distribution of irrigation water was not required in middle and tail branches for transplanting. It was observed in middle and tail branches that farmers had to postpone transplanting in order to let the extra standing water drain off from their fields. On the whole, it was observed that water was sufficient for seeding and transplanting this year and precluded the need for management to enforce water-distribution on rotation schedule.

The demand for water by particular branch command area people also largely dependent on the nature of topography and soil characteristics which influence the seepage and percolation loss from the fields. the regression lines for the sample data indicate that the

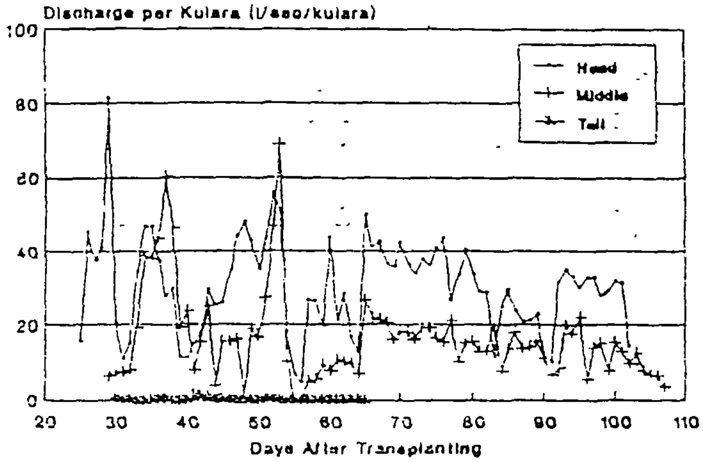


Figure 3.0 Daily Average Irrigation Supply per Kulara in the Three Sample Branches.

combined loss from seepage, percolation and evapotranspiration was on average about 100 millimeters (mm/day) for head branch, 70 mm/day for the middle branch, and 20 mm/day for the tail branch. With losses of 70 mm/day, more than 8 liters per second per ha continuous water application would be required to maintain ponded water conditions. Due to high S&P losses farmers had to maintain a strict rotational schedules.

Rice Yield Distribution in the Sample Branch Command Area: The rice yield estimates for each crop cut sample of plots receiving irrigation from the system are shown in Figure 5.0. The mean of the estimated yield from the twenty-two sample crop cuts was 3.7 t/ha with a standard deviation of 0.9 t/ha. This yield was well above the national average yield of 2.5 t/ha for the year 1988 and also near to target yield of 3.8 t/ha used in preparation of Nepal's irrigation master plan (CIWEC, 1989). From an agricultural production prospective the CMIS performed well in the 1988 monsoon rice season.

Though the crop cut sample was small the trend found was toward a slightly higher yield in the middle branch. Analysis of variance comparing the mean yield in the head, middle and tail areas shows that there is no significant difference at a 95% confidence level. The conclusion drawn was that difference in water delivered to different parts of the system did not have an adverse effect on rice production. there could be numerous causes for the

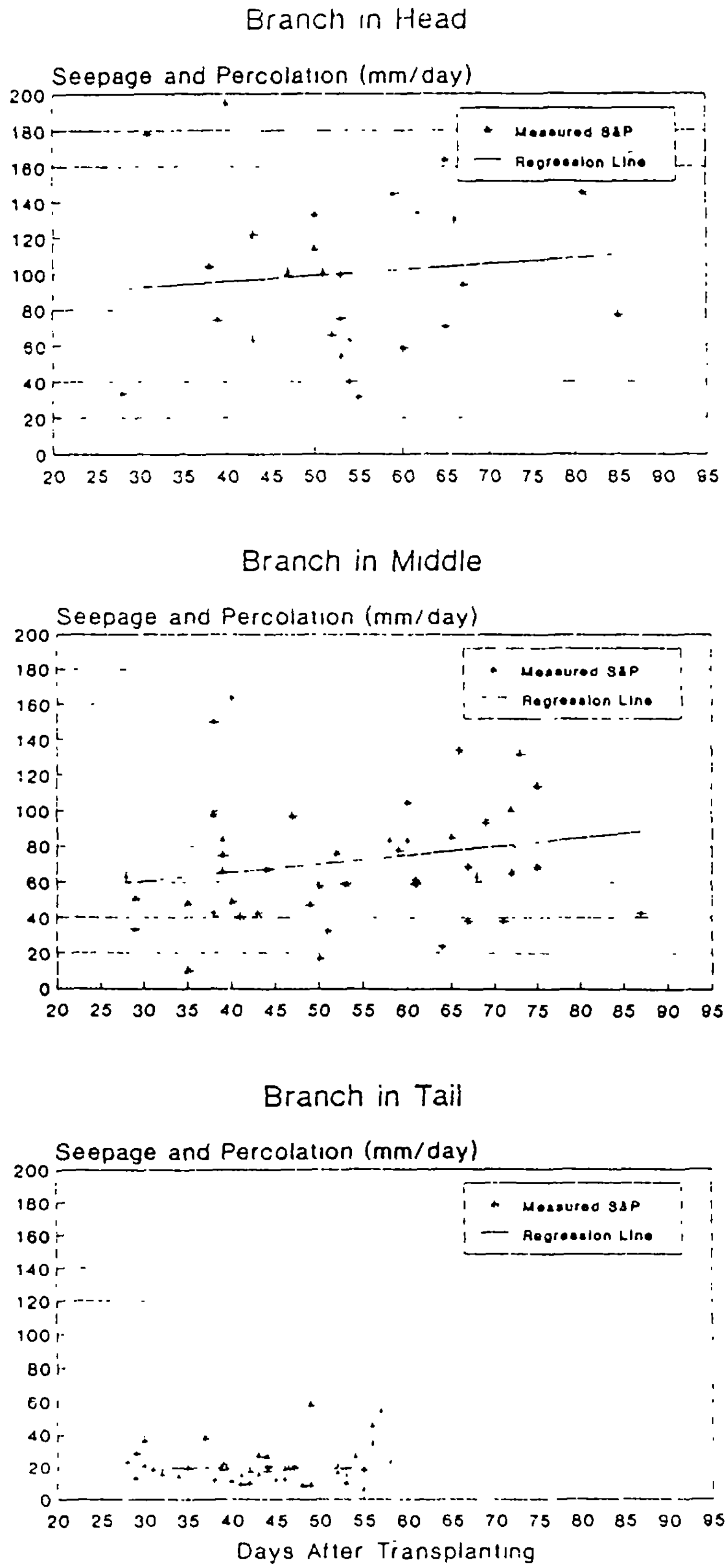


Figure 4. Seepage and percolation rates estimated from surface water subsidence measurements.

observed low variation in yield among the sample branches.

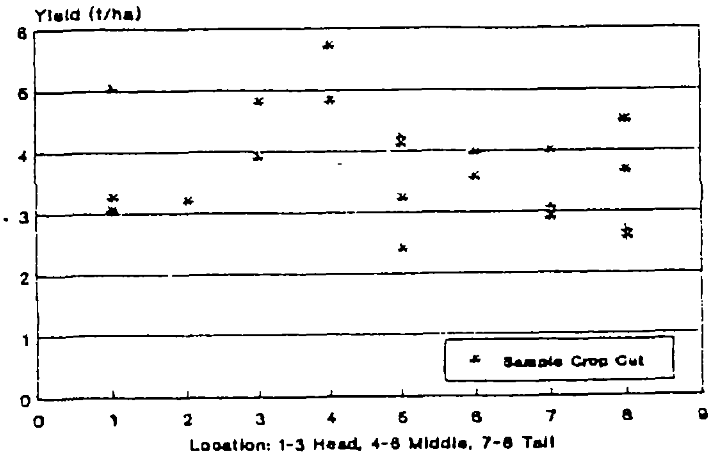


Figure 5.0 Crop yield Estimates from the Sample Branches.

Conclusion : Need of an Alternative Framework for Investing in Natural and Cultural Capital

The growing environmental degradation, resource deficit and failure of some traditional management systems associated with the management of commons in Nepal demand a change in the overall economic policy and investment criteria. The sustainability criteria developed indicate that the problem of poverty and environmental degradation is closely linked with natural capital. The best way to invest in natural capital is to analyse the nature of physical degradation and its link with the functioning of the locally managed systems. The maintenance of natural capital and sustainable use depend largely upon the capability of these local organisations. However, in project formulation and decesion making processes these factors are not considered properly. The lack of political and bureucratic committment to solve these issues demand the change in investment mode. It should go directly to the building up of local institutions and only then investment decesions should be made. We need to work out separate criteria for making investment decesions that involves both the natural and cultural capital. The first task is periodical ecological-economic accounting of the systems on watershed basis through the use cf local knowlege and expertise. The second is integration of economic and environmental accounting at the national level. An alternative frameowk with integration of economic and environmental accounting is being developed to change the policy in Nepal (Tiwari, 1992). The third is to empower local organisations by launching more decentralised approach and creating awareness to the local people. Will the international development agencies revise the present investment criteria to build up local organizations for managing commons and give pressure to the national governments to change in this direction? Both the sustainable use and management of the commons and the future of the local organisations as well as people living in the degraded watersheds will depend on how the international community will respond to these challenges.

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(The GIS Part is not included in this paper if some one of you are interested I can send you my final paper later on).

Thank you!

Tiwari

Table . . Physical characteristics and nutrient levels of soils in the study branches.

Parameters	Branch Head	Branch Middle	Branch Tail
PH	7.5	7.4	7.6
Total Nitrogen (%)	.080	0.090	0.087
Available Phosphorous (Kg/ha/ppm	24.66	27.60	4.40
Available Potassium (Kg/ha/ppm)	67	109	64
Organic matter (%)	1.898	2.121	2.546
Soil texture	Sil	Sil	Sil
Wet density (gm/cc)	1.16	1.76	1.52
Bulk dry density (gm/cc)	1.29	1.55	1.33

Source: Soil test results

SORAH CHHATTIS MAUJA JOINT COMMITTEE

Joint Committee Chairman

Joint Committee Vice-chairman

Joint Committee Meth Mukhtiyar* -- (1)

Joint Committee Messengers* -- (1)

Member** (1)	Member (2)	Secretary (1)	Member** (2)	Member (3)	Member (4)	Member
From Sorah Mauja		From Chhattis Mauja				

*employees
**ex-officio members

WATER FLOW & DISTRIBUTION MECHANISM IN CHHATTIS MAUJA SYSTEM

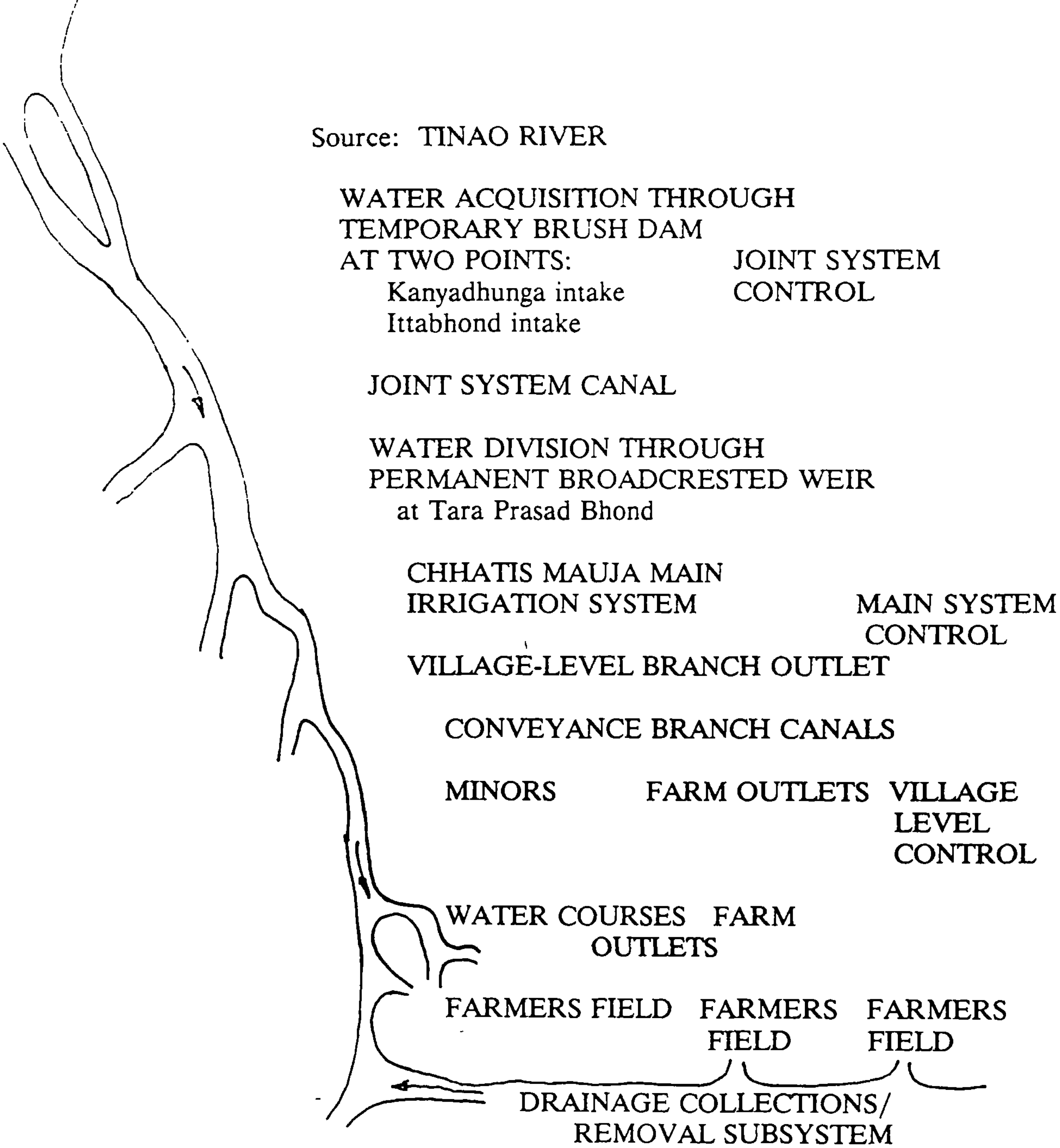


Figure 1.3 Watershed condition in the districts of Nepal

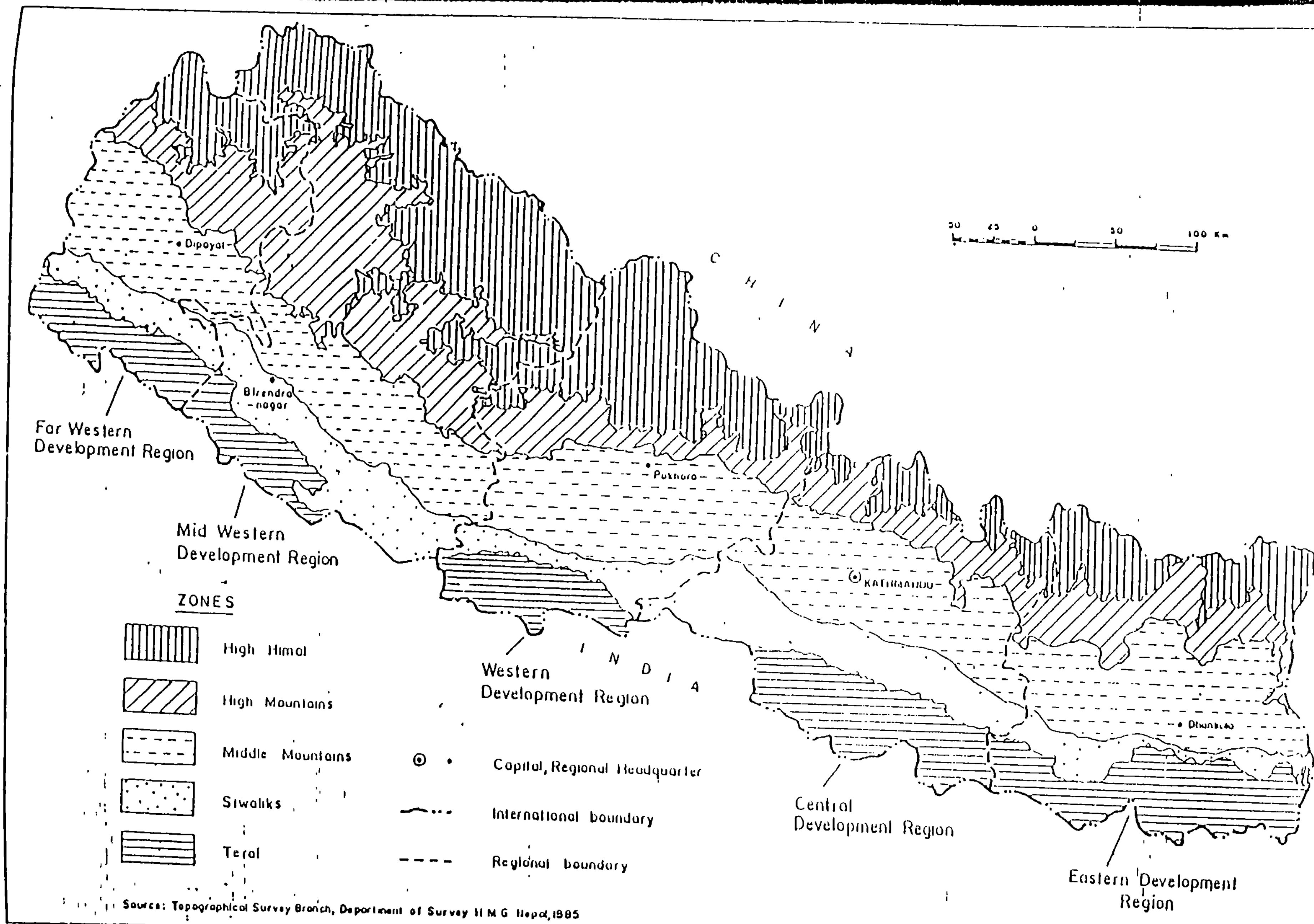
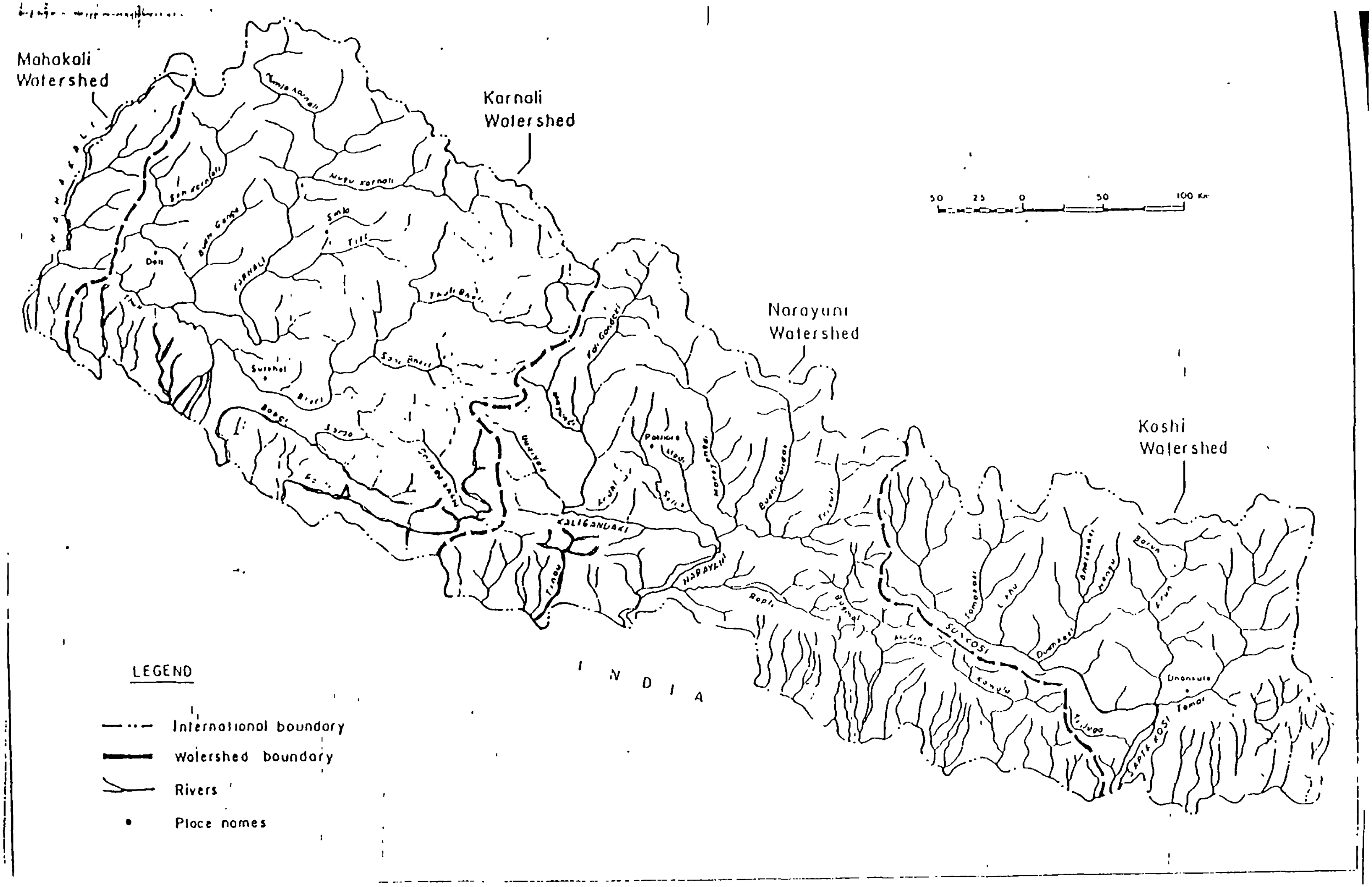


Figure 1.1 The subregions of Nepal


Mahakali Watershed
Karnali Watershed
Narayani Watershed
Koshi Watershed
50 25 0 50 100 Km
INDIA
LEGEND
International boundary
Watershed boundary
Rivers
Place names
KALIGANDAKI
NARAYANI
SUNKOSI
SAPTA KOSI