Introduction to the Watershed Project: Issues and Overview

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1. OVERVIEW OF THE WATERSHED STUDY

Given the lack of long term information on land use, resource degradation, sediment transport and soil fertility in Nepal, in 1989 the Jhikhu Khola watershed was established as the key research area for a long term monitoring program. With the support of the International Development Research Centre (IDRC), we focussed our research on documenting climatic conditions, soil erosion, sediment transport and redistribution, stream flow, irrigation, deforestation, agricultural intensification, soil fertility, socio-economic conditions and population growth in the watershed. After the first three years, we initiated a number of smaller projects which attempted to translate our gained knowledge into development efforts. These activities included the construction of a suspension bridge, upgrading of rural water supply systems, reclamation of degraded areas, electrification of three houses with solar-powered photovoltaic cells, and introduction of a water-conserving trickle irrigation system. Computer technology was used in monitoring as well as in data organization, and a PC-based Geographic Information System (GIS) was used as the main tool for data integration and modelling.

No standard methods exist to examine resources in an integrated and interdisciplinary manner, so we focussed our efforts on trying to gain a better understanding of the intensification of biomass production and environmental consequences. A watershed approach was used, involving an interdisciplinary team, and relied on GIS for data integration. The papers compiled for these workshop proceedings are intended to inform other researchers and NGO's about the Mountain Resource Management Project (MRM), highlight the most important findings and discuss directions for ongoing research activities. The project attempts to address all relevant issues associated with the development of a rural watershed. Much of the initial efforts were spent on building a comprehensive resource database. In 1991, we held the first workshop, entitled: "Soil Erosion and Fertility Issues in the Middle Mountains of Nepal", and this workshop resulted in a status report on the most pressing resource and socio-economic conditions in the watershed. These second workshop proceedings are intended to provide a better understanding of the key resource degradation processes with emphasis on cause and effect relationships and rehabilitation options.

The gaps in our understanding of these processes are still large and what we present is our modest contribution to understanding the dynamics of land use and management in this very intensively used Middle Mountain watershed. The conditions for intensive biomass production are far from optimum, and the population pressure is such that it raises the question of whether the current resource use will maintain the long term productive capacity in the watershed. The issues and processes are complex, and innovative solutions and successes are few. The input and constructive suggestions by all participants during the workshop are greatly appreciated and, with the proceedings, we hope to foster dialogue between disciplines, researchers and resource users concerned with the deterioration of resources and environmental quality in this watershed.

2. GENERAL INTRODUCTION

Rapid population growth and resource constraints are putting severe pressure on the subsistence economy in the Middle Mountains of Nepal. Claims about massive deforestation, soil degradation, accelerated slope

instability, and losses of the productivity base for agriculture are widespread. Unfortunately little quantitative information shows the rate and magnitude of these changes. In the absence of such information, predictions of the possible long term consequences of the current land use intensification and the use of marginal lands are difficult to make. To stimulate future development, initiate conservation programs, and point the way towards sustainable resource use, bio-physical and socio-economic processes must be better understood. It is the aim of this research project to address the issues of food, animal feed and firewood sustainability in the Middle Mountains of Nepal and to document the changes that have been taking place over the past 40 years. This information will be used to arrive at development scenarios which include the consequences of resource degradation and alternative development options.

3. BACKGROUND, PROJECT JUSTIFICATION AND AIMS

3.1. Background and national resource issues

Nepal has resource constraints that are somewhat unique in the developing world. These constraints include extremely high rates of natural erosion, marginal terrain conditions for biomass production dominated by steep slopes, a distinct dry season, very rapid population growth, and no room for population migration. To answer these challenges, Nepalis have converted their hill slopes into a multitude of terrace systems that are under double and triple annual crop rotations. The introduction of short growing season crop varieties and the use of an intricate network of irrigation systems have made it possible to increase food production levels, but shortages are still widespread. Given the remoteness, lack of infrastructure and difficult topography, questions have been raised as to whether such intensive cropping systems are sustainable given the naturally high rate of erosion and the relatively low availability of inputs.

The world's press has devoted much attention to the claims that rapid deforestation in the Nepali Himalayas are in part responsible for the recent devastating floods in the Ganges Lowland of India and Bangladesh. Little scientific information is available to substantiate the claims that human activities are influencing the frequency and magnitude of lowland flooding. Additionally, the multiple annual crop rotations are a relatively recent phenomenon (last ten years), and the effects are becoming apparent as the intensification proceeds and the inputs decrease. Very little long term data on land use, soil fertility maintenance, erosion and sedimentation processes are available for this part of the world, and the project was initiated to fill this important information gap.

There are many international development assistance programs in Nepal, but neither the aid organizations nor the recipient government agencies have been able to successfully translate this assistance (which is substantial) into improving the local economy or the subsistence level of the mountain farmers. The issues of long term sustainability are rarely addressed by these programs.

The recent introduction of democracy to Nepal has been hailed as the way towards development, but it is increasingly clear that changes are slow and difficult to initiate because of a lack of experience in the democratic process and a government infrastructure that is unable to cope with the demands and aspirations of its people. This is aggravated by the very marginal environments in which the people in the mountains live. These mountain systems are not as resilient and productive as the lowlands, and the issues of sustainability are far more challenging with consequences that reach far beyond the boundaries of the headwaters regions.

The Land Resource Mapping Project (LRMP, 1986), which was conducted between 1978 and 1984, represents the first systematic inventory of the soil, forestry and agricultural resources in the country. The information obtained by this survey provided the basis for the development of the Forestry Master Plan

(HMGN/ABD/FINNIDA 1988), the Master Plan for Irrigation Development (HMGN, 1989), and the Master Plan for Horticultural Development (ADB, 1991). More detailed evaluations were carried out for food, feed and fuelwood resources by Schreier et al. (1991), and Smith et al. (1993). From these studies it became evident that animal feed was the most critical resource in 1981 with 57% of all districts reporting feed deficits. The overall food production was estimated to exceed the demand by 25%, and fuelwood was considered the least critical resource at that time (Schreier, 1991). Using the human and animal population growth rates between 1980 and 1986, projections were made to the year 2000 using the assumptions that the resource base is not changing and the production capacity obtained in the early 1980's can be maintained. The results from these calculations indicated that by the year 2000, animal feed would be insufficient in 74% of Nepal, and food deficits would occur in one third of the country. While these calculations are highly speculative, they do provide a general indication of priorities and the magnitude of the resource problems. It became evident that inventories are essential to obtain a status report of the country, but, unless we monitor rates of change, we will have great difficulties arriving at a better understanding of the resource dynamics, production performance and degradation. This puts future plans for conservation, maintenance of carrying capacity and improvement of biomass production into question. Because of the lack of information on resource dynamics, resource demands and degradation processes, a detailed watershed study was justified.

3.2. The Jhikhu Khola Watershed Project

3.2.1. BACKGROUND

The Jhikhu Khola watershed, which is one of the most intensively used Middle Mountains areas of Nepal, was chosen for the project because all of the problems commonly associated with population growth, agricultural intensification and deforestation in a marginal environment are present in this watershed. The watershed has all of the infrastructure and make-up of a typical Middle Mountain valley. What sets it apart is that the watershed can be reached by motorable road and the Arnica highway which connects Kathmandu with Tibet passes through the centre of the watershed. This road can be reached from the most remote village by a five-hour walk, and the distance to Kathmandu is about 40 km. This watershed provided a number of advantages since it allows us to examine how traditional subsistence agriculture can be modified to a more market-oriented economy. In some ways this makes the Jhikhu Khola a futuristic Middle Mountain watershed and should allow us to document possible development opportunities that may be applied to other watersheds within the Middle Mountain region.

The watershed is located in the Kabhrepanalchok district some 40 km east of Kathmandu (Figure 1) and covers 11,141 ha. The elevation ranges from 750-2,100 m, and the watershed is subject to a monsoonal climate with an extensive dry season from October to May. A 1:20,000 scale topographic base map was produced as part of the project and served as a basis for all resource inventories and GIS analysis. Historic 1972 aerial photos were available, and new aerial photos were obtained in 1990. These photographs served as a basis for the historic analysis of land use, and the 1990 cover was also used for the soil survey study. Both set of photographs were enlarged to 1:5,000 scale and became the basic planning tools for the socio-economic survey and determination of population trends since each individual house could be identified on the enlargements.

3.2.2. JUSTIFICATION OF PROJECT

The reasons for the selection of the Jhikhu Khola watershed as the study site are manyfold but the most important ones are:

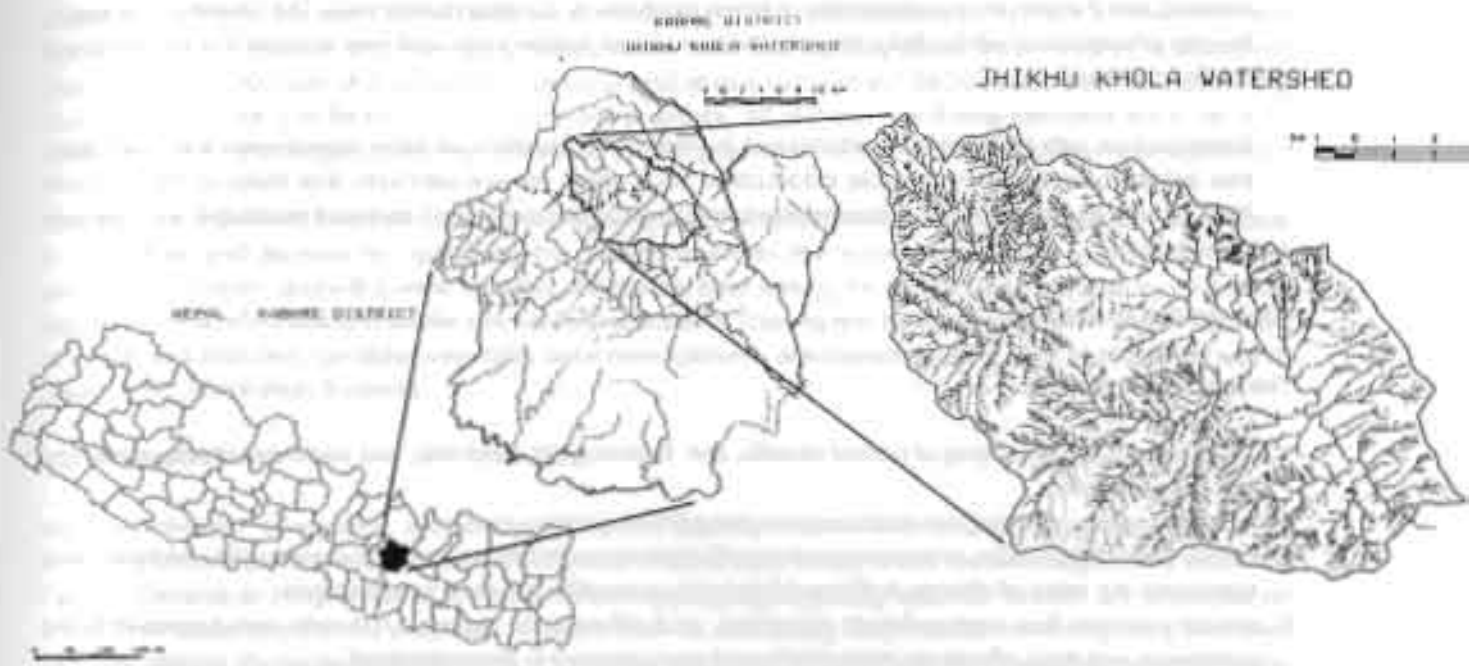

Figure 1. Location of Jhikhu Khola watershed.

- Hydrological processes in the Himalayas are substantially different from those in more temperate regions, yet little good scientific data is available to document these differences. This is particularly critical in view of the fact that the Middle Mountains represent one of the most modified human landscapes in the mountains of the world. The hydrological processes also need to be better understood in view of the extensive hydro-power potential that is constantly advertised by Nepal and aid agencies. The philosophy of building large hydro-dams is still prominent in spite of recent concerns about environmental stability and economic viability.

- Agricultural intensification is putting into question the long term sustainability of the productive capacity of the mountains, and in this context soil erosion, soil fertility maintenance, and irrigation are the key issues.

- In order to progress from a subsistence economy towards a market system, transport is a basic necessity. Having a road infrastructure which is currently being upgraded, and having growing market access in the capital city which is within 40 km of the watershed, provide the essential footings for introducing additional cash crops into the agricultural system.

- Historic aerial photographs (1972 and 1979) and land use change evaluations are available to provide historic land-use dynamics which are required to document rates of degradation and levels of sustainability.

- The watershed has a very active afforestation program, the Nepal-Australia Community Forestry Project (NACFP), and their staff expressed interest in obtaining better resource information in exchange for supplying vital historic information about forest management practices and afforestation efforts.

- Successful tree planting programs have been introduced at the community level by NACFP, but until now, little attention has been paid to soil fertility issues. The forests are losing nutrients by fodder and litter

removal, and the long term sustainability of forest productivity is being questioned. The existing community forestry infrastructure will facilitate the introduction of new fodder trees and new approaches for forest soil fertility management.

- Relationships with local farmers established in Phase I will facilitate on-farm experiments such as fodder tree establishments and vegetable introduction. As a result, we are optimistic that many of the research findings can be translated into development that has a better scientific basis and points the way towards sustainability.

3.2.3. AIMS OF PROJECT

The main aims were to:

1. produce a detailed inventory of current climatic, soil, hydrological, land use, and socio-economic conditions in the watershed;
2. determine rates of change in land use over the past 40 years;
3. identify major degradation processes such as soil erosion, sediment transport and soil fertility declines, and determine the rates of change in these processes under different land use practices;
4. quantify stream flow and sediment dynamics, and differentiate between naturally and human-induced processes and their effects on productivity and management in the watershed;
5. identify successful land use practices (traditional and introduced) that can be used as a model to improve land use, productivity and management in other parts of the Middle Mountains;
6. develop GIS techniques that facilitate the integration of resource information, assist in quantitative modelling of processes and serve as effective communication tools in educating farmers and managers about carrying capacity and sustainability and
7. provide suggestions on how the scientific information can be used for development and translated into actions leading towards more sustainable resource management in the watershed.

4. RESEARCH PROGRAM AND TEAM COMPOSITION

4.1. Research Components

During the first three years, a basic resource inventory was conducted which included the generation of a general geological map, detailed soils map, current and historic land use maps, topographic map and detailed drainage system map. All of these maps were digitized into a PC-based GIS system and have formed the basis for our integrated analysis. Part of this inventory also included a number of socio-economic surveys, and all of the houses used in the interviews were georeferenced and incorporated into the GIS system.

The second component included setting up a detailed monitoring network and an intensive monitoring program. A large effort was made to establish a climate monitoring program which consisted of five automated tipping bucket rain gauges, about fifty manual 24-hr rain gauges, and five stations equipped with manual and automated air temperature monitors. Erosion monitoring was conducted at five erosion plots located in upland bari fields. Seven hydrometric stations were selected, staff gauges were installed in all of them, and four were equipped with automated pressure transducers to measure stage height on a continuous basis. A flow and sediment monitoring program was carried out from 1990 to 1995. During the pre-monsoon and monsoon season the monitoring effort was particularly intensive, allowing us to monitor most of the important storms each year. In addition to these networks, twelve forest plots were selected for a very detailed analysis of soil and biomass conditions in 1989, and these sites were resurveyed in 1994 to determine biomass and soil fertility

changes. Similarly, ten agricultural fields were selected in 1989 and resurveyed in 1994 to determine soil fertility changes. A socio-economic survey conducted in 1989 was partially repeated in 1993/94 to document changes. Finally, 200 agricultural fields and grazing land sites examined in 1993/94 were used for monitoring changes in biomass, soil fertility and management practices. All of these monitoring networks were set up to determine rates of changes in the key processes affecting biomass production and land use management.

The third component involved community development projects where we attempted to assist local communities and farmers in upgrading the infrastructure in the watershed. These activities included constructing bridges, upgrading water supplies, introducing solar energy for electricity and irrigation, reclaiming degraded lands, and training in fodder tree nursery operations. Training and technology transfer were important activities and included computer use, data base management, automated logging, data transfer and use of Geographic Information Systems.

4.2. Research Team

Multidisciplinarity, integration, and enthusiasm were the key themes that characterized the team which consisted of three groups: local farmers, the ICIMOD/MRM & UBC teams and a number of graduate students. Farmers became an integral part of the field monitoring program. Typically up to 40 farmers are employed on a part-time basis to carry out a number of tasks such as measuring daily rainfall, collecting daily sediment samples, making discharge measurements, monitoring erosion plots and assisting in reclamation work. Many of them allowed us to use their fields as a research laboratory, and all participated in the socio-economic surveys.

The MRM team was made up of a core group consisting of a soil scientist, geologist, geographer, and hydrologist. Additional members, participating on a contract basis, included an agronomist, land use specialist, engineer and several assistants with various backgrounds. The UBC team provided expertise in GIS training, hydrology, soils, land use and socio-economic analysis. Finally, the graduate students came from many different areas and had experience in forestry, agronomy, soils, hydrology, economics, and geography.

We also interacted with the National Agricultural Research Council (NARC), Soil Science Department, Topographic Survey, Department of Meteorology and Hydrology, National Planning Commission, Forestry Department, Soil and Water Conservation Department and the Nepal/Australia Forestry program.

5. RESULTS TO BE HIGHLIGHTED IN THE WORKSHOP PROCEEDINGS

Not all of the results of the research have yet been analyzed and completed, but the key components that were highlighted in the workshop cover the following topics: population and socio-economic profiles of the farmers in the watershed, land use dynamics and intensification, soil erosion, hydrology and sediment dynamics, soil fertility in agriculture and forestry, processes leading to degradation of soils and biomass, indigenous knowledge in soil classification and irrigation, experiences in rehabilitation of degraded land, community projects, use of GIS techniques to model future scenarios, communicating science for development and lessons learned and mistakes made.

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