The Jhikhu Khola watershed project in the Nepalese Himalayas: Approaches used and lessons learned

H. Schreier, Sandra Brown and P.B. Shah

Abstract

Agricultural expansion into marginal lands and intensification in irrigated agriculture (triple annual crop rotations) are leading to rapid soil nutrient depletion, water shortages and water pollution. These processes were studied in the Jhikhu Khola watershed, one of the most intensively used watersheds in the Middle Mountains of Nepal. Forestry and livestock play a key role in maintaining agriculture and both systems are under stress. A combination of biophysical and community based socio-economic surveys were conducted to determine the status of the resources, and GIS was used to integrate and evaluate the data. The methods used in the research program have evolved from a heavy emphasis of biophysical surveys to a mixture of computerized monitoring and rapid participatory surveys. Using computer-based techniques proved to be very effective in integrating the information and in communicating the results. Good indicators have been identified to document degradation processes and rates of change, but the main research challenge is to rehabilitate degraded resources and to bring about changes in the degradation processes. Community based research approaches focusing on nitrogen fixing fodder trees and improved irrigation are examples which are being explored, and a major rehabilitation program on a degraded site was initiated in 1994. Such research is challenging and time consuming but the results obtained over the past two years are encouraging.

---

1. Introduction

The key issue in the Middle Mountains of Nepal is how to increase productivity within a subsistence system in a fragile and marginal environment, given the rapidly increasing population. The Jhikhu Khola watershed project was initiated specifically to address problems associated with soil degradation and long term soil fertility declines. The watershed represents one of the most intensively utilized basins in the region and both agricultural intensification and agricultural expansion into marginal lands are occurring simultaneously (Schreier et al ., 1995). Over the past 15 years irrigated agriculture has evolved from an average of 1.3 rotations per year to 2.6 (Wymann, 1991, Shrestha and Brown, 1995) and water shortages during in the dry season are becoming the key limiting factor for further intensification. Agricultural expansion into marginal lands has resulted in the conversion of steep shrub and grass lands to rainfed agriculture, and this is leading to extensive soil erosion problems. The forests which expanded during the 1980's due to an intensive afforestation program initiated by the Australians (Griffin et al , 1988, Gilmore and Fisher, 1991) are now playing a key role in sustaining agriculture, but forest biodiversity and productivity are declining. The forests provide timber, firewood, animal feed and organic matter for the community, and the latter is a key input into the

agricultural system. The farming system relies on foreign aid as the main source of fertilizer, manure from the local animals is insufficient given the demand and feed shortages, and forest litter collected from the forest floor is resulting in long term soil fertility decline within the forest.

Are the nutrient and energy flows within this system out of balance? What are the symptoms and indicators that can be used to monitor the state of sustainability? How can we effectively rehabilitate watersheds? These are the main questions to be addressed in our project.

2. Goals and Objectives

The overall goal of the project is to examine the dynamics within the entire farming system which includes agricultural expansion and intensification; the status and role of the forest resources in sustaining agriculture and supplying timber, firewood, fodder and litter, the role of land management; and the impact on the well being of the people maintaining this system.

The specific objectives were:

i. Identify indicators that can be used to quantify degradation and measure sustainability.
ii. Determine the status of water, soil, agriculture, forestry, livestock, and human resources, and determine the key processes and direction of changes.
iii. Project and compare resource conditions under different growth scenarios.
iv. Identify approaches for effective rehabilitation of degraded resources and initiate demonstration sites to disseminate the research findings, experiences and information.

3. Processes followed in conducting the research

3.1 Background:

The traditional approach in resource management is to first initiate an inventory of the basic resources and then set up a monitoring program to determine processes and rates of change. This approach is currently unpopular with funding agencies because inventories are costly and give little information on resource dynamics. Also, monitoring programs take a long time before useful data are generated. Alternative approaches that have become very popular in recent years are: participatory surveys, rapid rural appraisals, appreciative inquiry, etc. The advantages of these approaches are that you can rapidly gain a good overview of the resources and problems by relying on the indigenous knowledge. The disadvantages are that the information collected is often descriptive and highly dependent on the skills of the surveyor and the informers used in the survey. Our project started seven years ago and we utilized a mix of traditional and alternative surveys.

3.2 Approaches used :

Two decisions were made very early in the project: 1. Geographic Information Systems (GIS) were used as a basic tool to integrate all information pertaining to the management of the natural resources; and 2. A watershed approach was used as the framework for evaluating the resource dynamics. GIS techniques are difficult to learn and are very time consuming to use effectively, but in the long run GIS is proving to be one of the most effective tools for data management, integration, display and communication of results. The watershed approach was used because it represents a very effective natural system for studying dynamic processes.

Multi-resource data for the analysis was collected and integrated using four different approaches:

i. Soil and land use inventories using aerial photo interpretation techniques and field surveys. This was done in two stages: A traditional soil survey and a fertility survey for specific land uses.
ii. Monitoring water resources, climate and soil fertility using a mixture of manual and automated logging devices.
iii. Participatory surveys in the form of structured and unstructured interviews.
iv. Using Hyper-media as a communication tool.

All four techniques have advantages and disadvantages, however, the combination of these techniques provided us with an opportunity to introduce new techniques and to modify the traditional approaches with the introduction of computer based technologies. The computerized monitoring and the GIS techniques provided a great incentive to incorporate younger people into the project and to expose professionals to the new approaches of data gathering , data evaluation, and communicating results.

Computerized techniques without a people focus will be ineffective and the key to the project has been working with an interdisciplinary team that has common goals and dedication to the project. This meant rethinking and retooling. The process is evolutionary, and the best advice is to start with a small core team. Build in a selective manner with the primary focus on compatibility and dedication of the people for the common goal of the project. This also means that farmers play a very central role in the survey and monitoring programs. Our project employs some 30 farmers in the monitoring program. This approach involves more than gathering information on indigenous knowledge by outside researchers. Local farmers become an integral part of the research. This not only provides some additional income for the local farmers but involves them in the research questions we are trying to address. Over time a trust is developed between the researchers and the farmers which has many mutual benefits. It facilitates on-farm innovation trials and paves the way for more effective socio-economic data gathering (Brown and Shrestha, 1995).

These techniques enabled information to be gathered on geology, soils, land use, land use change, hydrology, cultural and economic information, farm management, off-farm

income and activities, population dynamics and water resource management. Over time this information was integrated into GIS which allows us to display the status of the resources in an interactive manner, develop scenarios and model key processes.

3.3 Training:

A very important component in the project is education and training, and has enabled the project to built effective and vital linkages between national institutions and Canadian academic participants. We view training and education as a continuous process and we are adamant that training should incorporate some of the best computer based techniques. There should also be a long term commitment not only to introduce new techniques but for up-grading courses because many techniques are complex (GIS, Hypermedia, data loggers) and are changing rapidly. This involves training courses at the project site as well as short courses abroad. We organize a workshop every 3 years where all members of the team present the results of their work to a local and international audience. They are coached before the workshop on how to improve their presentation skills and how to integrate their presentation with the overall goals of the project. There are mutual benefits for both partners because we share experiences and assist in the use of multi-media presentations. The involvement of students (both Canadian and national) is also of mutual benefit, particularly when they are teamed up with each other, have joint responsibilities and conduct the fieldwork and data analysis together.

3.4 The most important findings:

Collecting information is relatively easy, and with the computer based logging devices and participatory surveys massive data sets can be collected quickly. What is much more difficult is to assure data quality, integrate the data and convert information into knowledge that assists decision makers and managers. We feel we were fairly successful in documenting the status of the resources in our Nepalese watershed, and in identifying the key processes and issues that are indicative of degradation. The shortcomings are how to effectively ameliorate the situation.

The three most important findings can be grouped into:

i. Land use dynamics and soil fertility decline.
ii. Water quantity and quality problems are widespread and rapidly emerging.
iii. Rehabilitation of degraded lands is viable but challenging.

(i) *Land use dynamics and soil fertility decline.*

Both expansion of agricultural land into marginal grass and shrub lands and agricultural intensification (triple annual crop rotations) are taking place simultaneously, and nutrient inputs appear to be insufficient to sustain long term productivity. At the same time, nutrients contained in the forest biomass are continuously removed without any returns to the forests, and this is leading to long term forest soil fertility decline. There is clear evidence of soil acidification (inherently acidic bedrock, acid producing fertilizers, pine

dominated litter from the forest), and this is leading to phosphorus deficiencies and is impairing decomposition processes. Organic matter and associated nitrogen, soil pH, exchangeable Ca, and available phosphorus are all key indicators of soil fertility degradation process. The forest soils have the worst fertility status followed by grassland, and rainfed agricultural land. Only irrigated fields have fertility conditions that are considered adequate. Based on calculated nutrient budgets on individual farms (Brown, 1997) it is apparent that average N and P inputs are in deficit over crop demand, and nutrient losses occur in both irrigated and rainfed agricultural systems. This degradation process is confirmed from farm interviews which indicate that productivity is stagnating even with higher inputs of chemical fertilizers. There are significant shortages of animal feed which impacts the quality and quantity of manure input into agriculture, and up to 45 % of the farmers reported that the land they farm is insufficient to meet their families basic needs.

(ii) *Water quantity and quality are rapidly emerging problems.*

The prevailing climatic conditions are characterized by a distinct monsoon season followed by a prolonged dry period. To maintain triple annual crop rotations, irrigation is an essential requirement. Agricultural production has expanded in an attempt to keep pace with population growth, and with the introduction of cash crop production (potatoes and tomatoes) the demand for irrigation water during the dry period has increased dramatically. This has not only lead to widespread water shortages but water pollution is emerging as a key issue affecting drinking water supplies (Schreier and Shah, 1996). Eutrophication and the indiscriminate use of pesticides on potatoes and tomatoes are early indicators of emerging problems.

The investigations into sediment dynamics revealed that soil nutrient losses by erosion and clogging of the irrigation systems are the main problems relating to water resources management. The dominant source of sediments is the degraded shrub lands and the majority (60-80%) of the annual soil erosion occurs during the pre-monsoon storms when there is little vegetation on agricultural fields and degraded sites. Some of these findings were confirmed by the participatory survey in which water shortages for irrigation and drinking water were rated as the most critical issues to be addressed (Shrestha and Brown, 1995).

(iii) *Rehabilitation of degraded lands is viable but challenging.*

Based on the above findings it was decided that a key approach to preventing further degradation was to set up a demonstration site for rehabilitation techniques on a very degraded shrubland site (1 ha). These degraded lands are the only areas in the watershed that are non-productive and at the same time they are the cause of most of the sediment problems in the streams. This also provided an opportunity to experiment with soil fertility amelioration, a subject that has so far received relatively little attention. The focus was placed on using nitrogen fixing, native fodder trees as a means to stabilize erosion, produce animal feed and firewood, and to ameliorate the soils by incorporating nitrogen and phosphorus fixing organisms and processes into the farming system. We

identified some key species that are excellent colonizers of degraded lands, and were also able to establish a biodiversity garden that is producing a substantial amount of organic matter and fodder, some of which is made available to adjacent farmers, and the remainder is incorporated into the soil. Rehabilitating soil fertility, particularly building up the organic matter component, is a slow and challenging process. Hence the motto: conservation and degradation prevention is far easier than rehabilitation.

3.5 Research issues and processes:

The issues of soil fertility decline and water resource degradation are highly complex, extremely variable and not readily apparent. Soil fertility decline is hidden in lower crop productivity which is highly sensitive to climatic variability and resource degradation is only visible during critical periods of the year (end of dry season). The greatest challenge to the researchers is to find good indicators, to quantify degradation processes and to come up with solutions that ameliorate the identified problems. There are no quick and easy solutions. New approaches have to be introduced into the farming system in a cautious manner, and with full cognizance of the indigenous systems and social setting. This is an area where more research efforts and collaboration between physical and social scientists are needed. Such research also requires a different approach. The farmers need to be an integral part of the research team. Trust between farmers and scientists must be established and benefits have to be apparent early in the intervention. It requires a complete linkage between science, social science, management and economics, and few of us are equipped with the right tools, approaches, attitudes and patience.

Some of the key issues that have emerged from the research are:

Soil fertility decline is widespread and soil fertility rehabilitation needs to be given a high priority. There are no quick and easy ways to improve the conditions because the farming system is very complex and all parts of the system need to be considered (forestry, livestock, irrigation, fertilizers, organic matter management, decomposition, physical factors affection soil structure and hydrological properties, socio-economic settings etc.).

Water resources management is emerging as the critical issue for both agriculture and people. Water shortages and water pollution during the dry season are becoming the key limiting factors for further expansion of agriculture and the deterioration of human health.

The farming system is highly dependent on livestock to supply essential organic matter and nutrients to sustain soil fertility. There is ample evidence to suggest that fodder supplies are far too scarce to maintain a sufficiently large and productive herd of animals. Producing a more reliable and nutritious feed supply is emerging as a major issue. The use of leguminous crops and nitrogen fixing fodder trees as part of the farming system is a key issue requiring further research.

The farming system is very labour intensive with a highly elaborate terrace system and irrigation network that consists of thousands of channels and check-dams. In addition, the

dependence on livestock and firewood, and the absence of an adequate infrastructure (roads, market access, etc) makes this one of the most challenging and time demanding farming systems. Given the social and religious setting, women proportionally carry a far higher share of the workload than men. One of the key issues is that as the forests degrade the proportional effort to collect firewood, fodder and litter increases exponentially. Traditionally, the women are responsible for these tasks which are in addition to planting, weeding and harvesting. With agricultural intensification and degradation the workload for the women has increased significantly and ways have to be found to reduce their workload. The women spend and average of 3-4 hours a day per household collecting fodder and firewood, and with the deterioration of the forests this task becomes greater as travel distances are increasing and supplies are decreasing.

It is essential to focus the research on processes and rates of change. Only with such data can we create models and make projections. An essential research issue is to develop scenarios for the future. With GIS and computer models we can develop a range of scenarios that can be compared and sensitivity analyses can be used to assess which key variables contribute greatest to the outcome.

These issues have been identified using both bio-physical and socio-economic surveys. However, the more important research issue that is emerging relates entirely to how one can improve the stressed resource base. These are research issues that need to be addressed at the community level. Participatory research on how to introduce nitrogen fixing crops and fodder trees into the farming system is one of the main challenges. Improving irrigation efficiency is also an issue that can only be dealt with at the community level. Special attention must be directed towards user groups and in this context it is clearly evident that if we plan to improve the forests we have to incorporate our research with the women groups that use and manage the forests.

3.5 Lessons learnt and advice to others:

Subsistence farming in mountain watersheds is challenging and the indigenous farming practices are in most cases well adapted to the environment. The farmers are innovative and very perceptive, but often do not have the means or the option to experiment. Under current population pressure it is clearly evident that the farming system in the Jhikhu Khola watershed is under stress. There are a number of lessons that we want to share:

i. Involve the farmers in the research; it is of mutual benefit.
ii. Don't rely entirely on socio-economic or participatory surveys. Use quantitative measurements to calibrate indigenous knowledge and assess the magnitude of the stated problems independently.
iii. Work with a small interdisciplinary team of dedicated people and pay close attention to the team configuration. Incorporate women into the team at the start because without them you will obtain an very inadequate understanding of the farming system.

iv. Use a combination of traditional and new technologies in your research. This will assure better data reliability and allows you to calibrate measurements independently.
v. A long term commitment is needed to gain a good understanding of the dynamics of the system. Multiple surveys, repeated visits, and continuous monitoring are essential to verify and improve our understanding.
vi. Try many different experiments as some 50% may fail because of natural processes, human errors and technological failures.
vii. Make a long term commitment to training which includes constant upgrading and retooling.
viii. If you plan to use GIS be prepared for a very elaborate field effort to collect sufficient georeferenced data. Once you have the data the work has just begun. GIS is not user friendly, but data intensive, and time consuming. The payoff is long term. Be clear and selective on when and why you want to use GIS. It is an excellent integration tool but it is only cost effective if you plan on building and using the data over long time periods.
ix. To incorporate socio-economic information into the GIS system requires a new approach to participatory surveys. All information needs to be gathered in a georeferenced manner. The best approach is to use enlarged aerial photos during the field investigation and mark all observations in a spatially referenced manner so that the data can readily be incorporated into the GIS database.
x. Introduce computers into your project. It forces everybody to collect data in a more quantitative manner, it gives researchers more options for data evaluation, and it is a real incentive for young people to get involved.
xi. Using Hypertext and multi-media are highly effective communication tools and allows us as scientists to be far more creative in how to present information and knowledge. We as scientists have done a relatively poor job in communicating our results to politicians and decision makers. Combining GIS, computer graphics and text with images provides us with new opportunities to communicate better. This technology is becoming relatively simple and is very cost effective.

Research for development can be very frustrating, and patience and perseverance are key topics. Our project has evolved and progressed in spite of many failures. Setting up the monitoring stations in the wrong place, relying on the wrong people to collect data, introducing inappropriate technology and methods, conducting too many structured socio-economic surveys in the same place are all examples of failures. We have learned from these experiences. Probably the greatest lesson we have learned is to pay more attention to people. Involve the farmers in the research from the beginning, conduct rapid and diagnostic surveys and listen to the farmers complaints and demands. Then define and focus your research. Community based research is now the buzz word throughout the world. There is much to be gained from such an involvement, but at the same time we need to be realistic. Community based research without independent calibration and critical evaluation can be highly misleading. It is suggested that a hybrid and integrated approach is likely to be most effective.

4. Conclusions

Our project started before community based research was popular. As a result the methods we used evolved from a heavy focus on biophysical surveys to a mixture of computer based monitoring, diagnostic surveys and rapid socio-economic surveys. Based on our research it is clearly evident that soil fertility is declining, water resources are under stress (shortages and pollution) and both livestock and forestry which play an integral part in maintaining the farming system are under great pressure. There are widespread feed shortages and the forest soil fertility is declining because of the heavy removal of timber, firewood, fodder and litter. In the long run this leads to reduced biodiversity, a decline in forest soil fertility and reduced productivity.

Good indicators of degradation have been identified but a far more challenging research problem is how to rehabilitate degraded sites and reverse the degradation processes. We focussed on the use of nitrogen fixing fodder trees, improving irrigation systems, and rehabilitating degraded sites to ameliorate soil fertility. A community participatory approach is critical if we hope to make an impact and gender based research is proving to be essential.

Incorporating computer techniques into the research program proved to be very effective. Not only did it assist us in integrating the complex resource data but it provided us with the opportunity to experiment with new multi-media tools that we hope will lead to better communication between the scientists, the community and the decision makers.

5. References

Brown, S. 1997. Soil fertility, nutrient dynamics and human interactions in the Middle Mountains of Nepal. Ph.D. Thesis, Resource Management and Environmental Studies, University of British Columbia, Vancouver , B.C. 255 pp.

Schreier, H, P.B. Shah, and S. Brown (eds.) 1995. Challenges in Mountain resource management in Nepal: Processes, Trends, and Dynamics in Middle Mountain Watershed. Workshop Proceedings. International Centre for integrated Mountain Development (ICOMOD) Kathmandu Nepal, and International Development Research Centre, Singapore. 263 pp.

Schreier, H. and P.B. Shah. 1996. Water Dynamics and population Pressure in the Nepalese Himalayas. GeoJournal, 40 (1-2): 45-51.

Shrestha, B. and S. Brown. 1995. Land use dynamics and intensification. In Shrestha, B. and S. Brown. 1995. Land use dynamics and intensification. In Schreier, H, P.B. Shah, and S. Brown (eds.) Challenges in Mountain resource management in Nepal: Processes, Trends, and Dynamics in Middle Mountain Watershed. Workshop Proceedings.

International Centre for integrated Mountain Development (ICOMOD) Kathmandu Nepal, and International Development Research Centre, Singapore. pp. 141-154.

Shrestha, B. and S. Brown. 1995. People, Community Dynamics and Perceptions in the Watershed. In Schreier, H, P. B. Shah, and S. Brown (eds.) Challenges in Mountain resource management in Nepal: Processes, Trends, and Dynamics in Middle Mountain Watershed. Workshop Proceedings. International Centre for integrated Mountain Development (ICOMOD) Kathmandu Nepal, and International Development Research Centre, Singapore. pp. 129-140.

Griffin, D.M., K.R. Shepherd, and T.B.S. Mahat. 1988. Human impact on some forests in the Middle Hills of Nepal. Part 5. Comparisons, concepts and some policy implications. Mountain Research and Development, 8: 43-52.

Gilmore, D.A., and R.J. Fisher. 1995. Villagers, forests and foresters. Sahogi Press, Ltd. Kathmandu, Nepal, 212 pp.

Wymann, S. 1991. Landnutzungsintensivierung und Bodenfruchbarkeit im Nepalischen Hugelgebiet. Diploma Project, Institute of Geography, University of Bern, Switzerland, 170 pp.

Publisher : Institute for Resources and Environment, University of British Columbia and: International Centre for Integrated Mountain Development (ICIMOD)

Title:	Jhikhu Khola watershed project in the Nepalese Himalayas : approaches used and lessons learned
Authors:	Schreier, H. Brown, Sandra Shah, P.B.
Keywords:	IDRC SUPPORTED RIVER BASINS SOIL FERTILITY ECOSYSTEMS MOUNTAINS AGRICULTURAL EXTENSION WATER POLLUTION SUSTAINABLE DEVELOPMENT NEPAL WATER BALANCE FORESTRY RESEARCH IRRIGATION EROSION CONTROL GEOGRAPHIC INFORMATION SYSTEMS FORAGE CROPS STATISTICAL ANALYSIS COMMUNITY PARTICIPATION
Issue Date:	26-Apr-2007 1997
Description:	Also available in digital format at: http://www.idrc.ca/en/ev-6059-201-1-DO_TOPIC.html
URI:	http://idl-bnc.idrc.ca/dspace/handle/123456789/143
Project Number:	040340
Project Title:	People and Resource Dynamics in Mountain Watersheds (Hindu Kush - Himalaya)
Appears in Collections:	Asia/Asie