

Conclusions

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The watershed projects in Nepal have undergone significant evolution over the past few years with the move from a basic science approach to a more community-based participatory approach. The main issues that have been addressed in PARDYP-Nepal are listed in Table 109, which includes the methods used to address the issues and the indicators selected to determine the extent of the problem.

Many of these research activities were carried out in an interdisciplinary manner and with participation of both men and women farmers. Because the project benefited from long-term support, it is now possible to look at the overall dynamics of the watershed system in terms of water, nutrient, and biomass balances. The results show a somewhat disturbing pattern. The increases in population growth are greater than the innovations and productivity gains by the farmers. This is leading many male farmers to consider seeking off-farm jobs, which increases the workload for women since they remain behind to tend the farm. Also, fodder and fuelwood shortages are increasing because there are insufficient resources to sustain the population. Similarly, soil nutrient pools are declining and water shortages during the dry season are increasing. Efforts to introduce cash crops (potatoes and tomatoes) and the marketing of milk have the potential for improving household economics. However, with these developments come new problems such as excessive use of pesticides, insufficient nutrient additions, soil acidification as a result of using primarily acid producing fertilisers, and increased workload.

Table 110 shows some of the constraints that face the farmers in the Nepalese watersheds. It also contains information on the lessons learned and on the opportunities that can be addressed in future research activities during Phase II. Emphasis will be placed on opportunities, the specific research programmes are outlined in the Phase II proposal. To date, although not all findings are completely applicable in all study areas, the following conclusions can be drawn from the research in the PARDYP watersheds.

Water Issues

The problems. Water shortages are widespread during the dry season and include shortages for irrigation as well as for drinking water supplies. This is confirmed on the basis

Table 109: Issues Addressed, Methods Applied, and Indicators used in Researching the Nepali Watersheds

Issues	Methods Used	Indicators Used
Population pressure leading to land use intensification, land use changes	PRA and RRA surveys Airphoto, satellite image, and GIS analysis	Distribution of land holdings Population density Crop rotation and biomass production Changes in land use (GIS based)
Drinking and irrigation water shortages	PRA surveys, rainfall/stream flow, and irrigation water evaluation	Extent of water shortages Water quality, water harvesting effectiveness
Widespread soil nutrient deficiencies	Participatory (gender sensitive) soil fertility survey	Soil C, P, Ca, and pH values
Forest degradation, fodder, and fuelwood shortages	PRA surveys and intensive monitoring of forest plots	Forest cover and forest quality changes Species biodiversity measurements
Poor agricultural productivity due to insufficient inputs	PRA, biomass surveys, nutrient deficits	Nutrient budgets
Pesticide problems	PRA survey on pesticide use	Type and number of applications/crop
Socio-economic problems due to resource deficiencies	PRA, economic evaluations, off farm labour assessment	Gross margins Workload
Gender inequities	PRA, women user group surveys	Workload of women, resource access (common property and community forests)
Degraded land rehabilitation	Planting N-fixing fodder trees, legumes, and grasses	Biomass surveys, monitoring soil nutrient changes
Alternative energy sources	Demonstration fair	Acceptance of fuel efficient stoves
Marketing of milk and cash crops	PRA, milk survey, cash crops survey	Income, production and consumption, profitability
Sediment problems (erosion, transport, and impact)	Sediment monitoring and surveys	Mass balance, sediment nutrients
Training and extension	Participatory demonstration	Number of participants and level of interest
Communication	GIS and multi-media tools	Distribution of CD-ROMs

of stream flow measurements as well as from participatory surveys in both watersheds. The reasons for this include the continued expansion and intensification of agriculture and hence water demand due to rapid increases in population (growth and immigration), higher aspirations, and growing need for cash.

The initiatives. During Phase I, two water harvesting systems were constructed and are currently being tested to determine collection efficiency and irrigation options during the dry season. A water quality monitoring programme was started in 1998 in Nepal to determine potential water pollution problems, and an inventory of freshwater springs was also initiated in China, Pakistan, and Nepal. Irrigation system efficiencies are being tested and alternative application methods will be examined.

Table 110: Issues, Constraints, Lessons Learned, and Opportunities for Research

Issues	Constraints	Lessons learned	Opportunities
Water	Rainfall/runoff relationships Sediment dynamics Water availability for irrigation Drinking water supplies Climatic variability	Imperviousness Hydropower and irrigation Dry season shortages Health problems Coping with extreme events Shrinking land supply Make nutrient budgets Health, need for extension Workload for women	Reduce surface runoff Better site selection for projects Water harvesting Improving wells Improve water planning Improve crop rotations Balance inputs Natural pesticides, integrated pest management Reduce lime needed for, and better sharing of, major daily tasks Improve irrigation management Cover crops, legumes Focus on N-fodder Diversity, high value crops Systems approach Community forestry Native N-fixing trees Innovative management Improve diversity and management
Agriculture	Water supply shortages Use of marginal land High labour/marginal returns Agricultural biodiversity Integration with agriculture High fuel and fodder demand	Insufficient irrigation Erosion & soil fertility High risk crop problem Risk with single crop Interdependence Political/legal problems Pine plantation issue Revision of practices Selective use of litter Negative nutrient budgets Decline affecting quality Better use of fertiliser/manure Lack of microbial activity Slow & difficult process Market crops = more work Poor demand analysis Poor road access & network Food processing Farmers get little advice Diversity economy Immigration/market economy Creates hardship Systems approach Compatibility Effective multi-media tools	
Forestry	Biodiversity Forest policy Litter demand Nutrient deficiencies Carbon balance Soil acidification Microbial issues		
Soil fertility	Degraded sites rehabilitation Workload of women Limited markets & demand Poor infrastructure Alternative energy Lack of extension service Alternative employment High growth rate Uncertainty and extremes Interrelationships Appropriate people Training opportunities; access to technology		
Rehabilitation Socioeconomics			
Policy			
Population Climate change Integration Capacity building Communication			

Nutrient Issues

The problems. Soil nutrient deficiencies are widespread and have been well documented by the project in India, China, and Nepal. The primary problems include: a) lack of organic matter as a result of insufficient access to animal and green manure; b) high soil acidification due to the presence of acidic bedrock, the use of acid producing fertilisers, and the addition of pine litter to compost; c) low availability of phosphorus as a result of poor P distribution in bedrock, acidic soil conditions, and the presence of high quantities of amorphous Fe and Al in the red soils; and d) the lack of base cations as a result of leaching enhanced by the acidic soil conditions. In Nepal, nutrient deficiencies have been determined on the basis of soil sample analysis, by determining nutrient budgets for the main crops and cropping systems of 75 farmers, and by PRA methods.

The initiatives. Soil fertility improvement trials are underway with a focus on improving the organic matter content by addition of green manure, by introducing N-fixing trees and leguminous crops into the farming and forestry system, and by improving the composting processes at the farm level. The acidification problem is addressed by the addition of lime (from local limestone sources) to the soil, by discouraging the use of pine litter in composting, and by adding base cations to the soils through selective plant litter addition.

Erosion and Sedimentation Issues

The problems. From longer term data in the Nepal watersheds, erosion losses in rainfed agriculture are known to occur during the pre-monsoon season when the soils are barren and unprotected as a result of the lack of vegetation cover. Up to 80 per cent of the annual soil losses occur during this period. Sediments clog up irrigation systems, create problems for downstream hydropower development, and accentuate flooding. More than half of the annual sediments originate from degraded sites, which in spatial terms make up a relatively small portion of the watersheds in Nepal.

The initiatives. Experiments are under way to determine what kind of crop cover could be incorporated into the rotation system to assure that the soils are covered by vegetation at this critical time. Reclamation and rehabilitation experiments are taking place on degraded sites to establish a vegetative cover that stabilises the slopes, reduces erosion, improves the soil productivity, and generates biomass that can be used for fodder.

Forest Resource Management Issues

The problems. The pressure on forest resources is enormous in most of the PARDYP watersheds. In Nepal, based on a historic GIS analysis, it was found that the forest cover has undergone cycles of degradation and rehabilitation. Unfortunately these cycles are moving in a downward direction. This was confirmed by test plot experiments and PRA surveys of user

groups, which revealed that shortages of fodder and firewood are increasing at a time when the responsibility for managing the forests is being turned over to communities. In all watersheds, restricted access is essential to ensure forest recovery, but this places additional hardship on women in households with small land holdings since they are now even more deprived of fodder. A loss of trees, decline in biodiversity, and long term decline of soil nutrients in the forest soils has also been documented.

The initiatives. Experiments to improve grass production and to introduce rotational management in the forests are under way. The introduction of legumes into the forest grass cover is being tested. Introducing native nitrogen-fixing fodder trees into the community forests is being promoted because simple forest closure will result in a much slower natural recovery. Pressure has been put on forest managers to abandon the standard afforestation policy of establishing chir pine plantations. Instead demonstration sites have been set up and nurseries have been developed that promote the use of native nitrogen fixing fodder species.

Gender Issues

The problems. The workload of women is excessive and in Nepal it is increasing with the introduction of cash crops, such as potatoes and tomatoes, and with the new opportunities for marketing milk. As the forest and water resources degrade, forest access and fuelwood and fodder collection time increase. Also, the opportunities for off-farm labour are significantly better for males. Hence women often manage the farm while husbands seek off-farm work. In all watersheds, current farming systems are inherently labour intensive and all the above-mentioned trends are increasing the workload of women. Traditional, cultural, and religious practices play a large role in the unequal sharing of the workload, which further complicates the issue.

The initiatives. In all watersheds, training and education programmes are being conducted with women groups to assist in afforestation efforts. Demonstration sites have been set up to show how grass production can be improved in the forest, and how the use of fuelwood can be made more efficient by the introduction of fuel-efficient stoves. Efforts are also being made to improve drinking water supplies. A strong push is being made to extend female education programmes and to advocate that girls remain in school at least as long as the boys. Education of women is advocated to improve population control practices, to give women better skills in financial matters, and to introduce female members to jobs in the forestry and agricultural sectors.

Agricultural Production Issues

The problems. Crop yields are stagnating, intensification has reached average annual rotation levels of 2.7 crops per year, and many crops are not responding well to additional inputs of chemical fertilisers. In Nepal, the overuse of pesticides on newly introduced cash crops (potatoes and tomatoes) is causing health concerns, and the profitability and food

security for staple crops is poor. In all watersheds, land holdings for the great majority are small, agricultural expansion is limited (only marginal lands on steep slopes and degraded sites are not currently used), and further intensification is difficult due to water shortages during the critical dry period and insufficient access to nutrients (manure and chemical fertilisers).

The initiatives. In Nepal, the excessive use of pesticides on tomatoes and potatoes has been documented through PRA analysis and collaboration with NGO's. Health authorities and government agencies in charge of extension have been encouraged to educate communities in the proper use of pesticides. Efforts are also underway to document the effect and use of indigenous pest control practices and integrated pest management. Integrated nutrient management (combining manure, chemical fertilisers, and nitrogen fixing crops) is also promoted.

Socioeconomic Issues

The problems. Income and food sufficiency is inadequate for 2/3 of the farmers in the watersheds. Given the large population growths (over 2% in all watersheds) and the very small land holdings it is difficult to improve the livelihood of the inhabitants. Alternative employment is scarce and cash cropping requires additional labour. The income from cash crops and, in Nepal, milk production, is attracting immigrant labourers, but the markets are poorly identified, and demand and transport to markets are uncertain as a result of the poor infrastructure and conflicting policies.

The initiatives. Opportunities and constraints have been identified for milk production in the Jhikhu Khola, for floriculture in India, and for tea in China, India, and Pakistan. Alternatives to single cash crop production are being explored. The emphasis on vegetable production is being examined from an economic, workload, and agrobiodiversity point of view. A study on farm gross margins shows that basic staple crop production is in many cases a negative economic proposition and the introduction of alternative crops into the crop rotation is one of the options to consider.

Communication Issues

The problems. Scientific information has not been disseminated to farmers in an effective manner and better methods are needed before farmers will adopt new technologies and management practices. In addition, not enough information on the status and rate of degradation in water and natural resource management is reaching the policy and decision-makers. Alternative practices that are less fuel, labour, water, and nutrient demanding have not been described and promoted in an effective manner.

The initiatives. Leaflets in national languages are now being produced to take concrete positive messages to farmers via local CBO groups and NGOs. Hypermedia CD-ROM

techniques are used to present the results of the research to policy makers and donor agencies in the hope that greater attention will be drawn to the key problems of soil fertility, water shortages, pollution problems, and fodder shortages. On-farm interventions are being carried out and demonstration sites introduced to improve experiments and introduce management practices that take into account the constraints faced by the farmers. In this way successful on-farm initiatives are more likely to spread and become more widely acceptable.