ICIMOD

Mountain Agriculture

in the Hindu Kush-Himalayan Region

Proceedings of an International Symposium held May 21 to 24, 2001 in Kathmandu, Nepal

Editors
Tang Ya
Pradeep M. Tulachan

about ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) is an independent 'Mountain Learning and Knowledge Centre' serving the eight countries of the Hindu Kush-Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and the global mountain community. Founded in 1983, ICIMOD is based in Kathmandu, Nepal, and brings together a partnership of regional member countries, partner institutions, and donors with a commitment for development action to secure the future of the Hindu Kush-Himalayas. The primary objective of the Centre is to promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations.

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Plates

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Foreword

Improving the productivity and sustainability of mountain agriculture is a critical component of ICIMOD's integrated approach towards improving mountain livelihoods. Thus it was central to our mission for ICIMOD to organise the International Symposium on Mountain Agriculture in the Hindu Kush-Himalayas (HKH), May 21-24, 2001. This symposium represented the culmination of many years of work in the projects 'Appropriate Technologies for Soil Conserving Farming Systems', funded by the Asian Development Bank (ADB) and the 'Investigating Issues and Options for Improving Livelihoods of Marginal Mountain Farmers' project funded by the Australian Centre for International Agricultural Research (ACIAR), and brought in interim results from the project on 'Indigenous Honeybees in the Himalayas: A Community-based Approach to Conserving Biodiversity and Increasing Farm Productivity' funded by the Austrian Government.

Participants from ICIMOD's national collaborating institutions and from other organisations shared the findings of the various studies carried out under these projects and discussed the implications of the results and future approaches. Additional papers were contributed by ICIMOD's strategic and partner institutions in and beyond the Hindu Kush-Himalayan region on studies and projects related to the sustainable development of mountain agriculture.

The papers were revised and refined by the authors and were technically edited by Dr. Tang Ya, Dr. Pradeep M. Tulachan and Dr. A. Beatrice Murray prior to being published. Although this additional input resulted in some delay, it provided the opportunity to clarify points that will be of use to readers.

I am confident that the results published here will be of considerable value to all stakeholders engaged in the development and promotion of sustainable mountain agriculture for poor mountain farmers.

Dr. J. Gabriel Campbell
Director
ICIMOD

Acknowledgements

We are grateful for the generous financial support from the Asian Development Bank (ADB) for the two phases of the 'Appropriate Technologies for Soil Conserving Farming Systems Project' that have been implemented by ICIMOD over the past six years; from the ACIAR for the 'Investigating Issues and Options for Improving Livelihoods of Marginal Mountain Farmers' project, and from the Austrian Government for the 'Indigenous Honeybees in the Himalayas: A Community-based Approach to Conserving Biodiversity and Increasing Farm Productivity' project.

We deeply appreciate the cooperation and help of the ICIMOD national collaborating institutions in carrying out various activities across the HKH. We would also like to thank Dr. Niraj Joshi from the Institute of Agriculture and Animal Science (IAAS), Nepal, for the preliminary editing of the papers. Finally, our thanks are due to all the ICIMOD support staff who assisted in organising the symposium.

Executive Summary

The Hindu Kush-Himalayan region extends 3,500 km from east to west covering an area of 3.4 million sq.km in all or part of eight countries. It is a region of great natural and social diversity, resulting from the tremendous geographical and climatic extremes: altitudes ranging from near sea level to over 8000 masl over a distance of just 150 km; climates ranging from sub-tropical to alpine; and long periods of dryness alternating with torrential downpours during the monsoon. This is a challenging environment for human survival: there are few industrial resources, and the extreme terrain and climate mean that communications are often poor and infrastructure minimal. The great majority of the 150 million people who live in this region are farmers: agriculturalists, agro-pastoralists, or pastoralists according to location. These often isolated communities are for the most part poor and almost totally reliant on their own resources for survival: 'subsistence' farmers who rely on hard work and the local natural resources to meet their everyday needs. Over the centuries these people have developed strategies for survival that can be maintained independent of contact with the adjacent low-lying areas using approaches that spread risks, both socially and physically, rather than maximising potential output.

The situation is changing rapidly, however. Over the past 50 years there has been a massive increase in communication with the outside world: roads and airstrips have opened up; seasonal and long-term migration, including school boarding, has become the norm in many parts – bringing with it experience of other places and lifestyles and ready cash for purchases and investments; and TV, radio, and now the Internet bring scenes of very different lifestyles to those who stay at home. All of this is leading to a major shift in perceptions and expectations. Thus the same resources must now be used to maintain a dramatically increased population with higher expectations; at the same time new opportunities are being recognised for developing mountain farming and increased education has opened up new possibilities for understanding, insight, and change.

The challenge for farming systems is clear. How can the total value (and volume) of products be increased to meet the needs and expectations of the present and expected future population, whilst avoiding environmental degradation and ensuring that resources are maintained for future generations?

It was with this in mind that ICIMOD organised the International Symposium on Mountain Agriculture in the Hindu Kush-Himalayas in May 2001 to bring together people from all over the region and outside to discuss the diverse problems and multitude of approaches to developing environmentally sound mountain farming systems and improving mountain livelihoods. The discussions were restricted to sedentary agricultural systems (the problems of pastoralists and potentials of rangelands are being considered under a separate programme). The discussions were based on a series of invited and submitted papers, which are presented here in this volume in reviewed and edited form.

The papers are of a diverse nature, but all are concerned in some way with aspects of mountain agriculture, alleviation of mountain poverty, and environmental impacts. The papers can be divided into two broad categories, one dealing with socioeconomic and environmental issues, the other with possible technological options that could bring about a transformation in the mountain livelihoods and benefit the environment. Small size, low capital investment, poor productivity, lack of markets, and lack of appropriate technology have direct effects on mountain poverty. But there are also many potentials in terms of niche products, local (indigenous) knowledge and experience, and climatic and geographical advantages that are only now becoming fully recognised. In some areas like Himachal Pradesh (HP), considerable benefits are already becoming apparent from the focused introduction of new approaches with broad institutional support. Equally there are technological options available like contour hedgerow intercropping agroforestry technology (CHIAT, often called sloping agricultural land technology or SALT), that have been tried and tested at diverse sites in the HKH region and have proven their value both for increasing agricultural productivity and for preventing soil erosion from agricultural land, thus conserving the mountain environment.

The **Welcome Address** and two **Keynote Speeches** are provided as introduction, followed by the papers separated into six broad thematic topics: **Issues in Mountain Agriculture in the HKH** covering such topics as poverty reduction, land use change, and assessment of agricultural systems and identification of opportunities; **Technologies for Improving the Productivity of Mountain Agriculture** with assessments of soil and nutrient losses and methods for managing them including the results of studies of CHIAT and its potential for application; **Opportunities and Options for Income Generation and Transition** with an interesting and valuable group of papers describing pocket area success stories and the opportunities and constraints in areas like apple farming, non-timber forest products (NTFPs), and pigeonpea production; **Issues of Marginal Farms and Potential for Development** with broader studies of the different issues in different parts of the HKH region; **Gender, Empowerment and Community Approaches** looking at gender roles and relationships and the impact on farming practices, as well as approaches to increasing community involvement and ownership of agricultural initiatives especially beekeeping; and **Institutional Strategies for Improving Mountain Farming,** which looks at the general approaches being taken in different countries and states of the region.

This publication will be a valuable source of information for all those working for mountain development, in particular, mountain agriculture, in the HKH and other regions.

Acronyms and Abbreviations

ABA	Alital Beekeeper's Association
ACPC	Allo Cloth Production Club
ADB	Agricultural Development Bank
ADBN	Agricultural Development Bank of Nepal
ADOs	agriculture development officers
AIR	All India Radio
AJK	Azad Jammu and Kashmir
AKRSP	Aga Khan Rural Support Programme
ARS	agricultural research station
AZRC	Arid Zone Research Centre
CEC	cation exchange capacity
CGIAR	Consultative Group for International Agricultural Research
CHIAT	contour hedgerow intercropping agroforestry technology
CHT	Chittagong Hill Tracts
CHTDB	Chittagong Hill Tracts Development Board
CIB	Chengdu Institute of Biology
CLV	carnation latent virus
CPR	common property resource
CSIR	Council for Scientific Research and Industrial Development
CSIR	Council of Scientific and Industrial Research
DAC	direct antigen coating
DFID	Department for International Development
ELISA	enzyme linked immunosorbent assay
FAO	Food and Agriculture Organization (UN)
FD	Forest Department
FYM	farmyard manure
GBPIHED	G. B. Pant Institute for Himalayan Environment and Development
GDP	gross domestic product
HIMCU	Himachal Canning Unit
HLFFDP	Hills Leasehold Forestry and Forage Development Project
HMGN	His Majesty's Government of Nepal
HPMC	Himachal Pradesh Horticultural Produce Marketing and Processing Corporation Ltd.
HYV	high yielding variety

IAAS	Institute of Agriculture and Animal Science
ICAR	Indian Council of Agricultural Resources
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDE	International Development Enterprises
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFRI	International Forestry Resources and Institutions
INGO	international non-government organisation
IPMI	Integrated Pest Management Institute
ISNAR	International Service for National Agricultural Research
IUCN	International Union for the Conservation of Nature and Natural Resources
JKW	Jhikhu Khola watershed
KARINA	Karakoram Agricultural Research Institute for the Northern Areas
KBS	knowledge-based system
KHA	Kush-Hali Associates
KHARDEP	Koshi Hills Area Development Program
KVK	krishi vigyan kendra
LARC	Lumle Agricultural Research Centre
LCC	leguminous cover crops
LDDD	Livestock and Dairy Development Department
LRMP	Land Resource Mapping Project
LSU	livestock unit
MASIF	Mountain Agricultural System Information Files
NADRI	National Aridland Development and Research Institute
NAF	Nepal Agroforestry Foundation
NARC	national agricultural research council
NARC	Nepal Agricultural Research Council
NATP	National Agriculture Technology Project
NCI	national collaborating institution
NCT	National Council for Tibb
NGO	non-government organisation
NIH	National Institute of Health
NTFP	non-timber forest product
NVS	natural vegetative strips
NWFP	North West Frontier Province (Pakistan)
OM	organic matter
PARC	Pakistan Agricultural Research Council
PARDYP	People & Resources Dynamics in Mountain Watersheds of the Hindu Kush-Himalayas Project
PCSIR	Pakistan Council of Scientific and Industrial Research
PIAMS	Pakistan Institute of Acupuncture and Medical Sciences
PPD	Plant Protection Department
PRA	participatory rural appraisal
PTD	participatory technology development

R&D	research and development
RD	recommendation domain
RIMS	research impact and management study
RUWDUC	Rural Women's Development Unity Centre
SALT	sloping agricultural land technology
SCW	Soil Conservation Wing
SD	sustainable development
SDC	Swiss Development Cooperation
SMS	subject matter specialist
SSD	Soil Science Division
TN	total nitrogen
ToT	transfer of technology
UMB	urea molasses block
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
USP	Upland Settlement Project
UWB	University of Wales, Bangor
VDC	village development committee
VLWs	village level workers
WRP	Watershed Rehabilitation Project

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Opening Session

Welcome Address

J.Gabriel Campbell
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Honourable Minister, Distinguished Scientists and Agriculturalists, Ladies and Gentlemen.

On behalf of ICIMOD, it is my pleasure to welcome you all to this International Symposium on Mountain Agriculture of the Hindu Kush Himalayan (HKH) region. Many of you had long journeys to Kathmandu, and I am pleased that you have been able to come. Your presence at this meeting reflects the importance of agriculture in our mountain areas and your commitment to the development of mountain agriculture.

We know that agriculture is the basis of survival for the vast majority of the 140 million people who live in the mountains of the Hindu Kush-Himalayas. We know that mountain agricultural systems are highly diverse in comparison to those found in the plains. Complex cropping systems; animal husbandry systems; and water, forest, and range use systems have been built up over the centuries to deal with mountain dynamics and the diversity of micro-ecologies found on even the smallest farms.

Through the actions of millions of farmers over thousands of years, parts of our mountain landscapes have been transformed into terraces, kitchen gardens, and agroforestry or horticultural plots. Other parts have been transformed into denuded and eroded hillsides with bare and depleted soils.

The dynamic nature of these young mountains and the vast impacts of water running rapidly down fields, slopes, and valleys have created an ever-changing mosaic of mountain land use. Landslides wipe out fields and pasture, and in their wake create new fields. Forests are burnt and create new pastures. Many trees are cut down, but others such as the nitrogen fixing *Alnus nepalensis* return, and cash crops such as cardamom are planted to return fertility to soil previously lost.

However, these ever-changing mountain landscapes are too often caught in a downward spiral of degradation.

We know that most mountain women and men toil long and hard hours for very meagre returns and very difficult lives. The amazing fact to any outsider is that they manage to survive at all under the harsh conditions in which they work. With extremely small landholdings, extremely difficult conditions for land management, difficult access to markets, limited technological options, weak extension support, few basic services, and frequently changing market conditions, many – if not most – mountain farm households struggle to come up with less than subsistence. Their productivity is very low and many perceive their prospects to be dim. They then end up having to take on extra jobs as labourers to make ends meet, or migrate to cities and plains. The scale of poverty in our region continues to increase.

In general the research and extension support provided to address the problems of mountain agriculture has been substantially less than that available to farmers in the plains. The solutions for increasing long-term productivity are rarely as easy, and the effort involved in dealing with the complex interactions of mountain agricultural systems has discouraged both government and private-sector institutions from investing the necessary skills and manpower.

But dedicated farmers, researchers, and agricultural workers have worked long and hard to find some solutions, as well as to better define and understand the research and development agenda required by our mountain conditions.

You represent these people – the committed scientists and policy makers who have not feared to directly tackle the daunting challenges of improving mountain agricultural systems. You are the people who have had the vision to see opportunity where others see only gloom. You are the people who have formed partnerships with one another and with local farm households to introduce new technologies, methods, or approaches through research, field testing, and adaptation. You are the ones to help identify and foster improved cropping systems, improved horticultural systems, improved livestock systems, improved agroforestry systems, and improved soil conservation systems.

And as a result, we do have pockets of success – areas where productivity has increased, livelihoods have improved, and soil and forest loss have dramatically decreased. And where we do not yet have solutions, we have better ideas on how to identify them – how to work with farmers to set up research that will address real problems and opportunities.

This is why we are here this week – to share results, to share questions, and to think together about how to build on our knowledge and improve mountain agriculture.

ICIMOD is working with partners in the Hindu Kush Himalaya – many represented here today – to help support this effort. As a regional institution with each of the Hindu Kush Himalaya countries represented on our Board of Governors, we are built on a model of regional collaboration. We are fortunate in being able to take advantage of this collaboration to bring together scientists and development workers from most of the countries and ecosystems found in our region to facilitate cross-pollination of ideas and knowledge.

ICIMOD has also worked to serve our mountain farmers through a set of programmes identified in the second four-year Regional Collaborative Programme (RCP II) that commenced in 1999. Under the central theme of poverty reduction and sustainable livelihoods, two priority areas are recognised: improving the productivity of marginal farms and promoting options for generating income. With financial support from the Asian Development Bank (ADB), the Australian Centre for International Agricultural Research (ACIAR), and Austroprojeckt, ICIMOD has been collaborating with many of you to implement several projects in these two priority areas. These projects include 'Appropriate Technologies for Soil Conserving Farming Systems' (ATSCFS), 'Issues and Options for Marginal Farms', and 'Promoting Beekeeping with Indigenous Honeybees in the HKH Region'.

Within the context of the ATSCFS project, efforts have concentrated on testing, demonstration, and extension of the contour hedgerow intercropping technology (or SALT) and other appropriate technologies, along with capacity building of national and local institutions that can help in diffusing these technologies. The results so far have clearly demonstrated that the contour hedgerow intercropping technology can sustain permanent cultivation of sloping croplands. It can control soil erosion, improve soil chemical and physical properties, enhance crop yield, and provide enhanced income benefits. We are pleased to see that this technology has been adopted by a large number of farmers in China and Bangladesh, and has been recognised by the government of China as an important technology for environmental conservation and upland agricultural development. It has also been incorporated in many programme activities of many institutions in the ICIMOD member countries. We believe that with support from the governments of the member countries, and continuing research and adaptation, this technology will be adopted by increasing numbers of mountain farmers to conserve our precious soil and water for increased productivity and sustainability.

Experiences from the project on Issues of Mountain Marginal Farms and other related projects in the HKH indicate that productivity and income can be improved through appropriate management. ICIMOD studies have supported the conclusion that many marginal farms may not be productive for food crops but can be productive for certain cash crops. A number of ICIMOD reviews have helped identify many examples of successful cultivation of high-value crops and related practices in the HKH region. These examples need to be multiplied, studied, and supported so that a number of options for the diverse conditions and markets of the HKH can become available and adopted by mountain farmers.

In the beekeeping project, apart from a wide awareness generated regarding the Himalayan honeybee, ICIMOD is active in testing and disseminating improved beekeeping practices and training local farmers and local NGOs, especially regarding the native Himalayan species that have been neglected in most of the world. This project aims to increase the productivity of Himalayan bees and demonstrate how bee products can be diversified. Equally if not more importantly, the project documents the essential role of bees in the pollination of plants, especially many of the cash crops we hope to promote for mountain agriculture.

As I hope these examples demonstrate, ICIMOD seeks to work in an integrated manner to tackle the integrated nature of mountain agriculture. Furthermore, we have also identified some other important aspects of applied research in the mountains that we hope to strengthen in the future.

You know well, but unfortunately many policy makers still do not, that the primary mountain farmer is often a mountain woman. Gender roles in mountain agriculture are not those of the plains, and we still have a long way to go to incorporate these different roles within our research and extension agendas.

Second, while we do conduct tests and hold participatory planning meetings with local farm women and men, there are immense opportunities for increasing genuine collaboration with local farmers and their communities. Too often we do not systematically try to identify the innovations that farmers have already introduced and are testing on their own. Too often we do not seek to fully understand the wealth of local knowledge backing up present practices. The potential for knowledge sharing, and for identifying and testing new solutions by becoming real partners with local innovators, is another area we hope to develop much more fully in the future.

Finally, we are working to ensure that we make the knowledge generated by all of you and ICIMOD really useful to both the mountain farmers and policy makers. We realise that this will require far more attention to building effective communication of the results into our programmes and projects from the outset. It will require that results be communicated not just in research reports, but through print and other media in local languages and accessible formats.

We look forward to working with our partners in the region to take these initiatives forward, and we hope that while you are addressing the issues of mountain agriculture you will also provide guidance on how this can best be done.

I hope you have a very successful symposium and a pleasant stay in Kathmandu.

Thank you.

Keynote Speech

Mountain Agriculture, Marginal Lands, and Sustainable Livelihoods: Challenges and Opportunities

Tej Partap
CSK Himachal Agriculture University, Palampur (HP), India

Status of Farming in the Hindu Kush-Himalayan Region

Most of the mountain people in the Hindu Kush-Himalayan (HKH) countries (Nepal, Bangladesh, Bhutan, Pakistan, India, China, Myanmar, Afghanistan) depend upon agriculture for their livelihoods. Land ownership in these societies is not only a symbol of economic status but of social status as well. Shrinking cropland as a consequence of unrelenting demographic pressure and sub-division of holdings is endangering their food and livelihood security. Although a population of about 150 million inhabiting an area of 3.4 million sq.km in the HKH countries gives an overall population density of about 44 per sq km (with a range of 2-200 persons per sq.km), the actual pressure on sloping hills and mountains is better indicated by the number of people per sq km of agricultural land, a figure that is much higher. Table 1 shows that per capita availability of cropland in almost all countries of the region is too small to afford decent livelihoods. The uplands of the HKH region have limited cropland (11% of the total area) to support the livelihoods of rural households. The potential yield of cropland is further reduced because 37% of the cropland is sloping land, with farmers cropping lands with slopes even beyond 25° and 30° (Partap 1999). Unrelenting demographic pressure, thanks to the launching of numerous health and family welfare programmes, and continuous sub-division of holdings due to lack of alternative employment opportunities have further aggravated the scarcity of cultivable land.

The problem of shrinking agricultural land is compounded because new human settlements, urbanisation, industrialisation, and infrastructure developed by government are devouring the flat valley cropland. In his landmark study of global cropland loss, Gardner (1996) warned about the implications of cropland loss to food security and livelihoods. He predicted that hill and mountain areas would suffer most from cropland loss. Almost all countries of South Asia lack laws to prevent the conversion of cropland to non-agricultural purposes.

Table 1: Sloping lands and people in the Hindu Kush-Himalayan region

Country	Mountain area (sq.km)	Sloping land %		Agricultural land (%)	Per capita agricultural land (ha)	Population inhabiting marginal areas (million)	Population density (per sq.km)
		8°-30°	>30°				
Afghanistan	390,475	35.1	41.9	10.0	NA	13.8	35
Bangladesh	13,189	60.5	12.2	7.8	0.10	1.2	57
Bhutan	46,500	12.7	88.4	7.6	0.17	1.2	30
China	1,647,725	10.0	50.7	1.2	0.15	19.6	20
India	482,920	30.7	21.1	8.3	0.29	35.0	73
Myanmar	280,862	37.4	29.1	7.7	NA	5.8	21
Nepal	147,181	12.7	66.3	18.0	0.13	18.5	126
Pakistan	404,195	29.3	35.6	7.8	0.16	22.7	56

Sources: Partap (1998)

This has led to reduced numbers of small farmers, who find it difficult to resist the lucrative land market.

Mountain farmers have adopted multiple strategies in their desperate bid to maintain their livelihoods in the face of an ever-shrinking land base and dwindling crop yields. These include extending cultivation to steep slopes and increasing male migration to the plains. The former practice has accentuated the problems of falling crop yields and environmental degradation, manifested in increasing soil erosion, declining soil fertility, and so on. The studies have documented numerous indicators of unsustainable agricultural practices in different regions of the HKH (Jodha and Shrestha 1994). These are summarised in Table 2. The net result has been increased environmental degradation, abandonment of land, increasing drudgery for women, and impoverishment and endemic poverty. This whole process is aptly described as a poverty-environmental degradation-poverty cycle. This state of affairs poses difficult questions and paints a grim picture for times to come. We are obliged to ask several questions.

- Where do we go from here?
- How do we ensure the livelihood security of the households of upland areas?

Table 2: Indicators of unsustainable upland farming in the HK-Himalayas (*1954-1991*)

Indicators reflecting problems relating to resource base/production flow & resource management	Range of changes
1. Soil erosion rates on sloping lands	+20 to +30 %
2. Abandonment of agricultural land due to decline in soil fertility	+3 to +11%
3. Appearance of stones/rocks on cultivated land	+130 to +100 %
4. Size of livestock holding per family (LSU)	-20 to -55%
5. Area of farmland per household	-30 to -10%
8. Forest area	-15 to -85%
7. Pasture/grazing area	-25 to -90%
8. Good vegetative cover on common property land	-25 to -30 %
9. Fragmentation of household farmland (in number of parcels)	+20 to +30%
10. Size of land parcels of families	-20 to -30 %
11. Distance between farmland parcel and home	+25 to +60%
12. Food grain production and self-sufficiency	-30 to -60%
13. Permanent out-migration of families	none to 5%
14. Seasonal migration	high to high
15. Conversion of irrigated land to dry farming land due to water scarcity	+7 to +15 %
16. Average crop yields on sloping lands	
maize and wheat	-9 to -15%
millets	-10 to -72%
17. New land under cultivation	+5 to +15%
18. Human population	+60 to +65%
19. Application of compost (organic manure)	-25 to -35%
20. Labour demand for falling productivity	+35 to +40%
21. Forestry farming linkages	weak to weak
22. Foodgrain purchases from shops	+30 to +50 %
23. External inputs' needs for crop production	high to medium
24. Fuel wood or fodder scarcity in terms of time spent in collection	+45 to +200%
25. Fodder supply from	
common land	-60 to -85%
private land	+130 to +150%
26. Emphasis on monocropping	high to high
27. Steep slope cultivation (above 30%)	+10 to +15%
28. Weed and crop herbaceous products' used as fuelwood	+200 to +230 %
29. Conversion of marginal land into cultivation	+15 to +40%
30. Fallow periods	from 6 months to 3 months

Note: A positive sign (+) means increase and negative sign (-) means decline/ decrease
Note: adapted from Partap (1998)

- Are solutions available? Is the technology to support the solutions available?
- How do we preserve the environment and rich biodiversity available in the mountains?
- Are there any experiences of success in the HKH to draw upon?

These and other questions need to be answered to ensure food and livelihood security to mountain people without further degradation of their environment.

The availability of vast marginal lands provides hope in this otherwise dismal scenario. Besides marginal lands, in most South Asian countries a sizeable amount of land is available between the cropland and forest land. This is known by various names, such as wasteland, grazing land, rangeland, shrub land, unclassed forests, and so on. Much of this land provides crucial support to farming and the livelihoods of hill and mountain farmers (Partap 1998a,b). The hope lies in finding ways and devising technologies to use this land productively to both alleviate poverty and improve the environment.

Marginal Lands: Concept and Definition

Marginal lands have been defined in various ways and different terms like marginal, low potential, resource poor, fragile, vulnerable, or degraded lands are currently in vogue, even so 'marginal lands' is the most commonly used term (Partap 1998b,1999; CGIAR 1999). The term resists precise definition, however, because the productivity of such lands depends on their use. For example, a tract of sloping land that is marginal for crop production may be well suited for grazing or fruit farming. It may be prone to degradation under cultivation but can be used sustainably for forestry. Further, productivity not only depends on the biophysical characteristics of land, but also on the socioeconomic parameters of a specific environment. Likewise, technologies may be known but the necessary incentives, institutions, or inputs may be missing. In brief, the possible uses of marginal lands are too wide and socioeconomic conditions of upland, mountain, or highland farmers too diverse to encompass all the relevant factors in a single term.

Marginality of land results from several constraints. For instance, biophysically good land can be marginal due to its isolation from markets, the non-availability of inputs, or the small size of holdings. The nature, composition, and interaction of the factors determining marginality can also differ widely. Accordingly, four broad land types can be identified: (i) relatively favoured lands with high current agricultural value, (ii) lands at low or zero intensity of agricultural use value, (iii) marginal lands with low present agricultural use value, and (iv) lands at low or zero intensity of agricultural use.

A number of factors may shift such land from one category to another. These shifts may be upward through applications of appropriate improved technologies, or downward as a result of land degradation due to its inappropriate use. In net terms, marginality is a dynamic process, and sloping land that is marginal for crops requiring continuous irrigation and moisture for their entire growing period (e.g., rice) could be highly productive for perennial crops that need less moisture and can tolerate bouts of drought. Marginal cropping land may support productive and sustainable livestock production systems. Thus, whether land is 'marginal' depends on several key characteristics like use, biophysical characteristics, location, institutional and policy context, population pressure, technologies, and so on. A given piece of land may move out of or into marginal status depending on which of the dimensions are considered.

Agriculture on Marginal Lands: Past Neglect and Current Agenda

In the past, because of the perception that cropping is unsustainable on slopes beyond 15^0, marginal lands did not figure in the research agenda of national agricultural research systems (NARS). Thus because sloping lands (8%-30%) comprise much of the Himalayan region, most people remained deprived of the technological support necessary to adopt sustainable farming practices (Partap 1998b). One also finds misconceptions about the role of forest in the sustainable management of marginal lands. Forests not only play an important ecological role in maintaining the hydrology and soil movement of sloping lands, but also provide viable, economically sustainable options. This misconception about the role of forests has led to lost opportunities for using sloping, marginal lands in more productive ways.

This past neglect has led to a number of harmful effects.

- First, with the availability of improved technology for producing cereals, the indigenous crops and crop varieties have disappeared, and a rich source of genetic material has either been lost or is on the verge of extinction.
- Second, several potential crops that can be grown in the area remain unexplored.
- Third, although many high-value cash crops eminently suitable to these areas (like medicinal plants) are known and documented, the technology to grow these crops is not yet available.
- Fourth, the available technologies have remained in laboratories and are yet to be experimented on in farmers' fields.

Things have, however, started changing. At the international level, three ongoing developmental processes facilitate the shift in investment and international research towards marginal lands (CGIAR 1999).

- The environmental lobby has promoted a growing concern for vulnerable and fragile lands (because of the global dimension to the problem of degradation of sensitive natural areas), the deterioration of mountain environments, desertification, and destruction of biodiversity.
- The development lobby has promoted a concern for poverty. Because most of the world's poor live on marginal lands in the developing world, concern for making marginal lands more productive has become a proxy for reducing the poverty of those who inhabit these lands.
- The agricultural and environmental lobbies have promoted concern for mountain agriculture, where rainfed sloping farmlands are being marginalised or degraded through their overuse or misuse.

Recently, in its efforts to reorient research priorities and to give more attention to marginal lands, CGIAR (1999) defined marginal lands as marginal agricultural lands (MAL), which include sloping lands currently used for agriculture, grazing or agroforestry. They are characterised by poor soil fertility (nutrient deficiencies, acidity, salinity, poor moisture holding capacity, and so on); inaccessibility (with all its social and economic dimensions);

fragility; and heterogeneity (physical and cultural diversity that bring inherent constraints and opportunities).

Success Stories: Experiences and Lessons

Some of the success stories about the productive use of marginal lands in different regions of the HKH are discussed below. Among the indigenous technologies available, terracing is the most widely known traditional practice used for farming the sloping lands across mountain regions of Asia and the world. Countries like Nepal and Bhutan are outstanding examples of this (Das and Maharjan 1988; Thinley 1991). In the humid middle mountains of the central and eastern Himalayas, terracing is essential for crop cultivation on sloping lands over 20°. In recent decades, some institutions have evolved alternatives to traditional stone walls and terracing systems by using contour hedgerow technology, which uses nitrogen-fixing plants and grasses to build the contour hedgerows. While successful adoption of this has been reported in some cases, wider adoption is yet to come (Partap 1998).

Fruit farming on marginal farms

Small, marginal, subsistence mountain farmers of Himachal Pradesh succeeded in improving their food security and livelihoods by diversifying from crops to fruit farming. Adoption of this niche-friendly production system on large areas of marginal farms in the temperate regions of the state made a huge economic and environmental impact. In economic terms, the net domestic product of Himachal Pradesh increased 200 times, and net per capita income 26 times, between 1971 and 1991. There is hard evidence to show that fruit farming on marginal lands is a superior production option both economically and ecologically. The key benefits that accrued from this production system have been outlined by Partap (1995) and Sharma (1996).

The productive use and management of marginal land resources

More than 80 % of the fruit farming in Himachal Pradesh has been carried out on barren and uncultivated marginal sloping agricultural lands. This has led to an increase in the area of economic forests (areas like orchards that provide cash income from trees excluding from timber) in Himachal Pradesh.

Non-viable subsistence farming can be transformed into viable commercial farming through harnessing the appropriate niche potentials of marginal mountain lands. The percentage of small and marginal farmers in Himachal Pradesh has increased to over 75% during the past three decades, and their cereal-based subsistence farming did not yield adequate incomes to meet their needs. Farming thus became an unviable but inescapable option (Vaidya and Sikka 1992). Fruit farming helped reverse this trend and ensure food security and better livelihoods, particularly to marginal farmers. The fruit-based production system helped not only to alleviate poverty, but also to promote zero tillage on sloping farmlands, which led to diverse economic and ecological benefits.

Forest floor farming production system

Cardamom farming on the forest floor in Sikkim presents an example of developing an economically productive and ecologically sound and sustainable production system on marginal and sloping lands (Sharma and Sharma 1997). The following factors made cardamom farming on marginal sloping lands compatible with their biophysical features.

- Cardamom is ecologically adapted to farming on sloping lands and forest areas. The plants maintain a permanent green cover on the forest floor.
- Cardamom farming ensures ecological stability to fragile mountain slopes by requiring farmers to maintain a good forest cover of nitrogen fixing alder trees.
- Cardamom is a farmer-domesticated, indigenous, low volume-high value cash crop eminently suited to marginal lands.

Forestry production system

The large-scale planting of seabuckthorn in China is an example of ecological rehabilitation of marginal lands. The plant's fruit provides raw material for agro-industry. It is the best example of strategies by which people can raise and maintain good forest cover on otherwise unproductive marginal lands. For fragile and marginal mountain lands the environmental gains of seabuckthorn far exceed the commercial benefits. The plant has been used to control soil erosion in the loess plateau and Yellow River basin. A major programme of afforestation using seabuckthorn in the mid-1970s was launched in most of the marginal dry areas in these regions. By 1988, lush green seabuckthorn forests had spread over 113,300 sq km, of which 30% were mixed forests rejuvenated by seabuckthorn (Lu 1992). Today, these plantations have successfully rehabilitated the marginal land by converting it into a healthy forest ecosystem. In economic terms, the total value of the seabuckthorn products produced by the Chinese agro industry exceeds US$25 million a year (ICRTS 1997).

Summary

These examples of fruit farming, cardamom, and seabuckthorn reflect the incorporation of a niche-based mountain perspective in planning the development of marginal lands. In all three cases, suitable technological options were identified. The commonalities in the goals and benefits of these three cases are listed in Table 3. The moral of the story is that marginal lands are not constraints to productivity but in fact are huge, untapped potential resources if appropriate technological choices are made. The experiences described above add a new dimension to the process of linking marginal mountain land management to improving livelihoods. The trends unfolded by these examples define a role for leveraging biodiversity and agrobiodiversity to enhance the use value of marginal land for sustainable mountain development. Scholars have indicated the need for adopting this alternative land-use perspective, albeit in other contexts (Critchley and Reij 1996; Jodha 1992, 1996a,1996b, 1997; Partap 1998b).

Looking Ahead: Some Policy Options

In recent times, global efforts have been initiated for reducing poverty, enhancing food security, and promoting the sustainable use of natural resources in upland areas. Technological and institutional innovations have been made to enhance the productivity and sustainability of marginal land and other natural resources. Contextual specificities in technology generation are the key to targeting agricultural technology research that will mitigate poverty in upland areas. Focusing research on technological innovations for

Table 3: A comparative view of sustainability factors of success stories of upland farming			
Marginal land use experiences, goals, and impacts	Fruit farming Himachal	Cardamom farming Sikkim	Seabuckthorn forests China
Protecting and improving marginal farmlands for productive use	*	*	-
Improving support lands for productive use	*	*	*
Better soil water & nutrient management	*	*	*
Economically productive farming system as primary goal and ecological benefits are byproduct	*	*	-
Ecological restoration/rehabilitation as primary goal and economic benefits are byproduct	-	-	*
Emphasis on biomass production	-	-	*
Stability oriented location specific choice	*	*	*
Harnessing niche for tradeable item	*	*	*
Use of indigenous knowledge practices systems	-	*	-
External R & D inputs, public interventions triggered successes	*	-	*
Sole dependence on local resources	-	*	*
Replicated successful experience from similar environment	*	-	-
New generation crops from local wild biodiversity adapted to marginal lands	-	*	*
Larger scale community level participation a prerequisite to upgrade scale of niche product	*	*	*
Land ownership necessary prerequisite for success	*	*	*
Source: Partap (1999)			

marginal and sloping lands would be an effective way to reduce upland poverty. R&D focused on marginal lands promises to yield high returns.

CGIAR (1999) has made four recommendations for reshaping international agricultural research efforts to meet the needs of marginal uplands and sloping lands. First, sharpen the focus on poverty alleviation, particularly in setting priorities for research related to marginal and sloping lands. Second, establish new forms of partnership to effectively address poverty alleviation strategies to those who live in marginal areas. Because many factors determine poverty in these areas, a multi-pronged strategy that reaches beyond agriculture is required. There is an urgent need to promote participatory research that incorporates gender issues to identify the technology and institutional innovations for on-farm and off-farm employment of the upland poor.

In view of the above, the international and national agricultural research systems should focus on the following.

- Targeted research on marginal and sloping lands at the eco-regional level
- Drawing lessons from the success stories that identify factors complementing R&D efforts to enable poor farmers to adopt technological innovations in marginal areas.
- The innovations focusing on poor and marginal lands may promise higher rates of return for sloping lands and marginal areas. For example, biotechnological innovations that complement pesticide use (genetic resistance), fertiliser (nitrogen fixation), tillage and water practices (drought resistance), and possibly genetically modified organisms (GMOs) raise new hopes for evolving productive and sustainable practices for marginal lands.
- The comparative advantages of the sub-regions and landscapes need to be carefully identified and established. Evidence gathered from Asian uplands (Chang 1998; Gim

1998; Kim 1998; Partap 1998b, 1999; Takatsuji 1998) points at the potential of agroforestry and the production of cash crops to help harness the comparative advantages of sloping and marginal lands.

- Research should focus on the potential of sloping lands, defined in relation to water, infrastructure development, and markets. It is therefore important to address water/sloping land/poverty linkages beyond soil conservation programmes. Water insecurity appears to be a feature in hill, mountain, and highland areas, where sloping lands dominate. Efforts should be made to manage the excess supply of water to tide over periods of water scarcity and ensure access to water, especially to the poor farmers who work sloping land.
- While planning the above, the ongoing process of globalisation and its implications for mountain marginal lands need to be explicitly considered to minimise any harmful effects.

Governments and NGOs will have to take new roles in designing and implementing strategies. Governments may need to formulate policies favouring use of marginal lands for certain types of agricultural production systems that can support livelihoods of local people. More secure land rights may be a necessary precondition to stimulate farmers to invest in these areas.

The solution to the cropland crisis in the mountains appears technically possible, economically viable, and environmentally benign. Given the political commitment, food insecurity driven by the scarcity of cropland, and the poverty of small and marginal farmers, can be mitigated and farming can be made an economically viable and environmentally sustainable enterprise on marginal lands. There are a variety of potential niches and production systems suitable to marginal mountain lands, and their development can go long way to conserving a rich biodiversity. Two of the above-mentioned success stories, seabuckthorn and cardamom, indicate that investing in local bio-resources based enterprises and agro-industrial technologies can transform local and regional economies. Finding ways and means for productive and sustainable use of available marginal sloping lands remains a major challenge for planners, policy makers, scientists, and technologists across the globe.

References

Chang, S.F. (1998) 'Republic of China Taiwan-a Country Report.' In *Proceedings of the Workshop on Perspectives on Sustainable Farming Systems in Upland Areas*. Tokyo: Asian Productivity Organization

Critchley,W.; Reij, C. (1996) 'Recent Trends in Natural Resources Management in the Sub Saharan Africa: Illustrated by Experiences from the West African Sahel.' In *Successful Natural Resource Management in South Africa*, pp 18-30. Windhoek (Namibia): Gamesberg Macmillan

Das,D.C.; Maharjan,P.L. (1988) *Terracing in the HK-Himalayas: A Reassessment*. Working Paper No.10. Kathmandu: ICIMOD

Gardner,G. (1996) *Shrinking Fields: Crop Land Loss in a World of Eight Billions*. World Watch Paper 131. Washington DC: Worldwatch Institute

Gim, U.H. (1998) 'Republic of Korea- a Country Report.' In *Proceedings of the Workshop on Perspectives on Sustainable Farming Systems in Upland Areas*. Tokyo: Asian Productivity Organization

ICRTS (1997) *Worldwide Research and Development of Seabuckthorn*. Beijing: ICRTS

Jodha, N.S. (1992) *Rural Common Property Resources: a Missing Dimension of Development Priorities*. World Bank Discussion Paper No. 169, Washington D.C.: The World Bank

Jodha, N.S. (1996a) 'Enhancing Food Security in a Warmer and More Crowded World: Factors and Processes in Fragile Areas.' In T.E. Downing (ed) *Climate Change and World Food Security*. Heidelberg: Springer Verlag

Jodha, N.S. (1996b) 'Mountain Agriculture.' In Messerli, B.; Ives, J.D. (eds) *Mountains of the World: A Global Priority*. London and New York: Parthenon

Jodha, N.S. (1997) 'Agricultural Growth and Sustainability: Perspectives and Experiences from the Himalayas.' In Vosli, S.A.; Reardon, T (eds) *Sustainability, Growth and Poverty Alleviation: A Policy and Agroecological Perspective*. London and Baltimore: Johns Hopkins University Press

Jodha, N.S.; Shrestha, S. (1994) 'Towards Sustainable and More Productive Mountain Farming.' In *Proceedings of the International Symposium on Mountain Environment and Development: Constraints and Opportunities*. Kathmandu: ICIMOD

Kim, K.U. (1998). 'Mechanization of Hillside Orchards in Korea.' In *Proceedings of the Workshop on Perspectives on Sustainable Farming Systems in Upland Areas*. Tokyo: Asian Productivity Organization

Lu, R. (1992) *Seabuckthorn: a Multipurpose Plant Species for Fragile Mountains*. ICIMOD Occasional Paper No. 20. Kathmandu: ICIMOD

Partap, T. (1995) *High Value Cash Crops in Mountain Farming: Mountain Development Processes and Opportunities*. MFS Discussion Paper No. 95/1. Kathmandu: ICIMOD

Partap,T. (1998a). 'Sloping Land Agriculture and Resource Management in Semi Arid and Humid Asia: Perspectives and Issues.' In *Perspectives on Sustainable Farming Systems in Upland Areas*, pp 38-84. Tokyo: Asian Productivity Organization

Partap, T. (1998b) *Marginal Lands and Marginalized Farmers of the HK-Himalayan Region: Sustainability Challenges and Opportunities*. Paper presented at the DSE-ZEL-ICIMOD international conference 'Mountains 2000 and Beyond: Sustainable Development of the HK-Himalayan Region', June 21-23,1998, Wildbad Kreuth, Germany

Partap, T. (1999) 'Sustainable Land Management in Marginal Mountain Areas of the Himalayan Region.' In *Mountain Research and Development*, 19(3):251-260

Sharma, H.R. (1996) *Mountain Agriculture Development Processes and Sustainability: Micro Level Evidence from Himachal Pradesh*. MFS Discussion Paper 96/2. Kathmandu: ICIMOD

Sharma,H.R.; Sharma,E. (1997) *Mountain Agriculture Transformation Processes and Sustainability in the Sikkim Himalayas, India*. MFS Discussion Paper No. 97/2. Kathmandu: ICIMOD

Takatsuji, T. (1998) 'Labour Saving Technologies for Citrus Fruits on Sloping Lands.' In *Proceedings of the Workshop on Perspectives on Sustainable Farming Systems in Upland Areas*. Tokyo: Asian Productivity Organization

CGIAR (1999). *CGIAR Research Priorities for Marginal Lands*. CGIAR Document No. SDR/TAC:IAR/99/12. Washington DC: CGIAR

Thinley, S. (1991) 'Upland Conservation in Bhutan.' In Castra, C. (ed) *Upland Conservation in Asia and the Pacific*. RAPA Pub, 1991/15. Rome: FAO

Vaidya,S.; Sikka, B.K. (1992) *Small and Marginal Farms in Himachal Pradesh: Economic Viability and Potentials for Increasing Income and Employment.* Shimla (India): Himachal Pradesh University, Agroeconomic Research Centre

Verma, L.R.; Partap, T. (1992) 'The Experiences of an Area Based Development Strategy in Himachal Pradesh, India.' In Jodha,N.S.; Banskota, M.; Partap, T. (eds) *Sustainable Mountain Agriculture, Perspectives and Issues, Vol.2.* New Delhi: Oxford and IBH

Keynote Speech

Highland Agriculture as Peasant Perseverance

Harka Gurung
New ERA, Kathmandu, Nepal

In 1988, ICIMOD initiated problem-oriented research on mountain farming systems in selected areas of the Hindu Kush-Himalayas. This work, done in collaboration with national agencies and experts from the region, involved review of agricultural policies and programmes; and site-specific studies on crops, livestock, horticulture, technology, and rural institutions. The findings of this regional exercise were discussed during the International Symposium on Strategies for Sustainable Mountain Agriculture in 1990 (Jodha, Banskota and Partap 1992). The present symposium can be taken as a follow-up of that meeting to assess the progress made over the last decade.

Terminological Traverse

Our main objective at this International Symposium on Mountain Agriculture in the HKH is to share information and knowledge, and to exchange views on emerging problems and opportunities for development. Our communication will be better if we agree on some terminology at the outset, so I will start by clarifying some terms common in discussions of mountain development. The terms I cite fall into three categories: superfluous adjectives, conceptual fallacies, and spurious designations.

Take the buzzwords 'integrated development' and 'sustainable development'. The burden of 'integrated' was invented in the 1970s and that of 'sustainable' in the 1980s. If one reflects on the meaning of development as 'to cause to become better, more complete, or more advanced', it becomes clear that these terms are merely notional and superfluous. Can there be any intervention to affect such a development without the linkage of systems and sectors? The term 'integrated' as an adjunct to 'development' is mere jargon for a coordinated approach. If there is such a thing as 'sustainable development', one also has to assume the existence of 'unsustainable development'. This helps to clarify the distinction between *intrinsic development* (the former) and *linear growth* (the latter). A development process based on structural change with a propelling mechanism does not need a superfluous adjective that means the same thing. Any 'development' implies an integrated approach and sustainable objective.

The phrase 'fragile mountain' came into currency in 1976. It does highlight the environmental problems of mountain areas, but has the element of exaggeration. Seen on a geologic time scale, the mountain represents a dramatic intermediary stage between the plain (its orogenic womb) and the plateau (its senile form). In terms of geomorphic processes, mountain and hill ranges are outliers of extreme resistance against the gravitational pull. Excessive exposure to natural elements makes mountains a high energy area for mass wasting. Therefore, it would be more realistic to consider mountains as dynamic (Gurung 1987), but certainly not fragile.

Agricultural geography pertains particularly to places that have conventional designations. In Nepal, there are specific native terms for various elevation zones. Yet, so-called scientific endeavours tend to distort them. An FAO/HMGN/UNDP (1980) inventory on watersheds devised five major ecological units for Nepal (Table 1). These were: (1) high Himalaya, (2) transition zone, (3) middle mountain, (4) 'Siwalik', and (5) 'Terai'. Subsequently, another investigation on land systems in Nepal adopted these categories as physiographic regions, although relief forms cannot necessarily be equated with ecological expressions (Kenting Earth Sciences 1987). This is evident from the incongruity of the Land Resource Mapping Project's (LRMP's) 'high mountain' with FAO/HMGN/UNDP's 'transition zone', which actually pertains to areas of deep gorges and valleys. The distinction between Himalaya (1) and mountain (2) is spurious, while the adjective 'high' is equally superfluous to both. The middle mountain (3) actually refers to the conventionally recognised hill region (Table 1). The Siwalik (4) is actually a geological term for the sub-Himalayan foothills. There is no confusion with regard to the Terai (or Tarai) designation for the plains. This scientific obfuscation may be contrasted with native appreciation of their own landscape. In Nepal elevation zones are designated in relation to snow: 'pahar' (no snow), 'lekh' (winter snow), and 'himal' (permanent snow). Furthermore, names for similar landforms vary regionally: the inner Terai is called 'dun' in the west, 'madhi' in central Nepal, and 'khonch' in the east. I have made this terminological digression because agriculture is intimately tied to land, the scientific analysis of which can be enriched with indigenous knowledge.

Table 1: Nepal: elevation zones

Relief feature (Local term)	Ecological unit (FAO/HMG/ UNDP)	Physiographic region (LRMP)	Geographic zone	Main crops and livestock
1.Trans-Himalaya[1] (bhot) 2. Himalayan Axis (himal)	High Himalaya	High Himalaya	Mountain	barley, buckwheat, potato, sheep, goat, yak
3. Elevated Spurs (lekh) 4. Hill Complex (pahar)	Transition Zone Middle Mountain	Middle Mountain	Hill	maize, millet, sheep, goat, cattle
5. Dun Valleys (bhitri madhesh) 6. Foothills (churia)	Siwalik	Siwalik	Inner Terai	mustard, cattle
7. Plains (Terai)	Terai	Terai	Terai	paddy, cattle

[1]West of Ganesh Himal (Longitude 85°E)

Highland Agriculture

Since the Hindu Kush-Himalayas are a composite of various elevation zones that have distinctive ecologies, I prefer the term 'highland' to encompass their spectrum. In the case of Nepal, corresponding to the central Himalayas, these broad divisions are (1) temperate Himalayas, (2) sub-tropical hill, and (3) tropical inner Terai enclosed by foothills. Their agricultural zonation is reflected by indicator crops and livestock (Table 1). Yet, elevation is only one dimension of highland environment. Troll (1967) provides a three-dimensional landscape division of the Himalayan system as: (a) vertical gradation (altitude), (b) from south to north (latitude), and (c) east-west asymmetry (longitude). Rhoades (1992) suggests an overlay of 'human culture' as a fourth dimension over the three geo-ecological ones. The suggested cultural dimension has to do with type of technology. According to the ICIMOD research framework, mountain agriculture includes all land-based activities such as cropping, animal husbandry, horticulture, and forestry. A crop-dominated farming system is dominant in the lower zone, a livestock-dominated system in the higher zone, and in-between there are horticulture and mixed systems. These idealised models are modified by the climatic asymmetry between the arid north-west and the humid south-east. Thus, the typology of agricultural system varies both vertically and horizontally across the HKH region (Table 2). Beginning with the north-south vertical contrast, animal husbandry is dominant in the trans-Himalaya and temperate mountains. Agro-pastoralism is prevalent in the sub-tropical hills. Cereal cultivation increases in importance with decreasing elevation. Horticulture occupies particular niches in the hill zone. Tropical foothills are the domain of cereal cultivation.

Table 2: Agricultural typology across the Hindu Kush-Himalaya-Hengduan

Elevation zone (Climate)	West (Arid)	Central (Humid)	East (Per-Humid)
Mountain (Temperate)	- Transhumance (long-distance) - Cereal cultivation (irrigated) - Horticulture	- Transhumance (medium distance) - Cereal cultivation (irrigated)	- Agro-pastoralism
Hill (Sub-tropical)	- Agro-pastoralism - Cereal cultivation (irrigated) - Horticulture (apple)	- Agro-pastoralism - Cereal cultivation (rainfed) - 'Gartenbau' (Kathmandu)	- Shifting cultivation (rain-fed) - Tea plantation
Foothills (Tropical)	- Cereal cultivation (irrigated)	- Cereal cultivation (rain-fed)	- Shifting cultivation (rain-fed) - Tea plantation

Gurung (1999)

Second, in terms of the east-west variation, animal husbandry is mostly nomadic herding in the trans-Himalaya, long-distance transhumance in the west, and medium to short-distance in the central and east. Long-distance transhumance is represented by the Bakarwal, who traverse 250 km from Dras (3,500m) to Jammu (700m) (Casimir and Rao 1985). The Gaddi of Dhauladhar and Byansi of Darchula had been in the same league but have since been disturbed by development intrusions. In the Karnali zone, Khasa herders' sheep and goats used to travel over 3500m of vertical zone (Bishop 1990). This movement has been hampered by dislocations in the salt trade pattern and community forestry across their passage. Medium to short-distance transhumance is practised by the Magar, Gurung, and Tamang of Central Nepal, and is best documented regarding Sherpa yak herding in the Khumbu area(Stevens 1993). As one moves east, livestock rearing becomes less important, particularly among tribal peoples.

Cereal cultivation is the predominant livelihood mode in the highlands, with variation of crops according to climatic zone. The higher the elevation, the wider the range of crop combinations and the lower the productivity. In the west cereal cultivation is invariably irrigation-based, while the humid east relies more on rain-fed cultivation. Of all hill zone agriculture, that of the Kathmandu Valley may be singled-out as the most intensive (*gartenbau*), being based on hoe cultivation with use of faecal manure. The distinctive feature of agriculture of the east is shifting cultivation where humid climate aids luxuriant vegetation regeneration. Pockets of commercial horticulture and tea plantation are found in areas of road access, with apple prominent in the west and tea in the east.

Any discussion of highland agriculture needs to consider the construction of field terraces. Technical experts contend that sloping terraces contribute to more soil erosion and advise on how to make horizontal terraces! The laying-out of terraces is the highlanders' device to deal with verticality, and sloping terraces are not the product of ignorance or indolence but represent an equation between labour and output. Again let us consider terminology. Horizontal terraces with risers for irrigated crops are known as 'khet'. Sloping terraces for dry crops are called 'pakho'. But some recent works have substituted the term 'bari' for the latter, which is erroneous. Bari and pakho are unirrigated fields but differ in nature and extent. Bari is infield near the homestead, heavily mulched and fenced ('bar'), while pakho are outfields and extensive (Gurung 1987).

Peasant to Farmer

The relative fragility of the mountain may be debated, but there is no question regarding the poverty of the highlanders. Highlands everywhere are marginal areas of human occupation due to the harsh environment. Highland dwellers need to be mobile because of livestock's requirement for seasonal pastorage, and their own need to travel to exchange products and even engage in smuggling if on the border. They have to commute downhill for valley paddy and uphill for potato. It is pervasive poverty that compels the highlanders to impose on the woodland for cropland, fuel, and fodder or else to out-migrate, some as mercenary soldiers.

The objective of this symposium is the development of highland agriculture. Since most highlanders depend on agriculture, improvement in this sector would contribute to poverty reduction and environmental conservation. However, changes will be slow due to the nature of highland agriculture. This is inherent in its subsistence system constrained by relative inaccessibility. The juxtaposition of some aspects of subsistence and market-oriented agricultural systems will make this apparent. The clearest contrasts are shown in Table 3.

Table 3: Contrast in Agricultural Systems[1]

Aspects	Subsistence	Market-Oriented
1. Farming situation	Mostly rain fed	Irrigation and draining
2. Mode of cultivation	Animal and human power	Use of machine
3. Nutrient supplement	Animal manure and compost	Chemical fertiliser
4. Crop range	Numerous types	Limited (even mono)
5. Crop variety	Low to moderate yield	High-yielding and hybrid
6. Grain productivity	Below 2 tonnes per hectare	4-6 tonnes per hectare
7. Cash investment	Very little	Considerable
8. Production for	Domestic consumption	Sale
9. Economic process	Stagnant	Progressive
10. Operating agent	Peasant (culture)	Farmer (economic)

[1]Modified from Schroeder, 1985, p. 42, Table 7.

The main points are that

- the former is mostly rain fed, the latter irrigated;
- the former depends on traditional sources of labour, the latter machines;
- the former relies on organic manure, the latter chemicals;
- the former has wide crop range for security, the latter the most profitable few;
- the former has low input and low yield, which is reversed in the latter;

- the former's grain productivity is less than half that of the latter; and
- the former is for consumption, the latter for sale.

In sum, the former can be described as a stagnant economic process while the latter is a progressive one with external linkages. It is, therefore, tempting to distinguish the operating agents of the two agricultural systems: the subsistence system is operated by the peasant, and the market-oriented system is developed by the farmer. This imagery has an etymological basis. The word 'peasant' derives from the Middle French *paisant*, which refers to the rustic countryside and has a cultural connotation, a way of life. On the other hand, the word 'farmer' derives from the late Latin *firma*, which refers to fixed payment or tax collection and evokes economic calculation, obviously for profit.

The contrast between agricultural systems, stagnant versus progressive, aids in exploring the possibilities and limits of development intervention. If the prescription is to transform peasants into farmers, it becomes necessary to delve into the compulsions of subsistence economy. Part of the explanation has been indicated by the notion of mountain specificities enumerated as (i) inaccessibility, (ii) fragility, (iii) marginality, (iv) diversity, (v) 'niche', and (vi) adaptation mechanisms(Jodha 1992). Of these six, inaccessibility and marginality, on one hand, and diversity and niche, on the other, are expressions of the same attributes. Of the remaining two, fragility is a debatable proposition, and adaptation mechanism, a compulsion. Thus the core highland specificities are inaccessibility as a constraint and diversity as an asset.

Inaccessibility does pose a problem towards a market-oriented agricultural system. The remoteness of an area implies not only decay of innovations with distance but also a higher transport cost. Yet, many mountain areas tend to be of economic as well as political and security concern to governments in the plains. Thus, large tracts of the HKH have been penetrated by military roads that also sustain the highland economy with access to markets. However, most highland areas will still remain inaccessible, and one would hardly wish for wider conflicts to bring roads there. This would mean promotion of livelihood opportunities beyond subsistence agriculture. In the economic arena, the frontier phenomenon need not necessarily mean a limit but also an extension of possibilities (Gurung 1999). This refers to highland products of comparative advantage based on diversity and heterogeneity. The suggested strategy to exploit types of verticality in agriculture would be product specialisation whose high value can off-set the transport cost. Evidence from the countries of the HKH confirm that mere policy prescriptions do not assure their translation (Blaikie and Sadeque 2000), least of all in the highlands of politico-economic marginality. Thus, those concerned with highland agriculture need to devise practical solutions built on the chemistry of local knowledge and wider experience.

Highland Reality

I will conclude with a quotation. I happen to know both the place and the person who made the observation. Tagaring is the name of the place in Lamjung where a landslide precipitated by the earthquake of January 1934 submerged a flourishing salt brine beside the Marsyangdi River. H. W. Tilman is the person who made the observation (Tilman 1952). He was a pioneer of Himalayan climbing, then switched to sailing and was lost off the coast of Patagonia. He visited Langtang Himal in 1949 and passed through Tagaring in 1950 on his way to Manang.

"Whether it takes place little by little or in one swift calamity, soil erosion is generally attributed to man's careless greed, his idleness or neglect. It would not, I think, be fair to blame the people of these valleys on the Himalayan fringe for the frequent landslips which occur there. In turning the steep slopes into fruitful fields, they have been neither lazy nor neglectful.... One might say that on such hillsides, the forest never should have been cleared, in which case, the country must be left uninhabited; or that belts of trees should have been planted which would imply first the giving up of their goats by the villagers".

References

Bishop, B. (1990) *Karnali Under Stress*, p. 242. Chicago: University of Chicago Press

Blaikie, P.M.; Sadeque, S.Z. (2000) *Policy in High Places: Environment and Development in the Himalayan Region*. Kathmandu : *ICIMOD*

Casimir, M. J.; Rao, A. (1985) Vertical Control in the Western Himalaya: Some Notes on Pastoral Ecology of the Bakrwal of Jammu and Kashmir. In *Mountain Research and Development*, 5(3):221-232

FAO/HMGN/UNDP (1980) *A Reconnaissance Inventory of Major Ecological Land Units and their Watershed Condition in Nepal*. Kathmandu: HMGN

Gurung, H. (1987) 'Protection of Himalayan Environment: Traverse and Bivouac'. In *Himal Journal (Nepal)*, 9-11

Gurung, H. (1987) 'Interpretation'. In Blaikie, P.; Brookfield, H. (eds) *Land Degradation and Society*. London: Methuen

Gurung, H. (1999) *Mountains of Asia : A Regional Inventory*. Kathmandu: ICIMOD

Jodha, N.S. (1992) 'Mountain Perspective and Sustainability : A Framework for Development Strategies'. In *Sustainable Mountain Agriculture*, 1:41-82

Jodha, N.S.; Banskota, M.; Partap, T. (1992) (eds) *Sustainable Mountain Agriculture*. Vol. I (Perspectives and Issues), Vol. II (Farmers' Strategies and Innovative Approaches). New Delhi: Oxford and IBH

Kenting Earth Sciences (1986). *Land Resources Mapping Project (LRMP): Land, Systems, Land Use and Economics Reports* (text in 8 vols., maps of 1:50,000 in three vols.). Kathmandu: LRMP

Rhoades, R.E. (1992) 'Thinking Globally, Acting Locally: Technology for Sustainable Mountain Agriculture.' In Jodha N.S., Baskota M. and Partap, P. (eds) *Sustainable Mountain Agriculture*, 1:225-272

Stevens E.S. (1993) *Claiming the High Ground*. Berkeley: University of California Press

Schroeder, R.F. (1985) 'Himalayan Subsistence Systems: Indigenous Agriculture in Rural Nepal'. In *Mountain Research and Development*, 5(1):31-44

Tilman, H.W. (1952) *Nepal Himalaya*, pp 126-127. Cambridge: Cambridge University Press

Troll, C. (1967) 'The Climatic and Phytogeographical Division of the Himalayan System'. In *Khumbu Himal*, 1:353-388

Issues in Mountain Agriculture in the Hindu Kush-Himalayas

Poverty Reduction and Agriculture in the Hindu Kush-Himalayan Region: Some Emerging Issues

Tang Ya
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

Reducing poverty has become the single greatest challenge worldwide. In the Hindu Kush-Himalayan (HKH) region, where more than 50% of the population of 150 million people live in extreme poverty, this challenge is even greater than elsewhere. Compared to other mountain regions, the HKH has special development constraints. Among these are the geologically young and unstable topography, fragile and deteriorating environments, small and ever decreasing landholdings, and large and fast-growing population. Despite various measures taken and efforts made by international and national agencies, poverty in this region continues to worsen.

Agriculture is the most important livelihood sector in the HKH region and provides a substantial proportion of rural incomes and employment opportunities. Around 80% of the population are engaged in various land-based activities. Rapid agricultural development, along with improvement of the environment and conservation, is a prerequisite to alleviating rural poverty, and development of agriculture will to a large extent determine alleviation or aggravation of poverty in the HKH region. Unfortunately, agriculture in the region has shown an increasing unsustainability. Hence it will be important to revisit previous agricultural strategies and to improve our understanding of mountain agricultural development.

Experiences and Lessons from Previous Projects

Many projects aiming at poverty alleviation and environmental conservation have been implemented in the HKH region, but the achievements and impacts of many have been insignificant or significant only very locally. A critical review and analysis of some of the projects allows us to draw several lessons.

Technologies should combine improvement in cash income with environmental conservation

Poverty in the HKH region has been closely associated with environmental degradation. However, many poverty alleviation programmes focused on environmental conservation have failed. Environmental conservation is important, but the main players in the mountains are the local people. Therefore, no matter how good a technology is in terms of environmental conservation, if it is not acceptable to and adopted by local people, it cannot do anything for environmental conservation. For farmers to adopt any improved technology, potential improvement in cash income is a prerequisite. The issue of adopting improved technologies is often complicated by the researchers or promoters themselves, who may have involved many factors without carefully examining their significance.

From the farmers' point of view, the major concern is what positive changes occur after adopting a technology. For them, cash income is their first priority, and sufficient cash income gives them a feeling of livelihood security. This explains why, in some parts of the HKH region, farmers are practising highly intensive off-season vegetable farming that requires many external and labour inputs. They do this because it offers good cash income. Other evidence indicates that farmers are increasingly adopting practices that give fast economic returns, but that may lead to environmental and resource degradation. Practices with potential long-term but no immediate benefits are often not accepted, on-farm research and on-farm demonstration of sloping agricultural land technology (SALT) have indicated that SALT is effective in helping reduce soil erosion, improving soil fertility, and enhancing crop yields. Nonetheless, farmers are reluctant to adopt it, mainly due to the lack of visible and direct increases to cash income. Where cash crops planted in hedgerows (e.g., mulberry in China) or in alleys (e.g., sweet oranges and vegetables in China) have been included in SALT, there has been large-scale adoption of SALT practices.

Poverty reduction programmes should incorporate local biophysical and socioeconomic conditions in the project design and implementation

An analysis of successful poverty reduction programmes in the HKH region reveals that most successes occur in the course of transforming natural resource management in the context of local biophysical and socioeconomic conditions and markets. Further analysis indicates that, unless heavily subsidised by donors or government, success occurs only in places where the local biophysical and socioeconomic conditions have been correctly and sufficiently incorporated in the project design and implementation, with active participation of local government agencies and local people. In this way, the local niches can be best harnessed. Poverty continues in the areas where the local niches have not been well considered, used, or correctly analysed. Local organisations and local people may lack appropriate ideas or approaches about how to identify and harness potential local niches, however, and then interventions from outside are necessary.

Mountains in the HKH region are characterised by greatly diverse physical conditions, which provide a great number of unique habitats or niches and great opportunities for promoting specific niche-based farming systems. However, most of the past programmes have copied imported ideas, with little consideration of adopting options to best exploit and use local niches that can help gain maximum economic and environmental benefits.

Programmes should be attractive to both local people and the local government

Poverty reduction and environmental conservation have been major concerns of many national institutions and government agencies. But the interests of local people and of local governments do not always coincide. The proposed programmes or promoted technologies should address the interests of both local people and local governments. Experience shows that when a programme or a technology is in the interests of both local people and local governments, it is more likely to succeed or to be adopted. In the past, most programmes have been related only to improvement of the environment. Although many improved environmental technologies and practices have been developed and promoted, adoption of these technologies has not been always satisfactory because they primarily met the interests of governments rather than farmers.

Revisiting Mountain Agriculture: Some Emerging Issues

Though it is known that mountains have their unique characteristics different from those of plains areas, the strategies and policies for agricultural development in mountain areas have not differed much from those set for lowland and plains areas. Sustainable agricultural development in mountains requires different strategies from those set for plains areas.

Cereal crops vs cash crops and trees of economic significance

Lack of cash income is one of the major causes of poverty in mountain areas. Increases in household cash income cannot be achieved through development of normal staple food crops, mostly cereals, due to the small production bases and low prices for such crops. Until now most crop production in the HKH has been subsistence-based. However, increases in cash income can be achieved through promoting practices based on agroforestry centred on cash plants and fruit and nut trees. Mountains include unique niches not found in lowlands or plains areas, and certain cash plants are suitable only for such niches. Mountain areas will never be able to compete with the lowlands and plains in producing common crops. The most efficient ways to increase income will therefore be based on making use of conditions that are not present in lowlands and plains. This has become even more realistic with the fast development of globalisation and its associated market linkages. However, a quick review indicates that increasing food production generally has been the focus of agricultural development. As a result, the agricultural structure has been quite simple and income generation has fluctuated.

The biophysical background in mountains is diverse and complex. The diverse, unique, and complicated biophysical conditions should be fully utilised in selecting the most appropriate crop (cash or food) varieties to be promoted so as to develop a really niche-based mountain agriculture. Cash crop farming may be one option. Evidence from the HKH region indicates that cultivation of cash plants can provide a stable increase in income to local farmers. Such success stories can be found, for example, in Himachal Pradesh in India (apples), Ningnan County (mulberry, sugarcane, tobacco) and Wenshan Prefecture in China (pseudo ginseng), and Ilam in Nepal (broom grass).

The quality of croplands in mountain areas is usually low, and agricultural infrastructure (such as irrigation) is underdeveloped. Continuous cultivation has further degraded many mountain croplands in terms of fertility, productivity, water holding capacity, and so on. Some cash plants grow best in such habitats, and are poorly productive on fertile land; huajiao (*Zanthoxyllum bungeanum*) is a good example. Promoting low-risk perennial production in poor and marginal lands may be a promising option for generating income.

Full and correct understanding of a region

Correct analysis and understanding of the local physical background are prerequisites for economic development and environmental conservation. This is particularly important for cultivation of cash plants and crop trees. Research reveals that though a particular species can grow in many localities, it will perform best only in some specific ones. Grown in different localities, the useful chemical compounds of certain plants may differ considerably, which affects their value as food or medicines. For instance, one yam species has a wide natural distribution and has been cultivated for saponin production, but research indicates that only plants distributed or cultivated in specific areas yield effective compounds.

The effect of the temperature of spring water in Jiangkou County of Guizhou Province in China is another example. The water is colder than normal and the temperature varies by only 0.4°C throughout the year, despite large atmospheric temperature variations between summer and winter. This low temperature has affected paddy rice production; the water must be heated by sunshine before flooding the paddy fields. This water has been seen as less useful, until recently when it was found that the water is perfect for raising some high demand species of fish that sell for about 120-150 yuan per kg. The previously less useful resource has become an important source of income generation.

These examples illustrate the importance of a full, adequate, and correct understanding of the biophysical background of a region. There might be many niches or resources whose potential uses remain unrecognised. Since practical information is often scarce, a series of case studies needs to be carried out in selected sites to explore new uses of existing resources or niches.

Disadvantages vs advantages: potential to increase productivity

In developed countries and in many so-called 'rice bowl' regions of Asia, very high levels of output per hectare or per animal unit have already been achieved, and there is little room left for increase. Use of agrochemicals, including chemical fertilisers and pesticides, has reached a very high level in these countries and regions, and the continued and extensive application of agrochemicals has led to a reduction in the incremental yield increases from application of chemical fertilisers (Ruttan 1999) and pesticides.

In contrast, and in part due to physical constraints such as poor accessibility, fragility, and marginality, agriculture has remained largely traditional in many parts of the HKH region, and productivity has been quite low. The use of agrochemicals has been very low, and increasing such usage should be an important area for development. Continuous and extensive application of agrochemicals can cause serious soil and water pollution, however, which in turn have raised concern about food safety. Another option for mountain areas would be to focus on very low-level or no use of agrochemicals and thus produce 'safe' and 'organic' food for which there is a growing market.

Agricultural development vs environmental conservation

Agriculture remains the principal livelihood of poor people and accounts for most land use in developing countries; as such it is probably the single most powerful influence on environmental quality. There may be a potentially serious conflict between environmental quality and poverty reduction in agricultural areas. Examples from many developing countries indicate that in the past many poverty reduction projects have been implemented at an environmental cost; small rural enterprises based on locally available resources have been the main contributors to water and soil pollution.

While some mountain people are aware of the importance of environmental conservation, most marginal subsistence farmers are not much concerned about changes in the environment, including their causes and results. As a result, agricultural activities have been expanded to very fragile areas, leading to accelerating degradation of fragile environments and the consequent increasing impoverishment of mountain people. Human interventions have been recognised as important contributing factors in the deterioration of natural resources in the mountains, which again have made it even more difficult to eradicate poverty in the mountain areas.

Our understanding of poverty-agriculture-environment interactions and their importance to sustainable economic development has advanced considerably in recent years. However, our capacity to respond effectively is still limited, in part by the limited power of agricultural interventions to address poverty and environmental issues that reflect much broader socioeconomic and policy realities. Evidence shows that mountain people become concerned with the quality of life and environmental conservation only if they have extra income; only then will they participate or invest in environmental conservation. Thus, increasing income should be the priority of poverty reduction and environmental conservation programmes in the HKH region.

The time may have already come to compensate mountain people for conserving or managing valuable resources and for providing services to others.

Migration and seasonal labour vs mountain agricultural development

The trend of transition to a largely urban society in the 21st century is clear. However, it seems that the contribution of migrated farmers or seasonal labourers from mountain areas to economic development in urban areas has not been fairly recognised. Rural areas have been faced with problems of under-development and poverty, decreasing per capita landholdings, and increasing land pressure for many years, but few efforts to solve these problems have used migration as one of the possible options. Many organisations have tried to minimise this trend rather than to manage it in an organised way. Migration is seen as a negative occurrence, with a negative impact. The migration of more people to urban areas may be an unavoidable trend, however. As such we may need to consider it from a positive view. Experiences from many developing countries have demonstrated that seasonal labourers and migrated farmers have contributed to several areas.

- Reduced land pressure: field survey in the Wuling Mountain area of China indicates that as many as 70% of young people leave their family seasonally to look for work in urban areas.
- Economic development in the urban areas: without the contribution of migrated or seasonal labourers, the eastern and the coastal areas of China would not have developed as rapidly.
- Capacity building of the migrated farmers: working with enterprises is also a training process.
- Cash flow to rural areas
- Transferring new technologies and new ideas to rural areas
- Speeding up economic development and urbanisation

Although there have been few reports of efforts to organise seasonal labourers, in some hill and mountainous counties of western China, a government organisation has been established to help farmers to find jobs in coastal regions and to protect them. This is an area that should be considered more carefully.

Cropland dynamics

The HKH region is quite large compared to other mountain systems in the world, but a very large portion of the region is uninhabitable. As a result, the population density in the habitable part is high. An analysis of cropland loss reveals that urbanisation and natural hazards like soil erosion and landslides have been the most important causes of cropland loss. Furthermore, most of the croplands permanently lost were of high quality. Although there have been some increases in croplands through land reclamation, these lands are often of lower quality than the land lost. As a result, there has been both a net loss of croplands and an overall decrease in the potential productivity of croplands with an increase in marginal lands. The crops grown on marginal lands will have to provide the bulk of the requirements of the future population for food and cash crops. Most marginal lands are not good for food crops but are suitable for cash plants and crop trees. Development of perennial, economic, tree-based agroforestry is one possibility. Research has found that planting trees on flat fertile farmland has an adverse effect on crop growth and yield, but planting trees on marginal farmland can improve crop growth and yield. Even when tree planting leads to reduced crop yield, the overall economic benefits are likely to be higher than those for crops alone.

Decreases in per capita landholdings mean that farmers will have to invest more labour in cropland to support themselves. Improved technologies or practices that require intensive labour and more manipulative husbandry will be better suited to smallholder agriculture.

Organising mountain farmers

Farmers are often forced to sell their products at low prices due to lack of market information and mechanisms. In the HKH region, almost all farmers operate individually. Once cash crops and fruit trees are cultivated, organising farmers will be crucial to securing real increases in income. Farmers operating individually usually compete with each other to sell their products, which benefits the middlemen. In many developed countries farmers have benefited from being organised through the reduced the risk of lower prices.

Farmers' institutionalisation and capacity building

Poverty is a common phenomenon in mountains, but almost every community includes the richer of the poor. Though various factors contribute to these differences, often the different management of similar resources is the most important factor. It will be useful to study the cause of such differences, how these different management practices have helped harness various mountain niches, and the replicability of these practices.

Education has also played an important role in agricultural development in mountains. Compared to illiterate farmers, educated farmers accept new technologies more quickly and easily, manage resources better, demand innovation, and earn much more (Bao et al., this volume). In communities, the richer of the poor are usually those with more education.

Networking

Exchange of experiences and lessons is important for poverty reduction. Networking has therefore been listed as an important component of many projects. It is important to identify and document practices that have provided satisfactory cash incomes to local people. Studies of how these practices have helped harness various mountain niches and possible areas for replicating these practices should be emphasised. A synthesis of different successful practices and natural resource management approaches will help promote the best ways of using marginal farms to increase farm income.

Due to poor accessibility, isolation, and lack of access to information and technology, people in a specific mountain locality usually have limited information about practices in other areas. As a result they cannot learn from success stories in other areas, and mistakes are also repeated. To fill this gap, exchange visits to other regions should be organised. Up to now, most exchange visits have been organised to successful regions and there have been no exchange visits to failed areas. But visiting such areas is equally important, because such visits will help avoid repetition of mistakes. In addition, with the fast improvement in communication in many mountain areas, establishment of an internet-based network will be possible in the future, and the internet may become a significant force in helping people in remote areas to access more information about their products.

Future Directions

A number of factors contribute to increasing poverty in the HKH region, including national and international policies, lack of access to sources of income, lack of appropriate interventions and technologies, lack of empowerment, lack of basic services, and so on. Farmers' access to new income generating options and marketing information, availability of sustainable production technologies and their suitability for the poor, farmers' awareness and assessment of the importance of environmental conservation, and their capacity to mobilise investment resources through their own assets and networks are often very limited or even absent in many parts of the HKH region. These have made poverty reduction in the HKH difficult, and all development and other efforts must take them into consideration.

Poverty is increasingly seen as both a major cause and a result of degraded soils, vegetation, water, and natural habitats. Observers have conceptualised the link between rural poverty and the environment as a downward spiral associated with population growth and inadequate resources for resource management, or as the result of economic marginalisation of the poor leading to their migration to ever more environmentally fragile lands. Reducing poverty should not come at the expense of the environment. Therefore, the major concern of many international and national institutions and agencies is now whether it is possible to reduce poverty while protecting or improving environments.

Cultivation of cash plants has proven to be a useful way of increasing rural incomes. But in many parts of the HKH region, people look outside to learn about potential cash crops, while ignoring potential cash crops that are native to the region. There are many cash plants in the mountains, mostly known only locally. There are also many crops that are neglected or underexploited. Many of these plants may have great potential in achieving food security and improving livelihoods in the mountains, but are either under limited cultivation or completely wild. For example, cultivated raspberries have been an important cash crop in the USA and Europe, but not in the HKH region, even though there are many wild species of raspberry, some with very good economic traits. There has been some limited cultivation of raspberries on a trial basis, but nothing has been done to identify, assess, collect, or survey the resources in the region.

The demands for natural products in international markets have been increasing rapidly. Many international companies have entered the HKH region to buy raw materials because the HKH region is famous for being rich in medicinal plants, some of which are only found there. Apart from international markets, the member countries of ICIMOD include two big markets for medicinal plants. Cultivation of medicinal plants is thus another way of increasing income from marginal lands.

On the other hand, some constraints in mountains, such as low soil fertility, lack of irrigation, lack of marketing facilities, and so on, have limited agriculture largely to cultivation of food crops although other physical conditions may favour cash crop cultivation. Cultivation of food crops may not always be a viable option in mountain areas.

In the past three decades, the increase in total crop production has been an unarguable fact. But farmers' incomes have not increased concomitantly. The incomes of farmers are actually declining because the cost of inputs is increasing. Agricultural returns are likely to decline further, if not as a result of reduced production then certainly as a result of increased costs. In China, for example, grain production increased threefold from 1965 to 1983, but this increase was achieved through increased use of chemical fertilisers, pesticides, diesel fuel, and electricity for agricultural use by factors of 37, 2, 6, and 11 times, respectively (Weng 1987).

References

Bao Weikai; Tang Ya; Chen Jianzhong. *Role of Economic Trees in Mountain Farm Economy: A Case Study of Apple Cultivation in Maoxian County, Sichuan Province, China*. This volume

Ruttan, V.W. (1999) 'The Transition to Agricultural Sustainability'. In *Proceedings of the National Academy of Sciences* (USA), 96: 5960-5967

Weng Dazhong (1987) 'Industrial Energy Intensification and Improvement of Chinese Agro-ecosystems'. In *Journal of Ecology*, 6(3): 1-5

Land Use Change in the Middle Hills of the HKH: Insights from the Five PARDYP Watersheds

R. White
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

The People and Resource Dynamics in Mountain Watersheds of the Hindu Kush Himalayas Project (PARDYP) is a research for development project funded by SDC (Swiss Agency for Development and Cooperation), IDRC (Canadian International Development Research Center), and ICIMOD. PARDYP is working with national institutions in China, India, Nepal, and Pakistan[1] to improve understanding of natural resource management in the middle hills of the HKH. Further technical inputs are provided by the University of British Columbia, Canada and the University of Bern, Switzerland. The study areas are watersheds of between 30 and 120 sq.km in each participating country, with the exception of Nepal where two watersheds are included. PARDYP's activities seek to achieve the following:

- understand community institutions and develop community-based methods for solving natural resource management problems faced by the communities;
- understand the basic causes of inequity, and empowering and building the capacities and voices of women and marginalised people and to mainstream gender into the PARDYP programme of activities;
- generate and exchange information on water as a resource, its role in land degradation, and identify and test options to enhance water management decisions;
- improve the productivity and sustainable management of common property resources – forests, pastures, degraded areas, water, and other common resources;
- use participatory on-farm research methods to generate, test, and disseminate innovative practices and technologies based on indigenous practices and scientific knowledge to improve soil, crop, livestock, and farming systems; and
- identify and capitalise on the livelihood potentials associated with the use and management of natural resources in the PARDYP watersheds.

This paper presents a qualitative review of agricultural activities in the five watersheds from west to east. Farmers' perceptions of the problems and issues they face and a review of the research for development activities carried out through PARDYP are included.

The Watersheds

Pakistan: Hilkot watershed, Mansehra district

Maize is grown in the uplands and rice on irrigated land during the summer. Other annual crops are limited to some wheat for fodder and mustard/canola in the winter, but most fields have only one crop per year. There is a high level of off-farm employment and out-migration. Tenants farm most land, and many pay rent by providing the landowners with a share of the crop. The crop varieties grown are low yielding. In practice, there is no

[1]Teams from: Kunming Institute of Botany, Chinese Academy of Sciences; GB Pant Institute for Himalayan Environment and Development, Almora; ICIMOD, Kathmandu; and Pakistan Forestry Institute.

agricultural extension service. There is good potential for stone fruits. Government policy is to increase tea production in this region, but the elevation is marginal and soil pH is also on the high side. There will be a limited growing season. Hybrid poplars do very well.

Farmers' perceptions of natural resource issues, in rank order, are: low quality seed, soil erosion, soil fertility, lack of extension services, water shortages (irrigation and domestic), and pests and diseases.

PARDYP has introduced improved varieties of maize and rice to the region, trained farmers to graft fruit trees and walnuts, introduced off-season vegetables, and increased on-farm forestry. By improving farmers' access to some basic inputs, PARDYP has been able to make significant contributions to farm incomes. Surveys of medicinal plants found in the watershed have been undertaken, and further work on non-timber forest products (NTFPs) and medicinal plants will be undertaken in 2002.

India: Bhetagad watershed, Kauseni, Uttaranchal

Maize is grown in uplands and rice on irrigated land during the summer. Mustard and wheat are grown in winter. Other annual crops including winter season vegetables are becoming increasingly important. Nearby markets and the increasing buying power of residents are dramatically changing the crops grown, with an increase in floriculture and an intensification of land use and production via 'market garden' development, polythene tunnels, and so on. Tea is grown at the higher elevations, with strong financial and technical support. Apples, pears, and other fruit trees do very well.

Farmers' perceptions of natural resource issues (not rank ordered) include: out-migration; intensification of production (increasingly large amounts of chemical fertilisers are being used); income generation (the market economy is strong); the quality and quantity of drinking water.

PARDYP has demonstrated the use of VAM and rhizobium as biofertilisers to substitute for high levels of chemical fertiliser. The use of polythene lined pits ('polypits') for raising vegetable seedlings, and poly tunnels for growing off-season vegetables early in the year, has been embraced by many of the progressive farmers. Some demonstration fish ponds have been constructed, with interested farmers raising carp to sell to visiting tourists. Methods of rehabilitating degraded lands have been investigated, with a wide range of species tested under hostile conditions. The approach adopted by the PARDYP partner in India is more one of scientific research and applied research backed up with solid data.

Nepal: Jhikhu Khola watershed, Kavre Palanchowk district

Maize is grown on uplands and rice on irrigated land during summer. Mustard and wheat are grown in winter, but with intensive irrigation, vegetables, including potatoes, are produced in the valley bottom in winter. Intensification of land use has been particularly pronounced in this watershed, and now three crops are grown per year in many places. Further intensification is seen as polythene tunnels are starting to appear. Fruit trees are less important than in Hilkot or Bhetagad. The watershed provides excellent opportunities to monitor and understand the impact of rapidly changing land use as intensification proceeds.

The quality and quantity of water as well as changing soil fertility are very significant issues. Parts of this watershed show the extreme hazards of intensification of land use.

Farmers' perceptions of natural resource issues (not rank ordered) include: pests and diseases; the quality and quantity of water for irrigation; the quality and quantity of drinking water; market access; fodder shortages; workload of women; soil fertility; soil erosion; fuelwood shortages.

PARDYP has tested and continues to monitor a number of options for rehabilitating degraded land. The results of these long-term trials will be published in 2002. On-farm issues include management of organic matter, which is considered to be a crucial factor as intensification proceeds. This is a particularly complex issue in Nepal, as the interaction between forest lands as a source of grazing material and the recycling of farmyard manure is very important, and thus the management of forest land has a significant impact on arable land fertility levels. Other important activities investigated include alternative pest management, rainwater harvesting, and improving water use efficiency through drip irrigation systems. Improving fodder availability is a crucial activity that will be a major research topic in the coming seasons. Trials of bag silage and urea treatment of maize stova are planned for 2002.

Nepal: Yarsha Khola watershed, Dolokha district

Maize and millet are grown on uplands and rice on irrigated land during summer, but rice is restricted by temperature at higher elevations. Mustard and wheat are grown in winter. Some significant changes have taken place such as intensification of land use along the new road, but the area is still remote and farmers complain about lack of market opportunities. The construction of the new road gives an opportunity to monitor the impact of improved access to markets on farming systems.

Farmers' perceptions of natural resource issues (not rank ordered) include: market access; improving incomes (from a very low base); water for irrigation; quantity of drinking water; poor agricultural extension services; fodder shortages; soil fertility.

PARDYP has investigated the possibilities of managing the sustainable extraction and where possible the cultivation of NTFPs and medicinal plants, taking advantage of the important biodiversity in this agro-ecological zone. Improving livelihoods for these poor communities is a priority. Trials for cultivating local medicinal plants on farmers' fields show promising results.

China: Xi Zhuang watershed, Baoshan, Yunnan province

Maize is grown on the uplands and rice on irrigated land during summer. Mustard and wheat are grown extensively in winter. Other annual crops, including winter vegetables, are becoming increasingly important. Nearby markets are expanding, with some urbanisation taking place in the main watershed. Intensification of land use is noticeable, with maize now grown in poly-pots and later transplanted at the start of the monsoon. Tea is grown throughout the watershed, often intercropped with maize. Stone fruit trees and walnuts do well.

Farmers' perceptions of natural resource issues, in rank order, are: irrigation water; soil fertility; forest management and access to forest products; tea processing; pests and diseases.

PARDYP has helped design and construct small water tanks on farmer's fields to irrigate the early maize as well as for drinking water. Numerous fruit trees including improved persimmon, peach, apricot, and plum have been distributed. Training in grafting has been carried out and farmer nurseries for tea, walnuts, and stone fruits have been encouraged. Developing a greater understanding of participatory technology development has been at the centre of the activities carried out in this watershed.

Discussion

Agricultural development activities undertaken in mountain watersheds need to reflect the comparative advantages of that agroecology compared with plains agriculture. The cooler temperatures make cultivation of a wide range of crops, often of high value, possible. Agricultural extension and research should reflect these advantages rather than promoting plains crops in hill areas.

Intensification of crop production will bring with it increased environmental stresses, but there are options to increase agricultural production in sustainable ways if holistic and integrated approaches are adopted. Taking advantage of new biological methods, particularly adoption of bio-fertilisers, effective micro-organisms, and rhizobium, can result in significant yield increases without compromising the environment.

There is increasing demand for numerous medicinal plant species from inside and outside the region. Many medicinal plants thrive in the middle hills and some of these can be grown effectively on farmer's fields. Potentially, the cultivation of medicinal plants is a useful source of income and a sustainable alternative to collecting increasingly rare plants from the wild. It is possible that some of these species can also be grown on terrace risers or in hedgerows so that soil erosion can be reduced.

Consumers throughout the world are becoming increasingly aware of food adulteration. There is a growing, world-wide demand for organic products. While it is still a limited market at present, it is likely to grow significantly and may become a viable alternative to traditional practices if a large urban market and associated consumers are willing to pay extra for unadulterated quality produce. There is clear evidence from India and Nepal that this market is significant. Already many farmers grow vegetable crops in one plot for their own consumption and in another with different amounts and types of pesticides for the market. Linking consumers with growers for this niche market is a challenge.

The baseline data already collected from the five PARDYP watersheds, together with the planned long-term monitoring, should allow the PARDYP partner research institutes to quantify changes in soil and soil fertility in these mountain watersheds as land use changes under increasing human pressure.

Developing Sustainable Mountain Agriculture in the Hindu Kush-Himalayan Region

D. Nangju
World Association for Soil and Water Conservation, Ankeny (IA), USA

Introduction

Agriculture is the most important sector in the HKH region. About 60% to 90% of the population is engaged in various agricultural activities, including crop production, animal husbandry, forestry, and horticulture. During recent years, mountain agriculture in most HKH areas has been showing trends of increasing unsustainability due to increased population pressure; declining agricultural productivity; and declining soil, water, and forest resources. The basic issue facing mountain agriculture is low productivity of land, which is responsible for widespread poverty in the region. Thus, to reduce poverty, it is essential that the productivity of the mountain agriculture be increased on a sustainable basis.

This paper will discuss recent developments in soil and water conservation technologies as a key to the successful development of agriculture in the HKH region. The paper will also examine some important developments in institutional innovation that emphasise the prospective role of farmer-led knowledge sharing organisations.

Need for Investment in Mountain Agriculture

Mountain agriculture in the HKH is characterised by low productivity, which is attributed to many factors. The more important factors are: (i) soil erosion due to farming on steep slopes, (ii) shortage of water for crop growth, (iii) inadequate access to appropriate technologies, (iv) lack of marketing facilities, (v) inadequate credit, (vi) weak community organisations, (vii) small landholdings, and (vii) increasing population pressure.

To improve incomes and the sustainability of mountain agriculture in the HKH, there should be investments to improve agricultural productivity and environmental protection. These investments should also improve the management of watersheds[1] in the HKH region, since these watersheds play a critical role in the regulation of water flow in the lowlands of Bangladesh, China, India, Myanmar, Nepal, and Pakistan to reduce flooding and to provide water for irrigation and power generation; prevention of soil loss to protect power generation reservoirs and irrigation structures; conservation of biodiversity and protection of natural ecosystems; and sequestering carbon to alleviate the threat of global warming (Garrity and Agus 2000). In the past, the development of mountain agriculture in the HKH has been neglected as governments and funding agencies have focused their investments in the more accessible and productive lowland areas. However, recently there has been a shift in the development strategy of governments and funding agencies to focus on poverty reduction in the areas where the poor are concentrated.

[1] Here defined as the land area drained by a common river system

The renewed interest by funding agencies and governments in investing in poverty reduction programmes will provide an opportunity for the development of the HKH region, which is characterised by poor physical and social infrastructure. Poverty has been shown to be the root cause of a natural resource degradation that could have serious consequences on food security in the HKH region (Scherr 1999). Investment in poverty reduction programmes in the HKH region is imperative, as it will bring not only the benefit of income improvement but also environmental benefit both to local areas and to those in the neighbouring lowland. However, there is a need to identify and formulate suitable projects that have good prospects for improving the incomes of the people in the region.

Importance of Soil and Water Conservation

Many households in the HKH region are forced to grow food crops on steep slopes because of lack of alternative opportunities. But continuous crop production on steep slopes causes annual rates of soil loss that can exceed 100 tonnes per ha (Partap and Watson 1994; Sajjapongse and Syers 1995). The soil erosion problem is exacerbated by the widespread deforestation in watershed areas. Consequently, Asia has the worst soil erosion problems in the world. The combined effects of soil erosion and deforestation in the HKH region have resulted not only in reducing crop productivity, but also in flooding and destruction of road, irrigation, and hydropower facilities in lowland areas. Thus, soil and water conservation is the key to achieving sustainable agriculture in the HKH region.

Promising soil and water conservation technologies

- To address the problems in the HKH region, a soil and water conservation technique that can reduce soil erosion and conserve the valuable water resources is required. Conservation measures available to smallholders include bench terraces, planting of fruit trees and timber or pulp tree species, minimum tillage and mulching, grass strip cropping, sloping agricultural land technology (SALT), and natural vegetative strips (NVS). Among these techniques, SALT and NVS are probably the most promising techniques for the HKH region, since the others have serious constraints.
- SALT is a form of agroforestry for managing sloping lands using hedgerows. It is technically a simple system of growing food and cash crops in between rows of fast growing, multipurpose, nitrogen-fixing trees and shrubs planted along contour lines, and managed in the shape of double hedgerows at regular intervals of 3-6m depending on the gradient of the slope. The hedgerows are key elements of the entire system, since they act as erosion barriers; stabilise the slopes by facilitating the formation of natural terraces; increase soil fertility; conserve water; and become the source of animal fodder, fuelwood, and most importantly, mulching biomass. The main drawback of SALT, however, is that it is too labour-intensive to attract farmers' sustained interest. In addition, seeds of multipurpose, nitrogen-fixing trees and shrubs for the establishment of hedgerows are not readily available in some localities, and even if available, are not easily multiplied. Therefore, the adoption rate of SALT in Asia has been poor.
- The NVS techniques are contour strips that are installed simply by laying contour lines across a field, and then allowing natural vegetation to grow in a strip along these contour lines. They have proven to be exceptionally effective in soil and water

conservation, often virtually eliminating soil loss from a field 1-2 years after installation, even on slopes of 30-40%. Because they are composed of regenerating perennial grasses native to the area, they are robust and stable, needing only minimal maintenance over the years. They generally do not grow as vigorously as exotic forage grasses, but this ensures that they do not compete so vigorously with the farmers' more valuable annual and perennial crops, which is often a problem with forage grasses in contour strips. The unique quality of NVS is that they provide a contour buffer strip solution so simple that it is suitable for farmers who have no cash and very little labour to spare. The main drawbacks of NVS are that they do not improve soil fertility, do not reduce soil water evaporation, and do not provide animal fodder or fuelwood to farmers.

Transition from Food Crop System to Agroforests

In many parts of Asia, including the HKH region, sloping lands are not suitable for annual food and cash crops because the soils are fragile and infertile, but they have a strong comparative advantage for agroforestry[2] (Garrity 1999). In many Asian countries, a previously non-existent market for farm-grown timber has evolved, with farm-gate prices many times higher than previously. Many upland farmers can now earn money by planting timber trees on their farms. Generally, trees are planted along the borders of their fields, along the contours, or in their fields as intercrops with food crops.

Many farmers who have adopted SALT and NVS tend to see them as a foundation for further development of a more diverse and complex agroforestry system. In their farms they plant fruit trees or timber trees along the contour to take advantage of the deep, fertile topsoil that accumulates just above the contour lines. Nevertheless, they continue producing annual crops, often moving toward higher value crops or employing more intensive management on their food crops.

Farmer-developed agroforests already cover more than 1,000,000 ha in Bangladesh, India, Indonesia, Philippines, Sri Lanka, Thailand, and Vietnam. Villagers have created many types of complex agroforest land use systems. These agroforests are predominantly based on fruit trees, timber trees, or perennial crops (e.g., coffee, rubber, tea, coconut, and cocoa). The trees provide food, cash income, fuelwood, and livestock feed. Agroforests play a major role in regional economic development by supplying local agro-industries and providing inputs to marketing chains that branch out far beyond the rural areas.

In addition, agroforests protect watersheds from soil erosion and flooding risks, conserve a greater amount of biodiversity, and provide a greater sustained source of income for local communities than other forms of annual crop systems or tree monocultures.

If such agroforestry systems can be developed in the HKH region, they could also play a major role in its economic development, which can have a significant impact on poverty

[2] Agroforestry is defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits.

reduction and environmental protection. However, agroforests are successful only when they meet smallholders' income needs (De Foresta and Michon 1997). Such a system is usually composed of two sets of commercial tree species suited to local conditions; one set providing regular cash income and the other providing seasonal or irregular cash income. This composition ensures economic and ecological viability of the forest in the long run, provided that clear tenure rights on the basic units are recognised.

Farmer-led Organisations for Sustainable Agriculture

Many specialists in forestry and agroforestry now believe that in Asia the farmer will be the forester of the future. That is, small farmers will be producing timber for local and national markets, and the denuded upland landscapes will gradually be reforested. The question is how we enhance this process in the HKH region in terms of investment to ensure farm households' access to adequate agricultural extension, farm credit, good tree germplasm, better systems of agroforestry, and better market infrastructure.

Farmers in mountain areas will continue to grow food crops to meet their basic needs, but they can grow these crops in association with tree crops to optimise their incomes and protect their environment. Small farmers can engage in farming and management of agroforestry in both a productive and resource-conserving manner provided the agroforestry specialists give them adequate extension services. Awareness of this has focused attention on evolving demand-driven, community-based approaches to watershed resource management, in which those who occupy the land actively participate in management and sustainable utilisation of their local watershed resources for multiple purposes. Ultimately, only the land users can solve the problem of land degradation.

Much attention has now been given to the role of local organisations in the management of natural resources (e.g., forest, water, and soil). Among the organisational models for enhancing local initiatives in attacking land degradation challenges, one of particular interest is called 'Landcare', which was initiated by farmers in Australia. Through this movement, local communities organise to tackle their agricultural problems in partnership with public sector institutions. The experiences of 4,500 groups in Australia and 200 in the Philippines suggest that such an approach may provide a means to more effectively share and generate technical information, spread new practices, enhance research, and foster farm and watershed planning processes (Garrity 1999).

Farmer-driven approaches show promise of being more effective and less expensive than current transfer-of-technology approaches. Institutions like Landcare could revolutionise extension systems. Conservation farming based on NVS technology was one practice that was popularised in the southern Philippines through Landcare. Another has been the expansion of nurseries for growing new species of fruit and timber trees to diversify the farm enterprise. As a result of Landcare activities, hundreds of household nurseries have been established by the membership using their own resources, without outside financial support. A similar approach should be developed in the HKH region if the governments are keen to promote appropriate soil and water conservation and development of agroforestry among small farmers.

Environmental Transfer Payments

Farmers in the HKH region have a crucial role to play as stewards of biodiversity and watershed services. It is becoming evident that investment in upland development, including mountain development, may also have positive benefits for the world environment, since improvement in the management of watersheds in the HKH region will impact people and infrastructure in the lowland areas of several countries. There is, therefore, opportunity for society to support this through environmental transfer payments. Among a number of areas where environmental transfer payments may help alleviate key global and national environmental problems, one particular area is the planting of trees for carbon sequestration to reduce the amount of carbon dioxide in the atmosphere, which will reduce the threat of global warming.

Conclusion

The poverty problem in the HKH could be resolved through investment in effective soil and water conservation measures, which in turn will increase agricultural productivity and the incomes of the farmers. This investment should be supported not only by farmers in the mountain areas but also by people in lowland areas through environmental transfer payments. Two promising soil and water conservation techniques are sloping agricultural land technology and natural vegetative strips technology. The adoption of SALT and NVS will facilitate the development of a more diverse and complex agroforestry system, which will make agricultural systems more profitable and sustainable. To enhance the process of conversion of food crop systems to agroforestry systems, farmers must be empowered to manage their natural resources through the establishment of demand-driven, community-based organisations such as Landcare in Australia and the Philippines.

References

De Foresta, H.; Michon, G. (1997) 'The Agroforest Alternative to Imperata Grasslands: When Smallholder Agriculture and Forestry Reach Sustainability.' In Garrity, D.P. (ed.) *Agroforestry Innovations to Rehabilitate Imperata Grasslands. Agroforestry Systems Special Issue, 36(1-3): 105-120*

Garrity, D. P. (1999) *Investing in a Future for Asia's Upland Poor: What We Must Do – Technical and Institutional Options*. Paper presented at the IFAD Symposium on the Asian Crisis and the Rural Poor, 8 July 1999, United Nations University, Tokyo, Japan

Garrity, D.; Agus, F. (2000) 'Natural Resource Management on a Watershed Scale: What can Agroforestry Contribute.' In R. Lal (ed) *Integrated Watershed Management in the Global Ecosystem*, pp 165-193. Washington DC: CRC Press

Partap, T.; Watson, H.R. (1994) *Sloping Agricultural Land Technology: A Regenerative Option for Sustainable Mountain Farming*. Occasional Paper No. 23. Kathmandu: ICIMOD

Sajjapongse, A.; Syers, K. (1995) 'Tangible Outcomes and Impacts from the ASIANLAND Management of Sloping Lands Network.' In *Proceedings of the International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Challenges, Opportunities and Prospects*, pp 3-14. Bangkok: IBSRAM

Scherr, S. J. (1999) *Soil Degradation: A Threat to Developing Country Food Security by 2020.* International Food Policy Research Institute, Discussion Paper 27. Washington DC: IFPRI

Methodologies for Assessing Agricultural Systems in the Hindu Kush-Himalayas

A. Rotmans
Food and Agriculture Organization/International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

During the 1990s mountain development issues came to have a much higher profile on the international development agenda. The Hindu Kush-Himalayan (HKH) region is the largest, most diverse, and possibly the most economically and ecologically important mountain area in the world. This area is undergoing rapid wide-ranging changes, with much of the change coming about in an uncontrolled way. Many people in the rural HKH depend on agriculture for their livelihoods, and many mountain development specialists believe development efforts should focus on harnessing the potential of the great variety of mountain farming niches for developing sustainable agricultural systems. However, planners and policy-makers lack the tools they need to access information on existing systems and potentials, to evaluate changes, and to plan for the management of the agricultural and natural resource base. A methodology that can be used to identify and map mountain farming niches and resources is needed as a basis for planning further action.

Despite the growing awareness of the importance of mountains as global ecosystems, no agency has attempted to systematically map the complexity of their agricultural systems. In 1999, ICIMOD and the International Service for National Agricultural Research (ISNAR) agreed to implement a project under the Eco-regional Fund entitled, 'Methodologies for Assessing Sustainable Agricultural Systems in the Hindu Kush-Himalayan Region: An Eco-regional Framework'. The project, initially planned for three years, began in February 1999 and is one of the second batch of eco-regional projects around the world to support methodological initiatives.

Essentially the project aims to develop, test, and disseminate a methodology for assessing mountain agricultural systems within an eco-regional framework, with a focus on being able to evaluate the sustainability of these systems and thus support sustainable management of mountain agricultural and natural resources. This methodology is actually a set of interactive methodologies, techniques, and models to capture and analyse scaled (spatial/temporal) geo-referenced data sets that provide information on the different types of mountain agricultural systems and associated variability and dynamics.

MASIF and Land Use Analyst

The basis is a database and information-profiling system called the Mountain Agricultural System Information Files (MASIF). The MASIF database contains georeferenced, relational, time-series data and digital maps covering all aspects related to agriculture, including data related to the natural environment (meteorological, geological, topographical, soil properties, and so on), through land cover and use, crop types and yields, livestock, and demographic patterns. Data are mostly from secondary sources, satellite imagery, and existing maps, and where possible directly verified (ground-truthed). This database can be used to inform scientists and policy-makers, can provide the rich verified information needed as a control for GIS and rule-based modelling, and can serve as a baseline against which the impact of changes can be measured. It can also provide comparative and training materials, which are useful to link people from areas that are geographically separate but have similar agricultural systems.

The MASIF database is combined with the specially developed Land Use Analyst software to provide an environment based on 'MSAccess' and 'ArcView' software in which time series and spatial data can be combined interactively. MASIF and Land Use Analyst together allow time series data – on, for example, crops, climate, people, and all other variables in the database (separately and combined) – to be shown at any selected scale in map form. Various subroutines are being developed to identify, evaluate, characterise, and delineate the various agricultural systems in the region to assist in planning for sustainable agricultural development. The system can be used to identify mountain agricultural resources, evaluate resource conditions, characterise and delineate agricultural systems, and assist planning for sustainable development. Analyses can be performed from the eco-regional to the local planning unit levels.

The project is working with ICIMOD partner institutions in the HKH to test and refine the methodology, and to develop a collaborative network built around the exchange of information, technologies, and development principles between eco-regions. Three pilot areas were selected to test the system, each representing a major agricultural system in the HKH. These are Kabhre and Sindhupalchowk districts in Nepal's middle hills, representing mixed subsistence crop-livestock systems; Linzhou, Duilongdeqing, Nimu, Damshoing, and Naqu counties in Tibet, China, representing pastoral and agropastoral systems; and Himachal Pradesh, India, representing more commercialised agricultural systems based on horticulture (cash crops).

The project is very concerned to ensure that the system is both usable and used, and training on and dissemination of the methodology is a major objective. Once the software has completed the pilot phase, a concentrated programme of training and publication will make the database and tools available and extend the range of institutional partnerships and links. The methodology is intended to be directly transferable to other mountainous and highland regions of the world such as the Andes and the East African highlands. This will facilitate transfer and extrapolation of knowledge, characterisation of whole mountain ecosystems, and better appreciation of mountains as global ecosystems. Thus the new methodologies and principles will also be disseminated to institutions operating in other mountainous regions of the world.

Outputs and Impacts

Some of the specific outputs are described below.

A methodology for characterising and delineating agricultural systems in mountain areas

The project has worked on agricultural characterisation using an inverse deterministic approach – in other words concentrating on agricultural outputs like the amount of crops produced – and working backwards to analyse the conditions on the ground that led to them. So far procedures have been developed and tested on a regional scale. First, information is gathered on reported acreages for all major crops and livestock numbers for a specific year, then crop and livestock production values are estimated and further analysed in terms of total calorie and protein levels, and from this whether the people rely predominantly on crop products, livestock products, or a mixture for their minimum daily requirements. The relative proportions of crop and livestock products form the basis for identification of pure pastoral, mixed crop-livestock, and crop-based agricultural systems. The methodology has been incorporated into both the MASIF database and the Land Use Analyst, giving possibilities for direct use, reference, and comparison with other data and activities on multiple scales. As data are collected for other countries and areas, the approach will be expanded to the whole HKH region and other mountain areas.

Systematic collection of computerised databases on agricultural systems for homologous regions of the HKH

MASIF was designed as a flexible spatial and temporal georeferenced database, thus enabling compilation and integration of multi-thematic information on agricultural resources on a regional scale. A beta version of the MASIF database has been prepared on CD-ROM for first internal review. At present the database contains georeferenced, relational time series for regional data on crops, livestock, human population, meteorology, land resources, and topographic base maps. When it is complete, the system will enable efficient and effective information exchange of databases among various HKH institutions working in agricultural research, extension, planning, and policy.

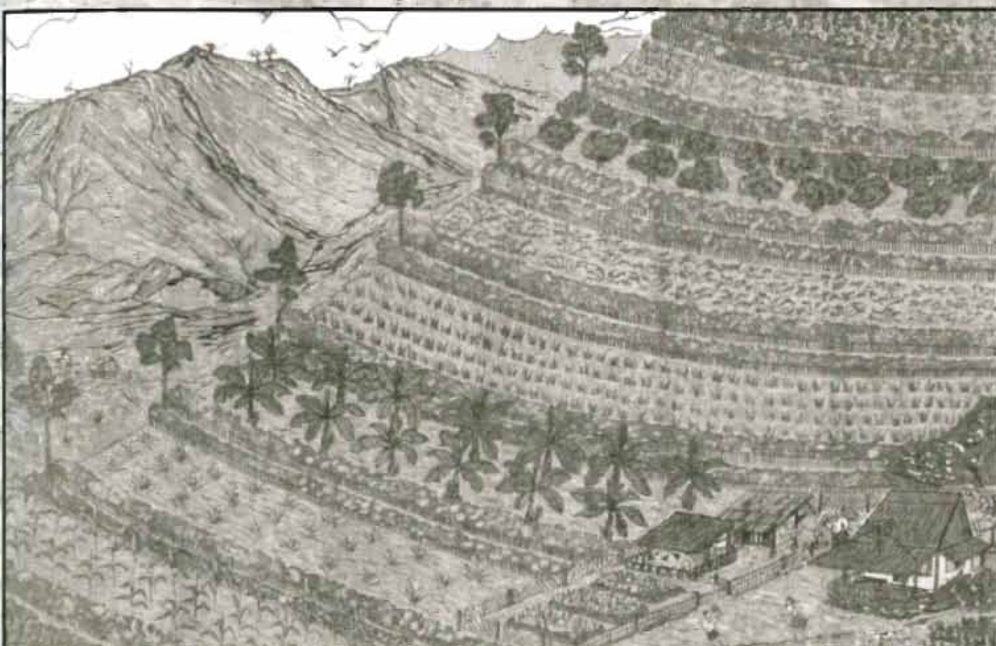
A framework for developing methodologies for explorative land use studies for planning and programming in the HKH and for developing mountain-specific policy strategies

The combined MASIF/Land Use Analyst system is a functional software platform for resource identification, resource evaluation, and agricultural characterisation and delineation. Thus it assists planning for sustainable agricultural development. Various case studies are being carried out to enable further refinement of the software. These include a scaling-down case study on grassland law and rangeland degradation in Tibet (in collaboration with ICIMOD's Rangeland Programme); a scaling-up case study on integrated watershed management experiences for the middle hills of Nepal (in collaboration with ICIMOD's PARDYP); a case study on revised planning for agricultural development in Himachal Pradesh; and image processing and remote sensing (RS) analysis for land cover to land use interpretation.

Collaborative eco-regional network of national collaborating institutions (NCIs)

Using MASIF as a base, we are building a network of NCIs with a capacity for implementing a a national eco-regional framework for mountain agriculture. This is crucial for the success of the Global Mountain Initiative of the Consultative Group for International Agricultural Research (CGIAR) and all mountain research and development projects. Eventually, a well-tested and verified eco-regional methodology will be available that will be able to combine spatial and non-spatial data using GIS/RS technologies for mountainous areas, and will be ready for use in any mountain area in any country. The project has already started training a critical mass of people in applying eco-regional methodology in their own countries.

Technologies for Improving the Productivity of Mountain Agriculture



Assessment of Soil and Nutrient Losses from Rainfed Upland (Bari) Terraces in the Western Hills of Nepal

B.P. Tripathi, S.P. Shrestha, G.P. Acharya, R. Gardner, K. Mawdesley, S. Gaskin, and S. Adams
Lumle Agriculture Research Station, Lumle, Pokhara, Nepal

Introduction

Rainfed upland ('bari') in Nepal is increasingly becoming a concern due to declines in soil fertility and poor management. Soil erosion is directly linked to fertility decline because of the loss of nutrients associated with eroded soil. The rainfall that promotes soil loss also facilitates nutrient loss in solution as runoff and water leached through the root zone.

Radioactive fallout Caesium 137 (^{137}Cs) measurement offers a rapid technique to estimate soil erosion. Because of its 30-year half-life and ease of detection, ^{137}Cs is a useful tracer for determining long-term rates of soil erosion or deposition (Hasholt and Walling 1992; Ritchie et al. 1975). Oztas et al. (in press) proposed a time- and depth-dependent, third-order polynomial model relating soil depth to ^{137}Cs activity; this technique has been used to predict soil erosion with reasonable success in temperate areas and in terraced terrains in China (Quine et al. 1992; Zhang et al. 1994). The extension of the technique to provide quantitative estimates of loss, as opposed to indications of spatial patterns of relative loss and accumulation of soil, remains to be developed (Walling and Quine 1990). However, it is as a relative tool that the technique was used for the first time in Nepal as part of this study, to complement the plot-based work.

This study attempts to quantify soil and nutrient losses from bari with regard to timing and intensity of the monsoon and to understand the reasons for the spatial and temporal variability of soil and nutrient losses from bari in order to be able to target the areas most susceptible, and to assist management of soil and nutrient retention in these areas.

Materials and Methods

Measurement of runoff and soil loss

In the beginning of 1997, plots were established at three sites: Landruk (Kaski), Bandipur (Tanahun), and Nayatola (Palpa). The sites differ in altitude, rainfall, and soil characteristics, and to some extent farming practices. Landruk and Bandipur showed high and low responses of the qualitative indicators, respectively, suggesting less runoff and high infiltration. Nayatola was chosen because the farming system there is very different from the other sites and the response was unusual in that it was particularly dependent on the less frequent, higher magnitude, rain.

A total of 24 erosion plots (approximately 5 m X 20 m) were established at the three sites. The plots were bounded on both sides and at the top (except for four plots deliberately left open to run-on) by metal sheeting dug to a depth of 15 cm. Plots of approximately 100 m^2 were established, and runoff and eroded soil captured via runoff troughs and collection drums, from where it was sampled and filtered.

Monitoring of runoff and soil loss was done from April/May to October/November. Local recorders were trained and then recorded data at each site. Runoff from each plot was measured daily, soil samples were taken on all days when runoff was greater than 10 litres. Seasonal totals were calculated by adding daily totals.

Measurement of water leached through the root zone

Water leached through the root zone was measured using small, bounded, undistributed lysimeters, 40 cm long and 10 cm diameter, on the erosion plots. The recorders measured the volume of leachate each day at the same time as the runoff in the drums was sampled. These lysimeters were installed on 20 erosion plots during April and May, and recording continued at each site until 30 September.

Measurement of nutrients

The losses of macro-nutrients (N, P, and K) through runoff and leachate were measured. The nutrients dissolved in runoff and leachate water were measured using a portable spectrophotometer (Hach HR 2010) to analyse samples taken directly from the collection drums and lysimeters. The NPK in the topsoil was also monitored.

Analysis of Caesium-137

For the analysis of ^{137}Cs, soil samples were collected at 10 cm intervals up to 50 cm soil depth from 10 terraces spread over 200m on the hill slope. A grassland reference site was also selected to provide a local benchmark. The samples were analysed by S. Adams at Queen Mary Westfield College, University of London, UK.

Cryptogams

A study of cryptogamic soil crusts was carried out during the monsoon of 1996 on 168 terraces across five field areas, Bandipur, Chambas (Tanahun district), Nayatola (Palpa district), Kimchaur (Myagdi district), and Landruk (Kaski district), using a simple quadrat-based sampling methodology.

Results

Rainfall pattern over three years by manual gauge and automatic rain gauge

The average rainfall in 1997, 1998, and 1999 from March to November at the Bandipur, Landruk, and Nayatola sites was 1620 mm, 3524 mm, and 1591 mm respectively. Bandipur's highest monthly rainfall (526 mm) occurred in July, followed by August (428 mm), and the lowest in October (16 mm). The Landruk and Nayatola sites had their highest rainfall in August (978 mm and 532 mm, respectively) followed by July (940 mm and 530 mm respectively).

The highest daily rainfall recorded at Bandipur was on 28 August 1999 while that at Landruk (140mm) and Nayatola (>250 mm) was on 12 June 1999. The high rainfall at the beginning of the rainy season at the Landruk and Nayatola sites might have significantly affected the runoff loss of soil and nutrients. By August, site ground cover might have developed, and this would have minimised soil and nutrient losses by runoff at Bandipur.

Runoff and infiltration of water

Water runoff and infiltration differed among different terraces and sites. Water runoff ranged from 30.1 to 443.5 l/m^2 with a mean of 112.9 l/m^2 at Bandipur, 36.7 to 302.2 l/m^2 with a mean of 112.2 l/m^2 at Landruk, and 1.3 to 14.6 l/m^2 with a mean of 7.1 l/m^2 at Nayatola. When compared with total rainfall, water runoff was the lowest (0.6%) at Nayatola, followed by Landruk (3.1%) and Bandipur (5.7%) .

Water infiltration at 40 cm depth in the lysimeter was 589.8, 1122.2, and 1027.6 l/m^2 at Bandipur, Landruk, and Nayatola, respectively. In other words 30, 31, and 85% of the total rainwater leached down to a depth of 40cm at Bandipur, Landruk, and Nayatola, respectively, indicating higher leaching losses than runoff losses .

Soil loss due to runoff water

Mean soil losses at the three sites are shown in Table 1. The losses in individual plots ranged from 0.5 t/ha to 15.4 t/ha, 0.6 to 5.9 t/ha, and 0.1 to 10.4 t/ha with overall mean soil losses over the three years of 3.4 t/ha, 2.5 t/ha and 2.6 t/ha at the Bandipur, Landruk, and Nayatola sites, respectively. The actual largest soil loss of 35.4 t/ha (at the Bandipur site) in 1998 was due to a high volume of water that caused the collapse of a terrace riser in the infertile soil under a maize-fingermillet system.

These soil losses are not very alarming in the western hills. Water run-on, slope angle, soil type, ground cover, and soil fertility status play important roles for soil losses from these hill slopes, however, and values for one site cannot be taken as typical for others.

Table 1: Mean soil and nutrient losses (1997-1999)

	Bandipur	Landruk	Nayatola
Mean soil losses (t/ha)			
1997	1.5	4.2	4.4
1998	7.3	2.3	3.1
1999	1.3	1.0	0.2
Mean	3.4	2.5	2.6
Mean losses (kg/ha)			
NO_3-N	1.2	0.6	0.2
P	3.5	1.5	0.9
K	7.4	7.5	3.0
Leaching losses (kg/ha)			
NO_3-N	10.2	53.0	34.0
P	21.1	8.7	9.7
K	44.9	114.5	70.0

Loss of nutrients

The mean losses in 1997-1999 of NO_3-N, P, and K dissolved in runoff water and in leachate at the Bandipur, Landruk, and Nayatola sites are shown in Table 1. The leaching losses were far higher than the runoff losses.

Caesium-137 analysis

The benchmark sample of (undisturbed) forest soil showed the typical pattern of exponential decrease in ^{137}Cs activity down the soil column, with most of the ^{137}Cs contained in the upper 20 cm. The total ^{137}Cs inventory, determined as the sum of ^{137}Cs content in each of the five 10 cm layers in the core, was 54.1 mBq/g.

In the cultivated terraces, the total ^{137}Cs inventories ranged from 29.6 to 156 mBq/g. With the exception of one extreme terrace (156 mBq/g), the values were generally within ±50% of the benchmark value. This suggests that there has been little if any net loss of topsoil from the terrace surfaces on the hillslope as a whole over the past 40 years of cultivation, although considerable redistribution has taken place among terraces, with some net losers and some net gainers.

The worst cases (Terrace 7 and Terrace 22) indicated losses roughly equivalent to 40 - 50% of the top 10 cm of soil over the 40-year period (average 1 mm/yr). These rates are excessive and would be unacceptable if they were the norm across all terraces.

The high spatial differences in net loss and accumulation suggest that where possible farmers should aim to manage surface runoff on the hillslope communally so as to minimise and spread risk.

Cryptogamic soil crusts

Several environmental variables, operating at regional and local scales, were correlated with cryptogam distribution. These included altitude (negative), rainfall (negative), soil sealing (positive), soil sand content (negative), pH (positive), microtopography (positive), and, to a lesser extent, weed cover (positive). Under the existing crop cycle, cryptogams developed within a few weeks during the main monsoon and reduced runoff and soil losses by about 50%. While recognising that the size of the plots restricts our ability to extrapolate to larger areas, cryptogams appeared to offer a substantial benefit in reducing soil erosion on bench terraces. They remained effective during the entire period studied.

Conclusions and Implications

In general, soil losses were surprisingly and consistently low, except for extreme events early in the pre-monsoon season or where there were high volumes of run-on. The high losses of nutrients are probably due to the shallow soil depth and light textured soils typical in the hills of Nepal, which encouraged leaching of nutrients. These losses can be minimised by following appropriate cropping systems and planting cover crops. The seasonal pattern of soil loss in relation to agricultural cycles has been confirmed. The importance of weed and crop cover in diminishing soil loss is paramount.

Although high rainfall in all areas can potentially lead to substantial losses of NO_3- N, P, and K nutrients through leaching, losses due to runoff are low. Those adsorbed to soil particles have yet to be determined.

Caesium 137 showed limited net soil losses through erosion from the hillside but highlighted the various processes of redistribution of soil between terraces. Caesium 137 has been shown to be largely immobilised and trapped on clay, organic matter and fine micaceous particles within the upper layers of the soil. Mixing resulting from ploughing is a probable explanation for the greater homogeneity of ^{137}Cs content within the upper 20 to 25 cm.

Cryptogams are as effective as weed cover for minimising runoff and soil erosion. They reduced runoff and soil erosion by about 50%. As long as the farmers' practice of allowing weed growth in the main monsoon continues, the greatest potential benefits of cryptogam cover may be in the early season when the soil is most exposed and vulnerable. The propensity for cryptogams to form at this time needs to be examined, as it was not part of the study.

Typically, cryptogams exist on the soil surface beneath the weed cover, and thus farmers should be encouraged to cut weeds rather than to pull them by their roots to minimise disturbance to both the soil surface and the cryptogam cover.

The potential role of cryptogams in fixing nitrogen in the Nepalese setting also needs further investigation.

Sustainable crop production requires balanced resource use, and the management decisions at a household level determine nutrient fluxes and the economic viability of enterprises. Traditionally, the agricultural systems of the mid-hills of Nepal have a close integration of forestry, livestock husbandry, and crop production, but increasing population and other social changes are straining these systems.

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References

Hasholt, B. ; Walling, D.E. (1992) 'Use of Caesium-137 to Investigate Sediment Sources and Sediment Delivery in a Small Glacierised Mountain Drainage Basin in Eastern Greenland'. In *Erosion, Debris Flows and Environment in Mountain Regions, Proceedings of the Chengdu symposium*. IAHS Publication. No. 209, pp 87-100. Chengdu: IAHS

Oztas, T.; Jones, A.J.; Millke, L.N.; Grossman, R.B. (in press) 'Parabolic Method to Predict Soil Erosion from Caesium-137 Activity', In *Nebraska Agric. Exp. Stn. J. Series*

Quine, T.A.; Walling, D.E.; Zhang, X.; Wang, Y. (1992) 'Investigation of Soil Erosion on Terraced Fields Near Yanting, Sichuan Province, China, Using Caesium -137'. In Walling, D.E.; Davies, T.; and Hasholt, B. (eds.) *Erosion, Debris Flows and Environment in Mountain Regions, Proceedings of the Chengdu symposium*. IAHS Publication. No. 209. Chengdu: IAHS

Richie, J.C.; Hawks, P.H.; McHenry, R.J. (1975) 'Deposition Rates in Valleys Determined Using Fallout Caesium-137'. In *Geol. Soc. Am. Bull*, 86: 1128-1130

Walling, D.E.; Quine, T.A. (1990) 'Calibration of Caesium-137 Measurements to Provide Quantitative Erosion Rate Data'. In *Land Degradation and Rehabilitation*, 2: 161-175

Zhang, X.; Quine, T.A.; Walling, D.E.; Zhouli. (1994) 'Application of the Caesium 137 Technique in a Study of Soil Erosion on Gully Slope in a Yuan Area of the Loess Plateau Near Xifeng, Gansu Province, China'. In *Geografiska Annaler,* 76A (1994): 1-2

Soil Fertility Status, Soil and Nutrient Loss, and Conservation Practices for Improving Rainfed Upland (Bari) Terraces in the Western Hills of Nepal

G. P. Acharya[1], B. P. Tripathi[1] and M. A. Mc Donald[2]
[1]Agricultural Research Station Lumle, Pokhara, Kaski, Nepal
[2]University of Wales, Bangor, UK

Introduction

The type of land called 'bari' in Nepal includes all non-irrigated terraces, flat land, and sloping land used for cultivation, and covers most of the cropped area in the hills. Maize is the main crop. Soil fertility is declining in bari mainly as a result of low application of farmyard manure and erosion (Turton et al. 1995). The ploughing and soil disturbing operations involved in cultivating maize accelerate surface soil loss. Soil losses from rain fed terraces and sloping farmland vary from 5-20 t/ha/year, and include losses of 150-600 kg/ha organic matter, 7.5-30 kg/ha nitrogen, 5-20 kg/ha phosphorous, and 10-40 kg/ha potassium (Partap and Watson 1994).

A wide range of technologies are available to support conservation of soil and nutrients. The main objective of this study was to explore the less eroding crop cultivation practices that exist in local farming systems in the middle hills of western Nepal to maintain the inherent soil fertility of bari.

Methodology

Survey of soil fertility status

Farmers' group discussions using participatory rural appraisal (PRA) techniques were held to gain understanding of the farmers' perceptions of soil fertility and soil nutrient losses from bari. Two representative sites, Nayatola in Palpa district and Landruk in Kaski district, were selected for the survey and soil sample collection. PRA was organised to collect information on crop productivity and soil fertility. Soil samples were collected from five farmers' fields representing each major land type such as slope and terraces. Benchmark soil samples collected from intervention plots were analysed in the laboratory for total nitrogen, available phosphorous, exchangeable potassium, organic carbon, pH, and texture. The results were compared within land variables.

Field experiments

Field experiments were conducted in the high rainfall bari areas with bench terracing systems, and in medium to low rainfall areas with flat land and gentle to steep sloping crop cultivation systems, to discover the effect of rainwater on runoff and leaching, which encourages the loss of nutrients and topsoils.

For the high rainfall condition, an experiment was designed and conducted in five complete blocks in farmers' fields in Landruk. An intervention of run-on diversion (closed plot) was selected as a control for the existing open plot practice. Treatments were randomised in the block using a previous research plot as a control. The net experimental plot size was 100 m^2 extending from 3 to 10 terraces. Farmers grew crops following their own existing cropping patterns, either maize-millet or maize-wheat/naked barley. The plots were marked by fixing a metal sheet to insure runoff collection in the trough and drum.

Similarly, an experiment on strip cropping land in the low to medium rainfall area was designed and conducted in five complete blocks in farmers' fields in Nayatola. Strips of maize and ginger were used as an intervention control to compare with farmers' practices in five blocks that varied slightly in slopes and fertility.

Data collection regarding soil loss and runoff

Runoff was measured from a 100 m^2 plot designed to collect runoff in drums. Runoff samples of 0.5 l were taken from each drum during each measurement, while stirring, for sediment estimation; a sample of clean solution from the last drum containing runoff was also taken for nutrient analysis. All drums were drained after each measurement and sampling.

Results

Soil

In Landruk, most farmers reported medium soil fertility in their fields. Laboratory analysis of the soil samples from this area showed that available phosphorous was high, while total nitrogen, exchangeable potassium, and organic carbon were low. The soil is slightly acidic. The soils measured from the plough layer contained about 27% gravel and stones larger than 2 mm, the remaining soil contained more than 50% sand, about 40% silt, and less than 10% clay; the soil was classified as sandy loam. The results indicated that in this area small soil particles are lost through runoff and that much of the gravel and stones remained in the fields. Organic matter and total nitrogen were lost from the soil along with runoff during the rainy season, and production depends on the application of heavy amounts of farmyard manure (FYM) each year. The variation in terrace size did not significantly influence the total nitrogen, available phosphorous, exchangeable potassium, organic carbon, or soil pH. The variance of total nitrogen, available phosphorous, and organic carbon was larger in the large plots than in the small plots, and that of exchangeable potassium was larger in the small plots.

In Nayatola, the soil depth of cropped fields was more than 25 cm; the colour was mostly red followed by brown, this is called locally 'gagreto mato'. Almost no chemical fertilisers were applied, application of FYM was heavy to low. Farmers know that planting legume crops improves soil fertility. Each farmer grew ginger on at least one piece of land and applied mulch to the ginger. The analysis of soil samples indicated that total nitrogen and organic carbon contents were low, available phosphorous and exchangeable potassium were medium, and the pH was slightly acidic. The soil contained 20% gravel and stone in the plough layer, the remaining soil contained 38, 50, and 31% sand, silt, and clay, respectively, indicating a clay loam soil texture. Field slope did not significantly affect soil properties except for exchangeable potassium, which was significantly higher in the more sloping area, indicating more leaching in the flatter areas. Organic matter was higher in flatter than in steep slopes. Farmers apply large amounts of FYM to the fields, but there was still a deficiency even on flatter slopes. Organic carbon loss was high compared to soil particles.

Rainfall

The weekly total rainfall was recorded from the second week of May to the last week of September in Landruk and from the last week of May to the second week of September in Nayatola (i.e. during the main monsoon period).

In Landruk, the highest weekly rainfall was recorded during the last week of July, followed by the third week of June. The maximum recorded intensity of rain was during the last week of August (96 mm/minute[1]) followed by 84 mm/minute[1] in different events. The maximum erosive rain occurred during the third week of June, when the Hudson Kinetic Energy (KE) was 2766 joule followed by 2250 joule in the last week of August.

In Nayatola, the highest weekly rainfall was recorded in the second week of June. The weekly total rain decreased after the third week of July. The rainfall was distinct before and after the second week of July, and the rain was most erosive during the second week of June, when the maximum intensity of rain was 84 mm/minute, producing 2002 joule of Hudson KE.

Runoff

In Landruk, the total runoff in the closed plot was low compared to the open plot. The highest runoff was recorded as 78 mm in the open plot and 34 mm in the closed plot during the last week of August. Lower runoff was found from the closed plot in weekly runoff measurements throughout the season except for the second week of July, when runoff was greater from the closed plot, with a difference of 11 mm.

In Nayatola, the runoff recorded from the strip cropping site was less than from that under farmers' practice. The difference was at a lower confidence level, even so strip cropping showed a trend of less runoff during most of the weeks for which runoff was recorded.

Leachate

In Landruk, the total seasonal leachate was significantly higher from the closed plot than the open plot throughout the season, except for the first time recording in the second week of May. The highest leaching of water was 250 mm in the third week of July in the closed plot and 153 mm in the third week of June in the open plot.

In Nayatola, the total leachate in the strip cropping control was lower than for farmers' practice, but the difference was at a low level of confidence and during the early rain, strip cropping had more leachate than farmers' practices. The maximum leachate was observed for both treatments in the second week of June when rainfall was at a maximum.

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[1] The editors think that rainfall intensity of 96 and 84 mm/minute is impossible; the authors assure us these figures are correct.

Nutrient Loss through Runoff and Leachate

In both Landruk and Nayatola, the loss of soluble nutrients with runoff was very low, and the difference between plots was insignificant. The loss of NO_3-N and exchangeable K was higher, but the effect of treatment was insignificant.

Loss of Sediment

In Landruk, sediment loss with runoff was more from the open plot than the closed plot, although the difference was insignificant. The sediments contained high concentrations of organic matter, phosphorous, and potassium. Organic matter loss in a single season was calculated as 79 kg ha^{-1} from the closed plot and 243 kg ha^{-1} from the open plot.

In Nayatola, the loss of sediment from strip cropping was less than for farmers' practice, but the difference was barely significant. Again the sediments had higher concentrations of organic matter, phosphorous, and potassium.

Discussion

Gravel and low organic matter in the soils tended to increase with increase in field slope, indicating loss of small soil particles and organic matter with runoff. In addition, the higher concentration of organic carbon in the runoff sediment and N and K in the leachate show that soil fertility losses occur continuously from bari during the rainy season.

The diversion of run-on (closed plot) reduced soil erosion in areas susceptible to high rainfall erosion (Landruk) without having a significant effect on the loss of nutrients. Landruk appears to be particularly susceptible to runoff and erosion, which relates to the high rainfall, run-on, and red/brown type of soils (Tripathi et al. 1999). The strips of maize and ginger reduced both runoff and leachate volume under low rainfall and sloping field conditions, but did not affect the losses of soluble nutrients in runoff or leachate; only sediment yield was low in the maize and ginger strip plot as compared to farmers' practice. Ginger strips were followed by mulching with plant materials. This mulching worked as a filter and stopped the movement of soil particles with runoff water so that soil loss was low in the maize and ginger strip-planting plot. Inclusion of grain legumes in the rotation, and mulching or recycling of forest litter or crop residues, are recommended practices for maintaining soil fertility in the lower hills (Subedi and Gurung 1991).

The existing cultivation practices for maize are the main reason for soil and plant nutrient losses from bari. However, ploughing and other operations can help prevent nutrients from leaching. The supply of nutrients to the crops is limited by the scarcity of resources. The way to improve soil fertility under such circumstances would be through utilising available technology in cultivation practices and a crop combination that protect soil and nutrients against losses and improve soil fertility. Mulching is being used on a small scale for a few crops like calocassia and ginger. It can be extended to other crops, provided that mulching material is available, or it can be extended in traditionally mulched crops through marketing. Intercropping of legumes with maize is the traditional practice, but this accelerates soil movement. Ginger is usually mulched in this area; cropping of maize and ginger with mulching reduce the soil loss through runoff significantly and improve the fertility status of the eroded bari for sustainable crop yields. Similarly a corn-soybean rotation reduces NO_3-N leaching loss as compared to continuous corn planting practices (Owens et al. 1995).

The percentage of rainwater and nutrient content in runoff is small compared to leaching, but the sediment movement carried much more organic matter and available phosphorous. Therefore, technical efforts should be based on decreasing leaching and increasing runoff containing less sediment.

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References

Owens, I.B; Edwards, W.M.; Shipitalo, M.J. (1995) 'Nitrate Leaching through Lysimeters in A Corn-Soybean Rotation'. In *Journal of Soil Science Society of America,* 59(3)

Partap, T.; Watson, H.R. (1994) *Sloping Agricultural Land Technology (SALT): a Regenerative Option for Sustainable Mountain Farming*. ICIMOD Occasional Paper No. 23. Kathmandu: ICIMOD

Subedi, K.D.; Gurung, G. (1991) *Soil Fertility Thrust towards Sustainable Agriculture. Experiences of Lumle Regional Agricultural Research Centre (LRARC).* Technical Paper No 4/1991. Kathmandu: Lumle Agricultural Research Centre

Tripathi, B.P.; Gardner, R.; Mawdesley, K. J.; Acharya, G.P.; Sah, R.P. (1999) *Soil Erosion and Fertility Losses in the Western Hills of Nepal: An Overview*. Lumle Seminar Paper No 99/9. Lumle: Agricultural Research Station

Turton, C.N.; Vaidya, A.; Tuladhar J.K.; Joshi, K.D. (1995) *Towards Sustainable Soil Fertility Management in the Hills of Nepal.* Chatham Maritime (Kent): Natural Resources Institute and Pokhara: Lumle Agricultural Research Centre

Application of a Knowledge-based Systems Approach in Participatory Technology Development: Developing Soil and Water Management Interventions for Reducing Nutrient Losses in the Middle Hills of Nepal[1]

P. Shrestha[1], M. McDonald[2], and F. Sinclair[2]
[1]LI-BIRD, P.O. Box 324, Pokhara, Nepal
[2]School of Agricultural and Forest Sciences, University of Wales, Bangor, Gwynedd, UK

Introduction

The middle hills (1000 to 2000m) occupy about 30% of the land area of Nepal (Carson 1992). Agricultural landholdings in the hills are very small – about 46% of farmers own less than 0.5 ha of land – and highly fragmented with about 4 parcels per holding (CBS 1996). Crops are cultivated mainly on rain-fed upland, locally called 'bari'. Bari constitutes 64% (1,717,000 ha) of the cultivated land in Nepal, and 61% of it lies in the middle hills (Carson 1992). The bari soils are particularly vulnerable to soil losses through a combination of natural factors such as sloping topography, heavy seasonal rainfall, and predominance of erosion-prone soils; and human factors such as intensive cultivation of land and erosion-prone farming practices (Sherchan and Gurung 1992; Tripathi 1997). Various studies conducted in Nepal show that soil loss through surface erosion from agricultural land in the hills varies from less than 2 t/ha per year to as much as 105 t/ha per year (Gardner et al. 2000). A recent study has revealed that nutrients are also lost through leaching and that such loses exceed those from runoff and soil erosion by up to an order of magnitude (Gardner et al. 2000). This soil loss has been regarded both by scientists and farmers as the major reason for declining soil fertility and crop productivity in the middle hills of Nepal (Carson 1992; Turton et al. 1995; Vaidya et al. 1995). Similarly, a recent study (Gardner et al. 2000) revealed that nutrient losses, especially of N and P, through leaching are higher than those due to runoff and soil erosion, and require more attention in soil fertility management.

This paper discusses the use of a knowledge-based systems approach in documentation and analysis of farmers' knowledge and the subsequent use of this knowledge in developing soil and water management interventions for the middle hills of Nepal.

Knowledge-based Systems Approach

The knowledge-based systems (KBS) approach to technology development involves the systematic collection, analysis, and use of farmers' local knowledge in the design, experimentation, and evaluation of new technology. The KBS methods discussed here have been developed by the Agricultural Research Centre, Pakhribas, in Nepal in collaboration with the University of Wales, Bangor, in the UK.

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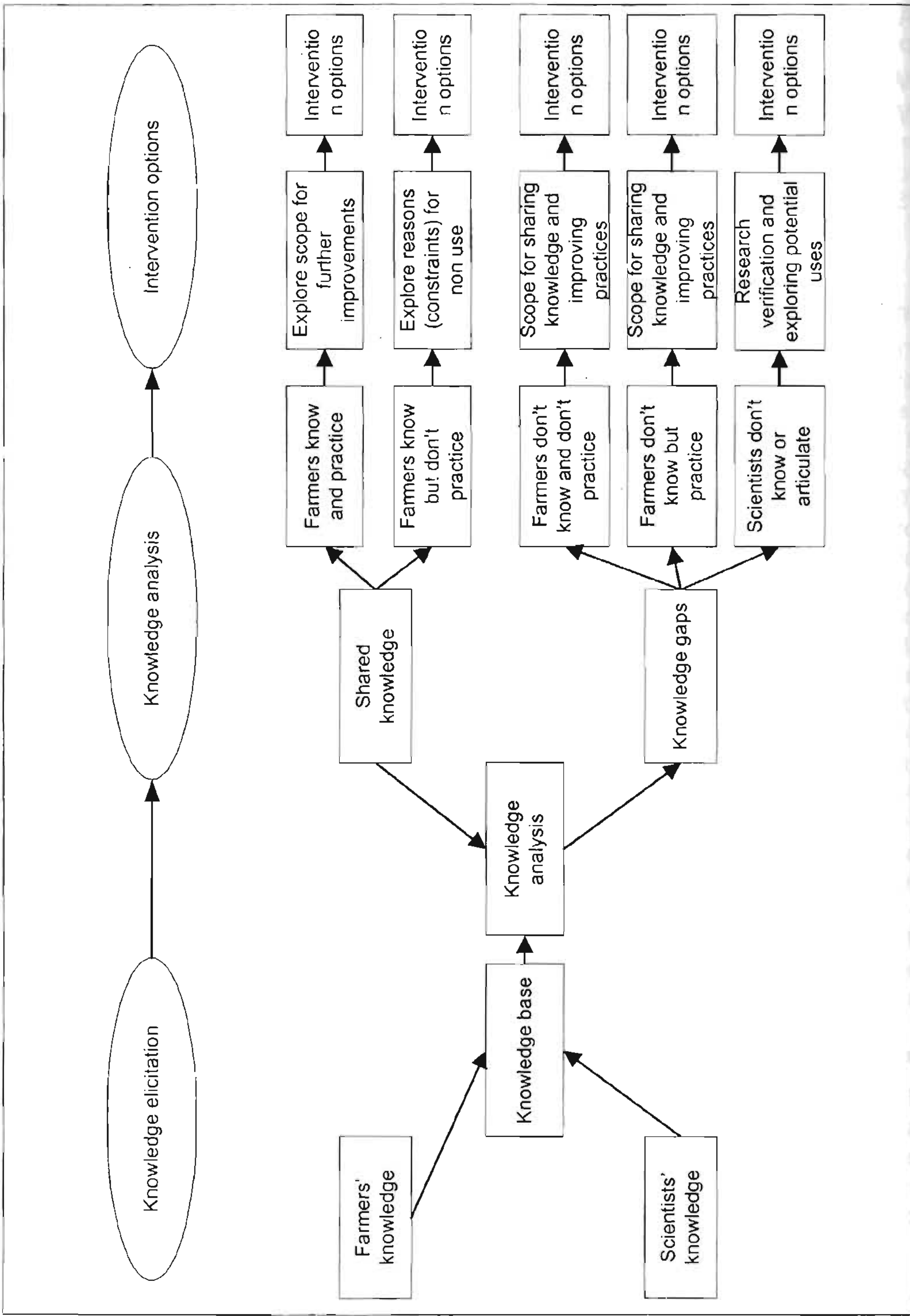

Figure 1: A framework for knowledge analysis and identifying intervention options for participatory techology development

Knowledge Elicitation: Analysis and Identification of Intervention Options

The KBS approach to technology development starts with elicitation of farmers' and scientists' knowledge relevant to soil and water management, followed by analysis of the resulting knowledge base to identify potential options for intervention that can be tested through a Participatory technology development (PTD) process. The framework for the process is shown in Figure 1.

For this study, farmers' local knowledge on soil and water management was elicited from selected farmers at three project sites: Bandipur in Tanahun, Nayatola in Palpa, and Landruk in Kaski district all in the western hills of Nepal. More than 20 men and women farmers, at each site were repeatedly interviewed. The results showed that the farmers possess a wide range of knowledge about soil and water management on their farms as well as in their communities, and have more knowledge about above-ground soil and water-related ecological processes than about below-ground processes. The knowledge generated by research scientists at these sites through a collaborative project between the Agricultural Research Centre, Lumle, and Queen Mary (Westfield) College, University of London, UK, was also collected. The knowledge was archived in an electronic knowledge base called 'soilwater', using WinAKT computer software. The WinAKT software is programmed with a powerful automated reasoning capacity and as a result it facilitates instant and iterative analysis of the knowledge base. The method and the software were developed at the University of Wales, Bangor, UK (see Dixon et al. 1999 for details) and have been used extensively in a number of projects in Nepal.

The analysis revealed a large set of knowledge that was common to farmers and scientists, and some knowledge known or articulated by only farmers or scientists – a knowledge gap. The analysis also examined the causal relationships among different aspects of knowledge and used the resulting information to evaluate farmers' soil and water management practices. The causal analysis has clearly established that the farmers' knowledge and their practices are quite different things and should not be spoken of interchangeably. Some knowledge has not been translated into practice, while a number of practices have been followed without much understanding of the underlying knowledge. Analysing knowledge and practices in this way provided clues for the identification of potential intervention options, which were then tested through the PTD process.

Participatory Technology Development Process

The participation of farmers at various stages of technology development is the essence of a participatory technology development (PTD) process. As a process, PTD has to be flexible to accommodate local variation in farmers' sociocultural environments and needs. The PTD process discussed here is modelled to empower farmers to design and experiment with improved soil and water management interventions by combining their local knowledge and practices with scientific understanding of the problem. The major steps used in this study are outlined in Figure 2.

Knowledge acquisition, sharing, and motivation

Village workshops were organised with the participating farmers at all three research sites to share findings of the knowledge acquisition survey and scientists' information on soil and nutrient losses and water management at these sites.

STEPS	PROCESS
1. Knowledge acquisition sharing and motivation stage	
1. Knowledge acquisition and analysis	Iterative interaction with farmers and use of WinAKT for storing and analysis of knowledge
2. Sharing knowledge with farmers and the farming community	Village workshop - share farmers' & scientists' knowledge
3. Identification/selection of research farmers	Selected by farmers themselves with common consensus in the village workshop
4. Formation of research farmers' committee and agreement on roles and responsibilities	Discuss and agree on these during village workshop
5. Exposing research farmers to R&D on soil and water management	Take research farmers to a week long study tour to R&D sites
2. Trial design and installation stage	
6. Facilitating farmers to conceptualise and design intervention trials	Research farmers' meeting - shared learning during tour, concept of systematic research, and discussion of other options
7. Selection of parcels/terraces for installation of trials	Scientists visit the possible parcels identified for the trial with the individual research farmer
8. Facilitating farmers in installing trials	Scientists estimate the trial area and required trial materials while farmers install trial with facilitation from scientists
3. Monitoring and evaluation stage	
9. Determining indicators for M&E of trials and agreeing on mechanisms of implementation	Meeting with research farmer, agreement on their own indicators for observation and recording
10. Facilitating research farmers in monitoring changes in trials using their indicators	Research farmers and scientist visit trial plots and make observations on agreed indicators
11. Synthesis and sharing findings of M&E among research farmers and community members, and planning activities for next season	Village workshop - share results of trial, discuss necessary changes, and explore prospects of dissemination of technology

Figure 2: **Eleven steps in incorporating farmers' knowledge into the participatory technology development process**

Farmers and village leaders who participated in the village workshops were asked to identify and select farmers to undertake research on soil and water interventions suitable for these farmers and the community. To facilitate communication and support among each other as well as with the farming community and with research scientists, these farmers were called 'research farmers', and their group the 'research farmers' committee'.

The experiences of this study show that taking the acquired local knowledge back to the farming community and sharing scientists' knowledge with them have motivated farmers to undertake new research initiatives.

Trial design and installation

A meeting of research farmers was called and facilitated by the research scientists to discuss the design and installation mechanisms of new soil and water management interventions at their respective project sites. The meeting started with a review of the knowledge shared in the first village workshop and the learning gained during the study tour to the research and demonstration sites. It helped farmers to conceptualise and identify potential soil and management interventions for farmers' experimentation. The concept of systematic research, including role of control and replication, was also shared with the research farmers. This helped them to:

- realise that whatever new intervention they would like to experiment with requires testing for several seasons to draw meaningful conclusions;
- visualise that the intervention trials they would experiment with need to be compared with their current practices to evaluate their effectiveness (the concept of control);
- think over the selection of land for intervention trials to enable comparison;
- think over means/indicators for judging the effectiveness of new interventions; and
- realise the need to test the interventions in different environments to judge their robustness or reliability (the concept of replication).

After thorough discussion, farmers came up with four intervention designs at each research site, and based on their interest divided into four groups of three farmers each to experiment with the identified interventions. These interventions included the use of legume and non-legume forage species, fruit trees, and water harvesting structures laid out in a way that conserves nutrients and water in the farmland. The next day of the meeting, the research scientists visited individual research farmers, made joint observations of the plots selected for the trial, and measured the trial plots to estimate the materials required. Farmers decided to begin the trials once they started to receive regular rain.

Monitoring and evaluation

- The interaction with farmers during knowledge acquisition and at other times revealed that they use a number of criteria to indicate soil erosion and the state of soil quality. Some of these include: changes in the number of stones exposed on the surface, exposure of base of terrace risers, changes in the height of the terrace risers, formation of rills/gullies, changes in soil depth, exposure of crop and tree roots, changes in plant vigour and health, changes in crop yields, changes in outward slope of terraces, turbidity of runoff water,changes in soil colour, and changes in soil structure.

After the farmers' trial begins, a meeting of the research farmers is to be facilitated by the research scientists to agree on the farmers' criteria/indicators for monitoring and evaluation of trials as well as mechanisms for implementing them. Farmers are provided with a notebook and a calendar to note the events and observations they will make during the year. In addition to this, research scientists also help research farmers to conduct joint monitoring and evaluation of farmers' trials at least twice during the summer season. The research scientists are to independently monitor and evaluate the farmers' trials, particularly on changes in soil quality, to supplement farmers' monitoring and evaluation.

At the end of the summer season crop, during which the effect of new interventions is more prominently observable, a village workshop is to be organised at each research site. This will give research farmers and scientists a chance to share their experiences of new soil and water management interventions with each other and with the farming community at large. The workshop aims to provide a forum to disseminate the findings of the farmers' trial to their fellow farmers in the community and to motivate others to try the new interventions on their own farms. The workshop also acts as a means to explore and monitor adoption or adaptation of the farmers' interventions by the research farmers as well as inside and outside the farming community at the research site.

Conclusions

The PTD process initiated in the study has provided some important and useful learning to the research scientists. The experiences so far suggest that application of the KBS approach not only ensures incorporation of farmers' knowledge and perspectives in the technology development process but also improves farmers' empowerment and participation in the technology development process.

The knowledge elicitation strategy and the knowledge analysis process ensure a systematic acquisition of farmers' knowledge, explore causal links between knowledge and practice, explain the rationale of current farming practices, and identify gaps in knowledge and articulation among farmers as well as scientists.

Sharing of farmers' and scientists' knowledge with the farming community and exposing research farmers to research and demonstration sites helps farmers to visualise the positive and negative aspects of their practices, to conceptualise the new interventions, and to motivate them to undertake their own research.

Involving the farming community and village leaders at various stages of the technology development process ensures their continued support in the smooth running of the research activities. The farming community and village leaders also feel an obligation to keep an eye on the process and provide feedback for further improvement. Similarly, their involvement in the selection of research farmers gives research farmers a feeling that they represent the community and that they should be committed to their experiment and share information and findings with other farmers in the community.

Farmers are usually keen to try out new ideas and technologies on their farms, especially when they see benefits from them. Such interest and motivation are even high when they are supported with technical information and material support from outside. The partnership and collaboration between farmers and scientists appear to target better research and to produce more useful outputs than work done by farmers or by scientists in isolation. The application of the KBS approach in the participatory development of soil and water management interventions is certainly effective in establishing and promoting such partnership and collaboration.

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References

Carson, B. (1992) *The Land, the Farmer and the Future: A Soil Management Strategy for Nepal*. ICIMOD Occasional Paper No. 21. Kathmandu: ICIMOD

CBS (1996) *Nepal Living Standards Survey Report 1996: Main Findings. Volume 2*. Kathmandu: Central Bureau of Statistics

Dixon, H.; Doores, H.J.; Joshi, J.W.L.; and Sinclair, F.L. (1999) *Agroforestry Knowledge Toolkit for Windows: Methodological Guidelines, Computer Software and Manual for WinAKT*. Bangor (UK): University of Wales, School of Agricultural and Forest Sciences

Gardner, R.; Mawdesley, K.; Tripathi, B.P.; Gaskin, S.; Adams, S. (2000) *Soil Erosion and Nutrient Loss in the Middle Hills of Nepal (1996-1998)*. Lumle: Soil Science Division, NARC; Queen Mary and Westfield College, University of London, UK

Sherchan, D.P.; Gurung, G.B. (1992) *Soils and Nutrient Losses Under Different Crop Husbandry Practices in the Hills of East Nepal*. Paper presented at the National Workshop on Watershed Management, August 24-27, 1992, Bhopal, India. Kathmandu: Pakhribas Agricultural Centre

Tripathi, B.P. (1997) *Present Soil Fertility Research Status and Future Research Strategy in the Western Hills of Nepal*. LARC Seminar Paper No. 92/2. Lumle: Lumle Agricultural Research Centre

Turton, C.; Vaidya A.; Joshi., K.D.; Tuladhar, J.K. (1995) *Towards Fertility Management in the Hills of Nepal*. Chatham Maritime (UK): NRI

Vaidya, A.K.; Turton, C.; Tuladhar, J.K.; Joshi, K.D. (1995) 'An Investigation of Soil Fertility Issues in the Hills of Nepal with Systems Perspective.' In Joshi, K.D.; Vaidya, A.K.; Tripathi, B.P.; Pound, B. (eds) *Formulating A Strategy for Soil Fertility Research in the Hills of Nepal*, pp. 83-103. Lumle (Nepal): Lumle Agricultural Research Centre

Why Don't Farmers Adopt Recommended Technologies? The Example of Contour Hedgerow Intercropping Technology

Tang Ya
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

Though mountains play an important role in providing ecological and environmental services to, and in safeguarding livelihoods for, more than half the world's population, these areas have been faced with numerous development constraints. In order to improve livelihoods and conserve the environment, a large number of improved technologies have been developed for and promoted in the mountains. However, the farmers' adoption/adaptation rate of these improved technologies has often been unsatisfactory. Since farmers are the key players both in agriculture and environmental conservation in mountains, it will be useful to analyse the factors influencing farmers' adoption of improved technologies. This paper will provide a case of testing, demonstration, research, and extension of contour hedgerow intercropping technology (also known as sloping agricultural land technology or SALT) in the Hindu Kush-Himalayan (HKH) region. It is hoped that the findings from this study will be useful for promoting the technology's extension in the HKH region and other regions.

A Brief Assessment of Contour Hedgerow Intercropping Technology

Contour hedgerow intercropping is a simple technology that involves growing hedgerows of densely planted nitrogen-fixing plants across slopes at a distance of 4-6m depending on the slope gradient. The alley areas between the hedgerows are used for cultivation of food and or cash crops. The very thickly planted hedgerows are the key element of this system. They act as barriers to soil erosion and are periodically pruned to provide materials to improve soil fertility, to avoid shading on companion crops, and to reduce competition with companion crops. Many studies have demonstrated the effectiveness of contour hedgerow intercropping technology in reducing soil erosion to a very low level, effectively improving soil fertility, and enhancing land productivity. In addition, properly managed hedgerows can also provide fodder and firewood.

Soil Conservation

Research carried out in the tropics (e.g., Kiepe 1995; Palmer 1995) and ICIMOD-coordinated research in the HKH region has indicated that thickly planted hedgerows can help reduce surface runoff by up to 30% and soil loss by up to 99% of traditional up and down farming (Sun Hui et al. 2001). Among the benefits of this technology, effective control of soil erosion has been confirmed by all the studies carried out so far.

Soil Fertility

Research in the HKH region shows that appropriately established and managed hedgerows help improve soil fertility through reducing nutrient loss and application of hedgerow prunings as green manure or mulch. Research on a very poor soil indicated that the content of total nitrogen and organic matter increased by 85-292% and 87-132%, respectively (Sun Hui et al., this volume). However, the magnitude of the effect depends on the amount of biomass produced by the hedgerows and the initial soil fertility. ICIMOD's project on Appropriate Technologies for Soil Conserving Farming Systems (ATSCFS) in the HKH region has indicated a positive effect in most cases (refer to Khisa; Sun Hui et al.; Sundriyal, this volume) but less effect on soil fertility in Godawari where a very fertile forest soil was used for the study (Tang Ya, in press).

Crop Yield

The effect of hedgerow technology on crop yield has been the most controversial. Roughly half of the papers reported positive effects, and half negative effects. The ATSCFS project revealed that application of this technology could enhance crop yield by 10-70% or at least maintain similar crop yield to that of controls (Sun Hui et al.; Sundriyal; Maskey this volume).

Farm Income

Due to diversified cropping systems, improved soil fertility, reduced soil erosion, and decreased inputs, farm income under contour hedgerow technology is increased (Sundriyal, this volume; Yuan Yongliang et al. 2001).

Factors Influencing Adoption of Improved Technologies

It is clear that contour hedgerow intercropping is a good technology. But in many places the adoption by local farmers has been unsatisfactory. Based on the author's own observations and experiences in the HKH region, many factors influence farmers' adoption, but the following may be among the main ones.

Technology Demonstration

For a technology to be adopted or accepted by farmers, adequate demonstration of its advantages and disadvantages are equally important. Farmers must learn the risks they are likely to face in applying a technology. However, project staff often try to communicate only the advantages of the technology and neglect to share any negative aspects or disadvantages. Generally speaking, a technology will have both positive and negative effects. Certainly positive effects should be promoted and maximised, and negative effects minimised, but the latter should not be neglected or hidden.

Often the benefits of a specific technology are not fully or adequately demonstrated due to lack of committed project staff. In the case of contour hedgerow technology, it has been shown to be very effective in reducing soil erosion, improving land productivity, and increasing cropping options. It has been developed to solve problems associated with small farmers depending on sloping croplands. In order to correctly use this technology, the following basic principles must be followed.

- It should be applied in sloping croplands.
- Hedgerows must be planted very thickly.
- Alleyways between hedgerows should be of appropriate width to provide sufficient land space for planting crops and for hedgerows to produce sufficient biomass to improve soil fertility.

- Alleyways should be fully and appropriately used.
- Hedgerows should consist of perennial woody nitrogen-fixing plants, and they must be pruned in a timely fashion. The later is very important because pruning can prevent shading of hedgerows on companion crops and also provide materials for improving soil fertility. In addition, timely pruning of hedgerows also reduces their root competition with associated food crops.

These principles look simple. Experiences in the HKH region have revealed that where these principles are followed the adoption by local people has been successful, and that where these principles are not followed the farmers' adoption has been extremely poor. At some project sites few of the benefits have been adequately demonstrated, and in some cases no correct principles of the technology have been demonstrated, possibly because the project staff was either uninterested or not committed. As a result, the following problems have been observed in the demonstration of this technology.

- Sites were selected on flat land or land with very gentle slopes where water-induced soil erosion was not a serious problem and there were better options for improving soil fertility.
- Hedgerows could not act as erosion barriers because the distance between plants in hedgerows was near to or more than 20-30 cm. Little soil conservation can be expected under such conditions. If the project staff do not seem to understand the principles of the technology despite their training, farmers may wonder what we 'scientists' are doing!
- Hedgerows were not pruned in time or even at all. Therefore they grew very tall, which had a severe adverse shading effect on companion crops, and could not demonstrate the use of prunings to improve soil fertility. Unpruned hedgerows might also increase the competition between hedgerows and crops for light, soil moisture, and nutrients, pruned hedgerows can recycle nutrients, and reduce evapo-transpiration and shading.
- Hedgerows were established with very narrow alleyways that could not be used to cultivate crops.
- Only hedgerows were established and no crops were planted in the alleys. If alleys are not used, there is no need of hedgerows because fallow and regenerated vegetation may do better than hedgerows for soil conservation in such conditions. Farmers may think that these 'scientists' are merely playing games.
- Hedgerows consisted of plants of 2-3 years' lifespan. As a result, they had to be replanted every 2-3 years, which greatly increases the cost.

Project Staff

Committed staff is the key factor for the success of a project. However, because most of the project staff in the partner institutions are salary earners and do not depend on land, it seems they are not much concerned about the success or failure of a project. Project team members often do not care what impact the implementation of a project will have on local people and are more interested in the outside world other than in their targeted local farmers. This partly explains why the above-mentioned problems have emerged.

Staff's feelings of equality with farmers also influences farmers' perception of technologies. Unfortunately most project staff often cannot treat our farmer partners as real partners and treat them equally. Farmers are the sole judges of a farm-based technology. Though participatory approaches have been advocated and promoted quite extensively by different organisations in the HKH region, there are still only a few project staff who treat local farmers (local cooperators) equally. Mentally the project staff regard themselves as 'higher' or 'more advantaged' than the local co-operators they are educating, teaching, or guiding in what to do and how to do it. Farmers in such cases will be very reluctant to tell a project staff member their real ideas. As a result, project staff usually cannot understand what the local people really think of the technology that the project is promoting. There is a long way to go before we really treat our farmer partners equally and treat them as real cooperators rather than only labour.

Technology

For a technology to be adopted by farmers it must have certain characteristics, and improvement in cash income is foremost among them. For many farmers, whether or not there is an increase in income, especially cash income, is a key factor in deciding whether to adopt a technology. The extension of the plastic film technology in China, Nepal, and other countries in the HKH region strongly supports this point. It is accepted quickly by many mountain farmers because of the obvious differences with and without the use of plastic films as mulch.

Contour hedgerow intercropping technology, on the other hand, lacks direct and visible cash benefits even though reduced soil erosion and improved soil fertility have economic value. In such case, efforts are needed to work with farmers to foresee the problems of continued soil erosion and the benefits of soil conservation, and to understand that changes in soil conservation and land productivity take a long time. Lack of direct and visible cash benefits is the major weakness. But this is also where research institutions can play a role in modifying the technology to suit local physical and socioeconomic conditions. Where modifications have been made to produce direct and visible cash benefits, the technology has been extended to farmers' fields on a large scale. Planting mulberry trees as economic trees within hedgerows, a joint innovation of the Chengdu Institute of Biology and local government, has become the key contributing factor for the wide extension of this technology in Ningnan County of China (Zhang Yanzhou et al. 2001).

Analysis of farmers' adoption of improved technology revealed an interesting phenomenon: that the technologies which have environmental significance (such as contour hedgerow intercropping technology) usually do not help improve income generation and those which can promote income generation (such as plastic film technology, chemical fertilisers, and pesticides) usually have negative impacts on the environment. Government has a crucial role to play In the extension of environment-friendly technology .

Government Support

Governmental support is very important to encourage farmers to adopt improved technologies, especially those that are more environmentally sound but lack direct and visible benefits. For instance, in the past two decades, almost all the terraces in China have been constructed with financial support from government. Though the contour hedgerow intercropping technology has shown better benefits than terracing in numerous aspects, no government support has been provided to encourage farmers to adopt this in China except for Ningnan County, where local government has a policy to promote extension of this technology. Without government support to adopt this technology, local farmers will prefer constructing bench terraces instead of establishing hedgerows, because they can get money for doing so.

Farmers' Perceptions of Environmental Degradation, Especially Soil Erosion

Success in soil conservation depends substantially on farmers. Only if farmers take environmental degradation seriously, especially the soil erosion that is diminishing their livelihood base, will they consider applying measures to mitigate the problem. However, because environmental degradation and soil erosion are slow processes and their effect on land and people is also slow, most farmers do not see soil erosion as a serious problem. This in many cases also affects farmers' attitudes to adopting new technology. Evidence indicates that if farmers wish to maximise their incomes they will not care for soil conservation practices, and this explains why up and down farming practices are still common in the region: they are more labour saving and easier to operate.

Future Implications

Farmers' unwillingness to adopt improved practices has been due mainly to poor economic returns, inadequate on-farm demonstration of both benefits and possible risks, and technical ineffectiveness under real conditions. Resource constraints of farmers, their small scale of production, and their exposure to high livelihood risks mean that the technologies they use must have certain key characteristics. These include improved food or cash security, rapid return on investments, minimal use of purchased inputs, and effective use of micro-niches to diversify production. Poor farmers require technologies that maximise returns, especially cash income. Unless likely economic returns are fairly attractive, farmers are unlikely to adopt any improved technologies.

Scientists and government agencies know that environmental degradation, including soil erosion, must be controlled. Farmers depend on land for their livelihood and therefore they should be more interested in the land's stability than anyone else. But it seems that those who are not directly dependent on land are more concerned about land problems. Is there something wrong? We may need to reconsider our approaches and rethink our strategies in this.

Why are farmers unwilling to implement recommended activities? Farmers do not adopt practices if they do not benefit from them. Analysis of technologies adopted easily or not by farmers indicates that in general the former will cause environmental problems sooner or later, and the latter usually promote environmental conservation. This strongly suggests that we need to invest in environmental conservation. In some cases, we may need to pay farmers not to use some technologies that have negative environmental effects. It will be important for people to understand that the returns on environmental conservation investments are not short term. This may explain why chemical fertilisers, plastic film technology, high yielding varieties, and so on have spread more widely and more quickly than any other technological innovations in the history of agriculture (Jha 2001).

References

He Yonghua, Tang Ya, Sun Hui, and Chen Keming (2003) *Effects of Contour Hedgerows on Runoff Flow and Soil Erosion Control in a Dry Valley of the Jinsha River.* This volume

Jha, P. K. (2001) 'Environment and Agriculture: Trends and Perspectives'. In Jha, P.K.; Karmacharya, S.B.; Baral, S.R.; Lacoul, P. (eds) *Environment and Agriculture: At the Crossroad of the New Millennium*, pp 48-62. Kathmandu: Ecological Society

Khisa, S. K. (2003) *Sloping Agricultural Land Technology for Hillside Farms in Chittagong Hill Tracts, Bangladesh.* This volume

Kiepe, P. (1995) *No Runoff, No Soil loss: Soil and Water Conservation in Hedgerow Barrier Systems.* Tropical Resource Management Papers. 10. Wageningen: Wageningen Agricultural University

Maskey, R. B. (2003) *Options for Sustainable Land Management in the Mid-Hills of Nepal: Experiences of Testing and Demonstration of Contour Hedgerow Intercropping Technology.* This volume

Palmer, J. (1995) *Sloping Agricultural Land Technology (SALT): Nitrogen Fixing Agroforestry for Sustainable Soil and Water Conservation.* Mindanao (Philippines): Mindanao Baptist Rural Life Centre

Sun Hui; Tang Ya; Wang Chunming; Chen Keming (2003) *Effect of Contour Hedgerows of Nitrogen Fixing Plants on Soil Fertility and Crop Yield of Sloping Croplands in Dry Valley of the Jinsah River, China.* This volume

Sundriyal, R. C. (2003) *Contour Hedgerow Farming in the North East India.* This volume.

Tang Ya (in press) Nitrogen Fixing Species. Kathmandu: ICIMOD

Yuan Yuanliang; Sun Hui; Tang Ya (2002) 'An Economic Analysis of Sweet Orange Orchard under Contour Hedgerow Intercropping System'. In *Chinese Journal of Eco-agriculture* (in press)

Zhang Yanzhou; Tang Ya; Chen Keming; Sun Hui. (2001) 'A Study of Leaf Yield and Total Annual Biomass of Leaves and Branches of Mulberry Planted in Contour Hedgerows of Nitrogen Fixing Plants.' *Chinese Journal of Applied and Environmental Biology*, 7(4): 303-307

An Ethnographic Enquiry into the Adoption of Contour Hedgerow Intercropping Agroforestry Technology by the Farmers in the Chittagong Hill Tracts, Bangladesh

N.A. Khan[1] and S.K. Khisa[2]

[1]Department of Public Administration, University of Chittagong, Chittagong, Bangladesh

[2]Chittagong Hill Tracts Development Board, Khagrachari, Bangladesh

Introduction

In recent years, shifting cultivation has largely failed to support farmers' livelihoods because of rapid population growth, scant and degraded soil and forest resource bases, a shortened rotational cycle of production, and changing demands and lifestyles (Khan and Khisa 2000). Contour hedgerow intercropping agroforestry technology (CHIAT) has been widely promoted in many parts of Asia to minimise erosion, restore soil fertility, and reduce poverty (Partap and Watson 1994). There has been great enthusiasm for CHIAT in Bangladesh, and the Chittagong Hill Tracts Development Board (CHTDB) fielded the Upland Settlement Project (USP) during the mid 1990s with a mandate to popularise CHIAT and associated technologies in the locality.

Notwithstanding the enthusiasm, however, the adoption rate of CHIAT by farmers has lagged far behind expectations. This article reports on the experience of the Upland Settlement Project (USP), a community focused land management and agroforestry programme, and its attempts to introduce and disseminate CHIAT in the Chittagong Hill Tracts (CHT) of Bangladesh. The project attempted to rehabilitate and develop some impoverished ethnic farmers who had hitherto been engaged in 'jhum' (shifting cultivation). This paper looks at selected dynamics of the adoption of CHIAT by the USP farmers.

Methodology

Under the USP, 1000 families have been resettled in 20 purposely developed project villages in the districts of Khagrachari and Bandarban (for an introductory account of USP, see Khan and Khisa 2000). Each village accommodates 50 households. A total of 100 households were randomly selected for this research, 5 households from each village.

The observations reported here draw on the authors' personal involvement in the USP in varied management and advisory capacities. Following Khan (1998), the methodology of our latest fieldwork consisted of personal observation (without controls), ethno-historical analysis, and group discussions.

Land Use Patterns and Dynamics of Adopting CHIAT

Each farming household was allotted a total of 2.1 ha of land, out of which 0.5 ha was intended for homestead agroforestry, and 1.6 ha for raising rubber (inter cropped with banana). Table 1 summarises the common land use pattern in the study area.

Table 1: Land use in the agroforestry plots				
Slope Category				
Level to gently sloping (up to 5%)	Sloping (5-15%)	Moderate steep (15-30%)	Steep (30-60%)	Very steep (above 60%)
Upland rice Vegetable Ginger Turmeric Banana Pineapple Lemon Guava Papaya Custard apple Areca nut	Upland rice Vegetable Ginger Turmeric Banana Pineapple Lemon Guava Papaya Custard apple Areca nut	Upland rice Banana Litchis Jack fruit Pineapple Mango Amra Bel Areca nut	Upland rice Banana Litchis Jack fruit Pineapple Bamboo spp	Upland rice Banana Forest species (especially *Gmelina arborea, Tectona grandis, Acacia* spp, *Cassia* spp, *Leucaena* spp) Bamboo

The USP staff suggested that farmers plant contour hedgerows with nitrogen fixing tree and shrub species (e.g., *Leucaena* spp.,*Tephrosia* spp., *Flemingia* spp., *Indigofera* spp.) in the moderate to steep sloping parcels. Although almost all the families initially adopted CHIAT, many of them discontinued after a lapse of a few years for the reasons discussed in the next section. At the time of the survey, 42% of the respondent farming households actively practised CHIAT (Table 2)

Table 2: Adoption of CHIAT

District(s)	Project village	No. of HH	No. of sampled HH	No. of sampled HH practising CHIAT
Khagrachari	Bailyachari 1,2,3	150	15	7
Khagrachari	Taimatai 1,2,3	150	15	9
Khagrachari	Wasu 1,2,3,4	200	20	11
Bandarban	Chemi 1,2	100	10	4
Bandarban	Kuhalong 1,2,3	150	15	4
Bandarban	Rajbila 1,2,3,4,5	250	25	7
Total	10	1000	100	42

The farmers who practised CHIAT gave the following reasons: it helps reduce soil erosion, restores soil fertility, encourages diversified cropping, and is economically more rewarding that shifting cultivation. Recent and ongoing research have corroborated the farmers' views that CHIAT contributes to a significant reduction in soil loss and surface run-off, and increases biomass production (Khisa 2001).

Constraints to Adopting CHIAT

The following constraints to adopting CHIAT were identified.

- Insecurity of land tenure was the major reason for the farmers' reduced interest in investing in land development through CHIAT. Despite repeated attempts by the project authorities, formal title to the land has not yet been secured due to bureaucratic red tape and procedural complications.
- The four CHIAT demonstration plots are concentrated in one location (Alutila), leaving the majority of farmers beyond its domain of service and influence.
- The farmers' experiences suggest that CHIAT is a labour intensive and physically exhausting technology.

- Many farmers still consider shifting cultivation to be the major source of food and fear that CHIAT may not adequately satisfy their food needs.
- The farmers report that CHIAT requires substantial monetary investment. Some of the respondents candidly admitted that poverty forced them to spend and divert the money meant for agroforestry to household consumption.
- In some areas the soil and terrain are particularly harsh and infertile and in these locations, the performance of CHIAT is discouraging.
- Some issues associated with the poor technical design of the project have subsequently caused problems. Initially, for example, *Tephrosia candida* was used to establish hedgerows, but it later proved to be inefficient (primarily due to its intolerance of intense pruning) and gave people a negative impression of CHIAT. Furthermore, at the time that CHIAT was prescribed, some of the plots had already been covered with different perennial crops, which left little room for the introduction of hedgerows.
- In most cases, exotic species were prescribed for hedgerows and land development, but the farmers have their own preference for mostly indigenous species.
- Seventy-two per cent of the respondents considered the project support and services, especially regarding the provision of planting materials and fertiliser, micro-credit services, and hands-on technical advice on hedgerow establishment and maintenance, to be inadequate.
- The relevant extension and research activities were mostly carried out on a piecemeal, superficial, and uncoordinated basis. The USP's motivational and extension approaches for CHIAT involved arranging purposely tailored training courses and maintaining demonstration plots. Out of a total of 1000 farmers, some 175 (92 from Bandarban and 83 from Khagrachari) have so far received training, but none of them were women. The impact and purpose of training seem somewhat blurred.
- Although some audio-visual tapes and vernacular publications for the promotion and dissemination of CHIAT have been developed, their number and impact are limited.
- Most farmers find it psychologically strenuous to come to terms with the process of transformation from their pervious nomadic mode of life, that pivoted around shifting cultivation, to the relatively permanent mode of life required by the project.

Conclusions and Recommendations

The extent of adoption of CHIAT has remained low, which is primarily attributed to factors such as unsecured land tenure, economic hardship, high degree of labour intensity, high cost of the technology, lack of institutional credit services, insufficient logistical support, and the psychological strain associated with the transformation from a nomadic culture to a relatively permanent form of living. Even with these limitations, however, CHIAT remains a promising technology which has contributed significantly to reducing runoff and soil loss and augmenting biomass production and, more importantly, has sparked a sense of interest among selected farmers who are actively practising the technology. These farmers, albeit few in number, generally express satisfaction and hope for CHIAT. Drawing on the intimate discussions with farmers and our empirical observations, a number of recommendations can be made for improving the effectiveness of CHIAT and facilitating its adoption by farmers.

- The USP could experiment with establishing natural vegetative strips on contours, which has met with considerable success in other parts of Asia (Stark et al. 2001)

- Formal title to land and written contracts concerning distribution of the project's benefits should be arranged to reassure the farmers.
- The CHIAT demonstration sites need to be extended and dispersed to the major concentrations of farmers.
- Mass media, especially local radio and television, may be approached to disseminate CHIAT.
- Markets and necessary market information must be ensured to enable the farmers to make informed decisions. The departments of agricultural extension and forest could play a significant role in this regard.
- Rather than attempting to put an abrupt ban on jhum, it should be phased out slowly and gradually. Limited jhum may be allowed alongside CHIAT to help farmers compare the relative performance of both systems.
- Practically oriented research on CHIAT should be increased to illuminate those concerned in exploring ways to improvement.
- When selecting species, farmers' preference has to be given the highest priority.
- The technical design of the project needs to be periodically revised, taking on board the farmers' views and felt needs.
- The training programme must be expanded to cover representatives of all households; the content and efficacy of the programme have to be closely monitored and revised, drawing on the farmers' responses.
- Door-to-door extension, on-farm demonstration, and follow-up of the field training are required; existing extension services need to be coordinated.
- Particularly harsh pieces of land, where CHIAT has little prospect of success, should initially be avoided so that potential failure will not cause a negative impact on the farmers' morale.

References

Khan, N.A.; Khisa, K.K. (2000) 'Sustainable Land Management with Rubber-based Agroforestry: a Bangladeshi Example of Uplands Community Development.' In *Sustainable Development*, 8 (1): 1-10

Khan, N.A. (1998) *A Political Economy of Forest Resource Use: Case Studies of Social Forestry in Bangladesh.* Aldershot (UK): Ashgate Publishers

Khisa, S.K. (2001) *Sloping Agricultural Land Technology for Hillside Farms in Chittagong Hill Tracts, Bangladesh.* This volume

Partap, T.; Watson, H.R. (1994) *Sloping Agricultural Land Technology: a Regenerative Option for Sustainable Mountain Farming,* ICIMOD Occasional Paper No. 23. Kathmandu: ICIMOD

Stark, M.; Mercado, A.; Garrity, D. (2001) 'Natural Vegetative Strips: Farmers' Invention Gains Popularity.' *Agroforestry Today*, 12(2): 32-35

Options for Sustainable Land Management in the Mid-hills of Nepal: Experiences of Testing and Demonstration of Contour Hedgerow Intercropping Technology

R.B. Maskey
Soil Science Division, NARC, Khumaltar, Lalitpur, Nepal

Introduction

Nepal is divided into five major agro-ecological regions, commonly known as the Terai, Siwaliks, Middle Mountains, High Mountains, and High Himalaya. The middle mountain region (mid-hills) is the largest, occupying about 30% of the total land area, and has the highest population density per unit of cultivated land. Much of the country's land base is environmentally fragile and susceptible to erosion and degradation. Cultivation on sloping and terraced land is a common feature of Nepalese hill agriculture.

Degradation of land and mountain ecosystems has become increasingly widespread in recent decades. The traditional farming system and cultivation on steep slopes have further accelerated soil erosion and degradation. Agricultural productivity, especially in the hills and mountains, is declining due to continuing erosion of topsoil. Realising an urgent need to develop and adopt soil-conserving farming technologies for sustainable land management and agricultural productivity in the country, the Soil Science Division (SSD) of Nepal Agricultural Research Council (NARC) carried out adaptive on-farm research in the mid-hills of central Nepal for six years (1995-2001) in collaboration with the International Centre for Integrated Mountain Development (ICIMOD).

The main objective was to test the applicability of sloping agricultural land technology (SALT) as an alternative farming system option to achieve sustainable production by reducing soil erosion on the hill slopes. The specific objectives were to:

- develop prototype cost-effective SALT models to enhance the productivity of agricultural land by conserving soil and its fertility,
- evaluate the acceptability of the technology by local farmers and disseminate the acceptable management technologies among them,
- validate the effectiveness of the technology in controlling soil erosion on sloping lands, and
- identify hedgerow plant species suitable to local conditions.

This paper presents the results of this collaborative project.

Materials and Methods

Biophysical characteristics of the site

The experimental site was located at Paireni village of Chandi Bhanjyang Village Development Committee Ward No. 9 of Chitwan district in central Nepal. The site is situated on north and north-east facing steep (60-80%) hill slopes.

This research study site, at an elevation of about 350m, has a subtropical climate. The annual mean temperature is 22.3 °C, with a maximum temperature of 35.0 °C in May and a minimum temperature of 9.4 °C in January. The annual total rainfall is around 2357 mm, of which about 89% falls during May-September. This study site represents typical cultivated sloping land that is considered as marginal land for crop production.

The soils are, in general, gravelly, shallow, and well to excessively drained. The soil textures are mostly sandy loam to loamy sand, and the bulk density ranges from 1.1 to 1.4 g/cm^3 in surface soil and 1.15 to 1.22 g/cm^3 in the subsurface soil. These soils are slightly to moderately acidic (pH 5.3-6.2) and organic carbon content varies from low (1.1%) to high (3.3%). Total nitrogen percentage is very low (0.04%) to medium (0.16%). The available phosphorous content is high (72 kg ha^{-1}) to very high (215 kg ha^{-1}), and the available potassium content is low (96 kg ha^{-1}) to medium (192 kg ha^{-1}). These soils are tentatively classified as eutric cambisols and eutric leptosols.

The general cropping pattern in the area is maize as a summer crop followed either by millet, buckwheat, winter maize, or mustard as a winter crop. In the experimental site, maize and millet were the main cereal crops during the project period. Moreover, most of the cultivated land in the area is degraded forest and shrub, marginal land recently brought into cultivation after the construction of a highway. Shifting cultivation is a common practice.

Treatments

An adaptive on-farm research experiment was carried out in randomised complete block design (RCBD) with five treatments and three replications. The individual plot size was 20m x 5m, and the cropping pattern was maize followed by buckwheat. The maize variety grown was Rampur Composite, and the buckwheat was local. The treatments were as follows.

Treatment 1. Farmer's practice (traditional)
Treatment 2. Farmer's practice + hedgerows (*Dalbergia sissoo*)
Treatment 3. Farmers' practice + hedgerows (*Dalbergia sissoo*) and without fertiliser
Treatment 4. Farmer's practice + hedgerows (*Desmodium rensonii*)
Treatment 5. Farmer's practice + hedgerows (*Dalbergia sissoo*) + fruit trees (mango)

Runoff and sediment collection

To monitor runoff water, soil loss, and crop yields, each plot was separated by GI sheets and each plot was provided with two runoff water and sediment collection tanks of 1 m^3 each. The first tank that received runoff water and sediment from the plot was provided with 10 outlets, one of which was connected with the second tank, which received the runoff water and mostly suspended sediments from the first tank after it was filled up. Both tanks of each plot were calibrated before the monsoon every year both for volume at different depths and for the outlets of a first tank after overflow. The runoff water volume at a particular depth was determined for each tank according to the volume calibration, and for the second tank the runoff water volume was determined by multiplying the observed water volume with the calibration factor of the outlets of the first tank. There were no covers on the runoff water and sediment collection tanks or the trough to the runoff water. Thus the actual volume of runoff was calculated by subtracting the calculated volume of direct rainfall water from the volumes collected in the tanks.

Testing of hedgerow plant species

Eight plant species were used to establish and develop hedgerows in the farmers' fields; hedgerows 20 to 25 metres long were selected and fixed for monitoring growth and biomass yields for each species. Fresh biomass yields were recorded for each harvest for each species and the total fresh biomass yield (kg m^{-1} $year^{-1}$) calculated.

Results and Discussion

Runoff and soil loss

The amounts of runoff water and soil loss were low in all the treatments (Figures 1, 2). This was partly due to the nature and type of soils at the experimental sites which were very shallow, stony, and coarse textured. There were heavy rains and storms for a few hours during the early monsoon in 1996 that went unrecorded, but caused erosion of most of the surface soil at the research site. This unprecedented event of heavy rain left behind mostly gravel and stones on the land surface. Thus there was not much soil left in the plots for further erosion during the monsoon in the following years so that soil loss for all the treatment conditions was very low. The mean runoff water volume for 5 years (1996–2000) was highest (218 m^3 ha^{-1}) for treatment 5 and lowest (146 m^3 ha^{-1}) for treatment 3. Similarly, the average amount of soil loss over 5 years (1996-2000) was most (669 kg ha^{-1}) for treatment 1 (farmer's practice/traditional) and least (203 kg ha^{-1}) for treatment 2. Soil loss was reduced by almost 70% under treatment 2 as compared to treatment 1, and by approximately 50% under treatments 5, 4, and 3. Thus all hedgerow treatments were promising options to reduce soil loss, with treatment 2 the best.

Crop yields

Maize

The yields of maize in all treatments were much less in 1997 and 1998 than in 1996, 1999, and 2000. This was probably due to the washing away of surface soil in 1996 after which the subsurface soil had to be cultivated. It took some time for fertility to be built up. The 5-year average yield of maize was highest (3.1 t ha^{-1}) in treatment 5 and lowest (2.1 t ha^{-1}) in treatment 4, which had a similar yield to treatment 1 (farmer's traditional practice) (Figure 3). The crop yields obtained showed some effect of treatment.

Buckwheat

The buckwheat yield was higher in 1996 than 1997 to 2000, probably due to prolonged dry winter weather in the later years. The erosion of surface soil in mid-1996 might also have made less soil available for cultivation of the winter crop. The highest 5-year average buckwheat yield (0.6 t ha^{-1}) was obtained in treatment 3 followed by treatment 2 (0.5 t ha^{-1}), and the lowest (0.4 t ha^{-1}) in treatment 1. The data obtained indicate some effect of treatment.

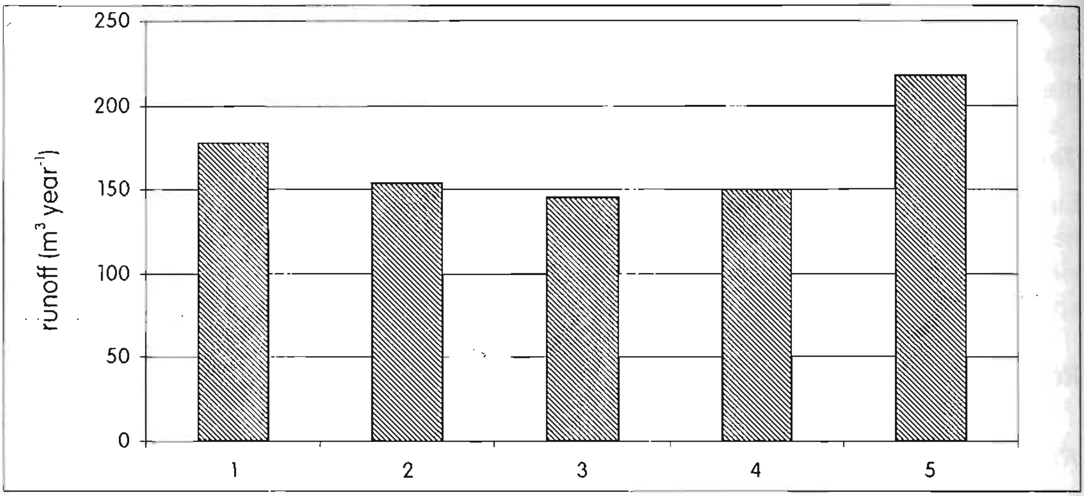

Figure 1: Volume of runoff (five-year average)

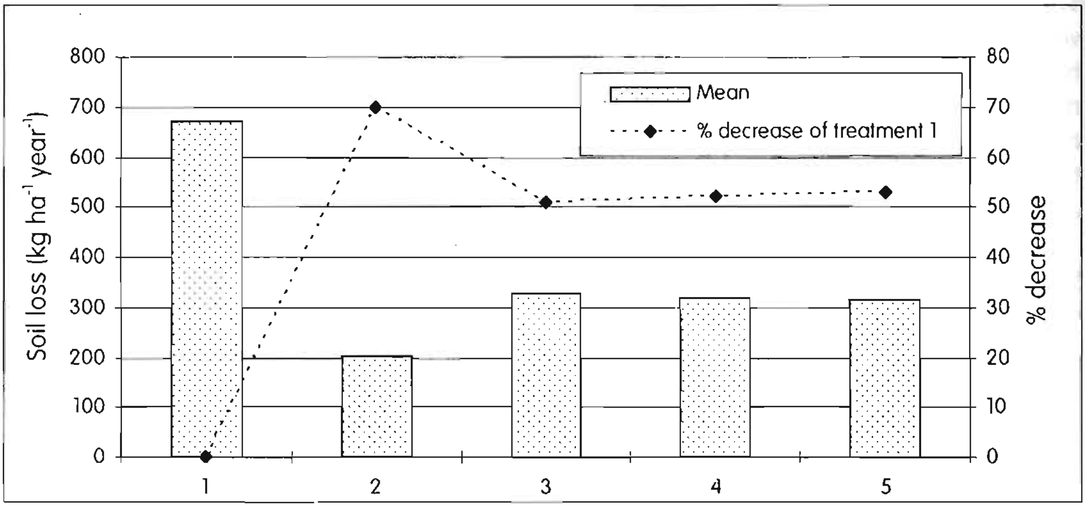

Figure 2: Soil loss (five-year average)

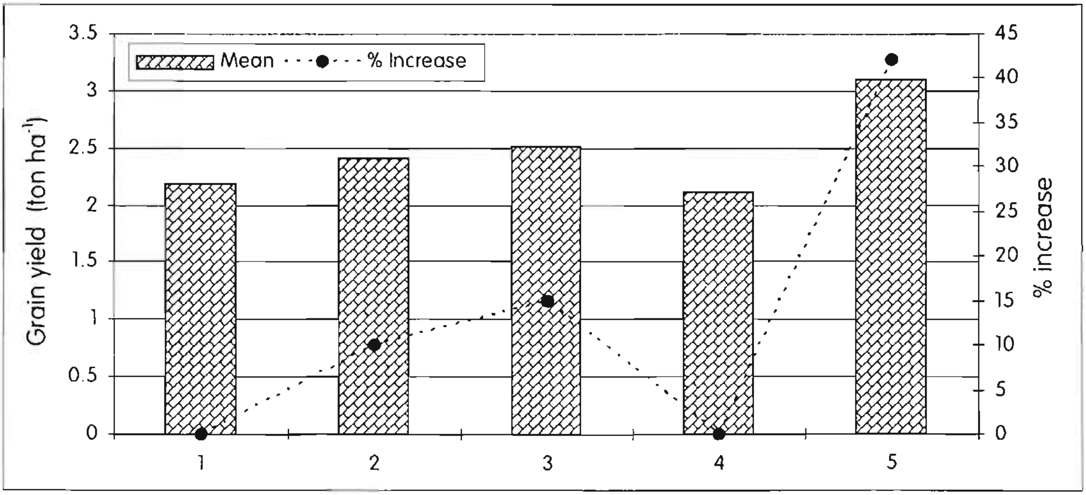

Figure 3: Corn grain yield (five-year average)

Selection of hedgerow plant species

Eight leguminous and non-leguminous perennial hedgerow plant species were tested (Table 1). The maximum fresh biomass yield (4.98 kg m^{-1}) was obtained from *Desmodium rensonii* and the lowest (0.5 kg m^{-1}) from *Albizzia lebbek. Flemingia macrophylla* gave the second highest biomass yield (1.0 kg m^{-1}). The vegetative growth was good in the case of *Desmodium rensonii, Leucaena leucocephala, Tephrosia candida,* and *Dalbergia sissoo,* and moderate in the other species. However, *Desmodium rensonii* and *Tephrosia candida* died after four years and had to be replaced by other suitable species. Similarly, *Flemingia macrophylla* was heavily attacked by insects from the beginning and it was difficult to save it and have a good plant stand. Considering all these results, the following plant species may be recommended for hedgerow development under the conditions at the test site: (1) *Leucaena leucocephala,* (2) *Dalbergia sissoo,* (3) *Indiofera sp,* (4) *Bauhinia purpurea,* (5) *Albizzia lebbek,* and (6) *Flemingia macrophylla.*

Table 1: Hedgerow biomass yields (kg m^{-1} year $^{-1}$)

Species	Year					
	1997	1998	1999	2000	Mean	Remarks
Dalbergia sissoo	0.32	0.41	0.69	1.52	0.73	Good growth
Bauhinia purpurea	0.33	0.41	0.31	0.92	0.49	Mod. Growth
Albizzia lebbek	0.28	0.23	0.31	1.07	0.47	Mod. Growth
Tephrosia candida	1.20	0.68	0.47	-	0.78	Good growth
Leucaena leucocephala	0.87	0.25	0.85	1.95	0.98	Good growth
Indigofera sp. (local)	0.49	0.28	0.47	0.72	0.49	Mod. Growth
Flemingia macrophylla	-	0.73	0.52	2.28	1.04	Mod. Growth
Desmodium rensonii	7.78	6.68	0.49	-	4.98	Good growth

Future Implications

The research activities have increased the awareness of the problem of soil erosion and land degradation and of the SALT farming system among farming communities and extension workers. The research site has become an important demonstration site for their visits, and is an important visual aid to help people understand the phenomena of soil erosion and land degradation and see an example of how to overcome or lessen the problems.

Many visitors have come to the project site to see and understand the various activities and SALT models under testing. They have included farmers, university students, extension workers, and research scientists from different districts under different programmes of government, NGOs, INGOs, and research organisations including NARC.

Many farmers have now started adopting SALT farming, not only in and around the research site but also in other areas and districts. Local farmers, extension workers, NGOs, and INGOs are requesting regular training programmes on the technologies in order to disseminate the knowledge more effectively and to encourage people to adopt the SALT farming system. These are certainly positive impacts of the research project. There are, however, some practical issues in initiating adoption of the technologies that must be considered while formulating any programme for developing and adopting the technologies for the future. These issues are as follow.

- Open grazing is generally practised during the winter season, and it is difficult to protect hedgerows from cattle since most of the farmlands are left fallow for 4-5 months.
- The winter season is generally almost without rain, and it is very difficult to keep the hedgerows alive during such a prolonged dry period, especially during the initial years of hedgerow establishment, since most of the farmlands in the area are under rain-fed cultivation.
- Large amounts of planting materials are required and should be made available in sufficient quantity to the farmers well in time.
- Farmers and even extension workers may need training on the technologies to ensure their wide and extensive adoption.
- Government departments and NGOs concerned with the dissemination and extension of the technologies should include this in their annual programmes and provide incentives to the farmers in adopting the new technologies.

Acknowledgements

I would like to express my sincere gratitude to Mr. D. Joshy, Executive Director of NARC, for his keen interest and constant encouragement to carry out this study. I am also grateful to Dr. S. L. Maskey, the Chief Soil Scientist of Soil Science Division (SSD), NARC, for her support in carrying out the research. The help and services rendered by the staff of the Soil Science Division and Soil Laboratory are duly acknowledged. My sincere gratitude is due to ICIMOD and ADB for the funding. Last but not least, my appreciation goes to the local farmers for their continued support and cooperation during the study period.

Contour Hedgerow Farming in North-east India

R.C. Sundriyal
G. B. Pant Institute of Himalayan Environment and Development, Itanagar, Arunachal Pradesh, India

Introduction

The north-east region of India is home to over 100 tribal communities (total population 31 million); its 260,000 sq.km land area accounts for 7.8% of all India. All the traditional societies are intimately dependent on the natural resources. 'Jhum' (shifting cultivation) is the predominant land use and economic activity. This practice aims at maintaining high crop diversity, achieving food security through utilising locally available organic resources for sustained yields, and cooperation/social integration at a local scale (Ramakrishnan 1993). Jhum was a sustainable practice in the past due to transfer of resources within and between different human managed systems, as well as within and between the village ecosystem and the natural forest systems. Unfortunately the recent rapid depletion of natural resources has remarkably reduced the productivity of the land. Due to their low socioeconomic status, the indigenous people are not in position to accept high quality technologies for land use development. Furthermore, the imported technologies require high inputs, and thus do not receive local attention. The government policies seek to discourage jhuming in the region, and thus the whole jhum system is marginalised.

This paper highlights some experiences gained through establishment of contour hedgerow farming systems in the jhum fields of Nagaland and Arunachal Pradesh.

Materials and Methods

Study area and experimental sites

The project was started in early 1994 with financial and technical support from the International Centre for Integrated Mountain Development (ICIMOD). Four sloping agricultural land technology (SALT) models, each with a minimum area of 1 ha, were established at Longnak, Nagaland, following the methodology recommended in the Planning Workshop of the Appropriate Technologies for Soil Conserving Farming Systems (ATSCFS 1994).

SALT-I was composed of traditional crop systems with double hedgerows of different N_2-fixing species.

SALT-II was an agro-livestock model, incorporating agriculture, hedgerows, and livestock components. Three fishery tanks including one duckery-cum-water reservoir and one piggery were established as a part of this model.

SALT-III consisted of an agroforestry system incorporating agriculture and hedgerows and timber/firewood species. For the initial two years, a few traditional crops (rice, maize) were grown along with *Crotalaria tetragona* hedgerows, which were discontinued from the third year onwards due to the shading effect of trees on crops and die back of hedgerows. *Gmelina arborea, Terminalia myriocarpa, Duabanga grandiflora, Albizia lebeck, A. chinensis, Parkia roxburghii, Melia azaderch, Canarium resineferae*, and *Mesua ferea* trees are now being maintained in this model.

SALT-IV represented a cash-crop based horticulture farm with hedgerows. Citrus, litchi, banana, mango, guava, coconut, pineapple were raised and maintained in this plot.

All these plots had similar vegetation cover and were used for jhum cultivation before being used for the present work. The control site was a traditional jhum plot without any hedgerows, and all local crops (i.e., rice, maize, tapioca, and colocasia) raised as grown by farmers; this plot was maintained for measurement of runoff and soil erosion.

Seeds of different nitrogen fixing species were procured from various sources and tested for their germination, growth, and biomass production. Germination tests for different hedgerow species were conducted in the laboratory as well as under field conditions. Various crops were grown on each plot, and records of all the inputs and outputs in each treatment were made. To monitor the effects of nitrogen fixing species on soil conservation, five plots of 20m x 5m were established initially, representing four SALT models and a control site with traditional jhum practices. Since 1998 only three treatments have been maintained for measuring runoff and soil erosion: the traditional jhum site (control), jhum+hedgerows, and an agroforestry model; each treatment has three replicates. Runoff and soil erosion were collected at the bottom of each plot in a tank. The impact of hedgerow biomass mulching on crop yield was measured with reference to the control site. The soil samples were collected from two depths, 0-15 cm and 16-30 cm, from different plots at the beginning of the demonstration work and thereafter each year at five different seasons, (January, April, June, September, and November). Soil samples were analysed for physical and chemical properties. On-farm research on biomass assessments, plant and soil nutrient analysis, soil fertility management, plant diversity, and crop yield analysis were done as per standard methods (Piper 1942 and other). In the course of model development, cost:benefit analyses were conducted for the jhum, jhum+hedgerow, and agroforestry sites.

Results and Discussion

Selection of hedgerow species

The land preparation activities at the Longnak site were initiated after slash and burn of the vegetation. Hedgerows were established by direct seeding in all the designated SALT models. A total of 10 species (*Flemingia macrophylla, Tephrosia candida, Cajanus cajan, Crotalaria pallida, Crotalaria tetragona, Desmodium rensonii, Acacia manguim, Gliricidia sepium, Indigofera anil*, and *Calliandra calothrysus*) were tested as hedgerows. All these hedgerow species were fast growing, and have multiple uses with N_2-fixing ability. The germination tests were done in the field as well as in the laboratory. The germination rate of most of the species was 56-98% in the laboratory and 20-80% in the field. *Tephrosia candida, Flemingia macrophylla, Cajanus cajan, Crotalaria tetragona* and *Desmodium rensonii* had high germination in both the field and laboratory. *Calliandra* *calothrysus* had poor germination under field conditions. Other species had medium rates of germination. Establishment of *Tephrosia candida* was very easy, required minimum inputs, and produced high biomass; thus it had a high impact on controlling soil erosion. Unfortunately the species recorded high mortality in the second and third years after germination and required high labour for maintenance; therefore it cannot be recommended for permanent agricultural areas, but could be adopted as the best hedgerow species for traditional jhum fields, which are left fallow after two successive croppings. *Flemingia macrophylla, Desmodium rensonii,* and *Indigofera anil* showed good growth, minimum mortality, and produced significant biomass in the three years of the experimental phase. These species also had high fodder values and affected soil and nutrient conservation; therefore they are recommended as the best species for this region. *Leucaena leucocephala* was recently introduced at the Midphu site and is still under observation.

Species biomass production

All the hedgerows need to be pruned to reduce shading of crops. The number of prunings also affected the biomass production of each species. Species that sustained 3-4 prunings with good biomass production on an annual basis were considered better. *Flemingia macrophylla* produced the maximum biomass, followed by *Tephrosia candida, Desmodium rensonii,* and *Indigofera anil*; therefore they are considered as the best performing species. *Acacia mangium, Cajanus cajan, Calliandra calothrysus, Crotalaria pallida,* and *Crotalaria tetragona* produced low biomass and did not respond well to pruning, and therefore are not considered good species for hedgerows.

Runoff and soil loss under different treatments

The runoff and soil loss have been monitored for different SALT models since 1995 at the Longnak site. In all the treatments (a traditional jhum plot and four SALT models), the runoff was very high at the start of the experiment, as was soil loss. Compared to the control figure of 60 m^3/ha, runoff was reduced significantly after the establishment of different models. The initial rate of soil loss was as high as 38.1 t/ha/year. However, there was a continuous decrease in soil loss in subsequent years in all the treatments, except for the control site. The soil loss was least in SALT 3, followed by SALT 1. Hedgerow incorporation brings significant reduction in soil loss even though the same agricultural practices were continued. The soil loss reduced to <5 t ha^{-1} in SALT 3 and <10 t ha^{-1} in SALT 1 after five years of the experiment. The control plot, however, had a similar level of soil loss to that recorded at the beginning of the study.

Change in soil nutrients

Hedgerows have a significant impact on the moisture content of soil. When applied as mulch, the pruned biomass maintained the soil moisture level for a long period due to less evapotranspiration from soil. There was a clear increase in soil nitrogen and carbon status in all the treatments, except for the control plot that showed a net decrease for C (Table 1).

Table 1: Impact of hedgerow mulching on soil nitrogen and carbon for different SALT models				
Treatment	At the beginning of study		After 4 years of mulching	
	C (%)	N (%)	C (%)	N (%)
Control	1.25	0.115	1.00	0.144
SALT I	1.34	0.160	2.06	0.193
SALT II	1.15	0.135	1.48	0.166
SALT III	1.03	0.180	1.53	0.190
SALT IV	1.51	0.160	1.49	0.166

Impact of hedgerow biomass mulching on crop yield

Hedgerow mulching had a positive impact on the crop yield except for rice (Table 2). For most of the crops grown with hedgerows, the yield increased by 1.5 to 3 times. The impact of mulch was more significant on vegetable and root crops.

Table 2: Impact of hedgerow mulch on yield (t/ha) of some crops		
Crops	Traditional practice	Plots with hedgerows
Rice	3.25±0.38	2.92±0.41
Maize	1.67±0.24	2.47±0.24
Ginger	4.45±0.33	25.15±0.36
Peanut	2.61±0.20	3.15±0.31
Turmeric	24.00±1.50	29.93±3.38
Taro	3.90±2.00	6.60±2.50
Tapioca	10.80±2.30	16.30±4.00
Tomato	20.60±3.56	51.60±4.95
Cauliflower	21.90±2.15	36.62±4.58
Green chilli	22.00±3.04	32.00±5.21
Lady's finger	11.70±1.58	16.00±2.49

Other appropriate technologies

Some other appropriate technologies were also included as an integral part of the project, with each activity identified based on its need and usefulness to farmers. Some important technologies incorporated were low-cost water harvesting by construction of deep earthen dams, which was also used as a fishery-cum-duckery; polythene tanks for rainwater harvesting; bio-briquetting; weed composting; and bamboo propagation. These activities received wide acceptance from farmers and NGOs.

Economic analysis

A comparison of major inputs and outputs from jhumland (traditional system), jhum + hedgerows, and agroforestry showed that in the first year profit was higher from the jhum system than from any other treatment. However this decreased in the second year of cropping. The high first-year inputs in the hedgerow + agriculture system were due to the cost of seeds of hedgerow species and of the establishment of hedgerows and maintenance costs, while in the agroforestry model this was due to the cost of seedlings. However, the contour hedgerow farming system provides a regular income year after year and also ensures food production, which is not possible in jhum practice. In the agroforestry model, there was no income through the fourth year, but in the fifth year the plots were thinned and 2.7 tonnes of firewood were harvested. This system seems highly profitable and could be adopted by farmers who have large landholdings, but may not be a good option for small landholdings. Poor farmers generally have small landholdings and their main priority has been food production, which can be achieved by applying the contour hedgerow farming approach.

Impact

Hedgerow technology has been tested and demonstrated from 1994 to 2001. The focus was to develop a prototype through careful trials for selection of hedgerow species and investigation of the impact on soil structure, fertility, crop yield, and runoff-erosion control. The impact in terms of replication of the model was not very high. However, a great deal of awareness was generated on the subject and a few NGOs are in the process of implementing the technology. Training programmes and short-term exposure visits were arranged for the planners, social workers, NGOs, and farmers to build their capacity to use the technology. The technology has positive effects on crop yields, runoff and soil conservation, and maintenance of fertility, and produce continuous financial returns year after year, which provides enough incentive to the farmers and developmental agencies to adopt the technology.

Future Implications

The jhum fields in north-east India are used for two successive cropping seasons and thereafter left fallow. Agricultural production is high in the first year after slash and burn of the land because of the high nutrient content of the soil; the production decreases in the second year due to reduced soil fertility and serious soil erosion. The field is then left fallow, as there is no concept of applying any fertiliser or manure fields to maintain soil fertility. As most jhumlands are prone to severe soil erosion, incorporation of hedgerow technology plays an important role in maintaining and improving soil fertility through pruning and mulching of hedgerow species and conserving soil through thickly planted hedgerows.

The experiments showed that the crop yield increased significantly after establishing hedgerows; thus permanent cropping is possible in jhum fields without external inputs. The technology is an integrated farming approach that contains agriculture, animal husbandry, agroforestry, and horticulture components (Jamir et al. 1998). Hedgerows reduced the runoff by over 50% and soil erosion by 6 times. The productivity for major crops increased by 1.5 to 3 times in agricultural fields. Similar results have been reported from other areas (Tang Ya 1998).

The initial labour requirement is higher than for traditional farming, and therefore some incentive to the farmers in the initial stages is highly desirable. Incorporation of economic species along with the hedgerow species may increase farmers' interest. There is a further need to evaluate more local and indigenous nitrogen fixing species as hedgerows; the criteria should include good germination and survival, high biomass production on a unit area basis, fodder and firewood production, high seed production, drought tolerance, and resistance to diseases and pests (Tacio 1992). It will also be wise to develop more such models in diverse situations before large-scale replication of the technology. Such models should incorporate multipurpose hedgerow species with cash and food crops, and livestock components, as the farmers choices vary from area to area.

References

ATSCFS (1994) *Appropriate Technology for Soil Conserving Farming Systems (ATSCFS) Project*, planning workshop report. Kathmandu: ICIMOD

Jamir, S.; Chnagkija, S.; Rao, K.S.; Sundriyal, R.C. (1998) 'Improving Jhum System Performance with Multipurpose Hedgerow Introduction in North East India.' In *Research for Mountain Development: Some Initiatives and Accomplishments*, pp. 83-98. Nainital (India). Gynodaya Prakashan

Piper, C.S. (1942) *Soil and Plant Analysis*. New York: Interscience

Ramakrishnan, P.S. (1993) *Shifting Agriculture and Sustainable Development: An Interdisciplinary Study from North-eastern India*. Delhi: Oxford University Press

Tacio, H.D. (1992) 'The SALT System: Agroforestry for Sloping Lands.' In *Agroforestry Newsletter*

Tang Ya (1998) *Bioterracing and Soil Conservation: Experiences with Contour Hedgerow Planting in Parts of the Hindu Kush-Himalayan Region*. Kathmandu: ICIMOD

Effects of Contour Hedgerows on Runoff Flow and Soil Erosion Control in a Dry Valley of the Jinsha River

He Yonghua, Tang Ya, Sun Hui, and Chen Keming
Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, China

Introduction

The Chinese Himalayan region in western China is characterised by a high percentage of mountains. Population pressure is becoming increasingly serious in many parts of the region. To meet the population demands for survival and day-to-day life, agricultural and economic activities have been extending to very steep sloping lands. Owing to deforestation and extensive cultivation on sloping land, farmers in mountainous areas have been facing such problems as serious soil erosion, declining soil fertility, and environmental deterioration. For example, in Ningnan County, the experimental area of this study, about 56% of the total arable land has suffered from land degradation through water erosion. More than 10% of farmers still rely on lands with slopes exceeding 25°. Meanwhile, the crop yields on sloping land are low due to soil fertility degradation or seasonal drought.

Contour hedgerow intercropping technology has been identified as an effective method to control soil erosion and improve soil fertility in mountain farming systems (Kiepe 1995; Narain et al. 1998; Palmer 1997; Partap and Watson 1994). In 1991 the Chengdu Institute of Biology (CIB), in collaboration with ICIMOD, selected Tanguanyao and Masangping in Ningnan County as sites for demonstrating contour hedgerow intercropping. Since 1994, on-farm research has been carried out at two project sites to assess the effect of hedgerows on soil and water conservation in this region . After several years' experimentation, some obvious changes have been observed. This paper evaluates the effects of contour hedgerows on runoff and control of soil erosion.

Materials and Methods

Study area

Ningnan County, located in the hot and dry valley of the Jinsha River, is characterised by a subtropical monsoon climate. Two experimental sites were established in Ningnan County representing two typical agro-ecological areas. The major features of the sites are listed in Table 1.

Table 1: Main biophysical features of project sites

Sites	Tanguanyao	Masangping
Location	Pisha Township	Lutie Township
Elevation	1100-1203 m	1400-1485 m
Slope gradient (at plots)	18°	23°
Soil type	Dry red soils	Red-cinnamon soils
Annual mean temperature	19.3 °C	14.7 °C
Annual rainfall	970 mm	1100 mm
Rainfall distribution	91% in rainy season	88% in rainy season

Experimental Design

Fifteen soil erosion plots were established at the Tanguanyao and Masangping sites in 1995 and 1996. Rectangular erosion plots 20 m along slope and 5 m across slope were built. Five rows of N_2-fixing hedgerows were planted in each plot except for the control plot. Concrete barriers were inserted in the ground to check surface and near surface flow. Runoff from the plot was collected in a tank through a runoff gutter. One control tank with runoff gutter but without a plot was established at each site to reduce the error caused by rainfall collection of the tank and gutter and water evaporation. The cross-sectional area of each gutter was 2 m^2 (0.4 m×5 m), and the volume of each tank was 1 m^3 (1 m long, 1 m wide, and 1 m high). A scale line was marked from bottom to top at every centimetre near the corner of each tank. Tanks were calibrated for water volume at each water height by addition of water, and calibration curves were obtained for each tank.

Five treatments with three replications were used; the treatments were:

- T1: Farmer's practice (without hedgerows and with fertiliser),
- T2: *Leucaena leucocephala* hedgerow + annual crops without fertiliser,
- T3: *Leucaena leucocephala* hedgerow + annual crops with fertiliser,
- T4: *Tephrosia candida* hedgerow + annual crops with fertiliser,
- T5: *Leucaena leucocephala* hedgerows + mulberry trees with fertiliser.

At the Tanguanyao site, peanut was planted in the plots every year except 1998, when maize was grown. Maize was cultivated at the Masangping site except that peanut was cultivated in 1998. Superphosphate was applied at a rate of 30 kg/ha for peanut; 30 kg/ha of urea was used for maize. Day-to-day management of crops in plots followed local farmers' practice.

The water level in each tank was recorded after every rainfall, and the runoff was calculated using the tank calibration curves. The sediment was thoroughly mixed and a bottle (0.625 l) of samples was collected if the water level in the tank was greater than or equal to 5 cm. Then all the tanks were cleaned before the next storm. The sediment samples were filtered and sent to a laboratory for air-drying and oven drying at 65-70 °C. Net weights of sediment on the filter paper were calculated and soil loss in every rainfall event was calculated for each plot.

Results and Discussion

The amounts of runoff from 1997 to 1999 at Tanguanyao and Masangping are presented in Figures 1 and 2, respectively. The results show that the contour hedgerow system is very effective in controlling runoff. Three years after contour hedgerow establishment, runoff was reduced to 26-31% of that under farmers' practice at Tanguanyao. In Masangping, *L. leucocephala* hedgerows were more effective than *T. candida* hedgerows in reducing runoff. Runoff from treatments with *L. leucocephala* hedgerows was 31-41% of the control plot, and that from treatment with *T. candida* hedgerows was 47-60% of the control. The results indicate that almost half of surface water flow is intercepted into soil by contour hedgerows, which helps to alleviate temporary drought and topsoil erosion.

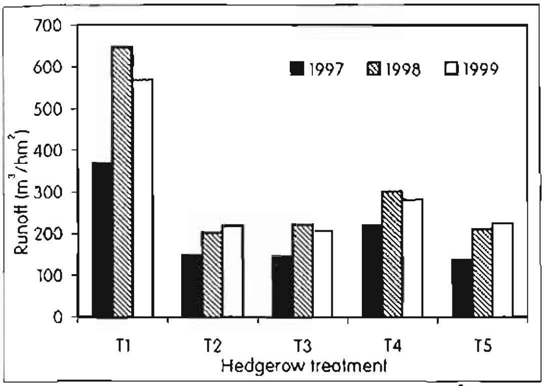

Figure 1: **Runoff at Masangping site**[1]

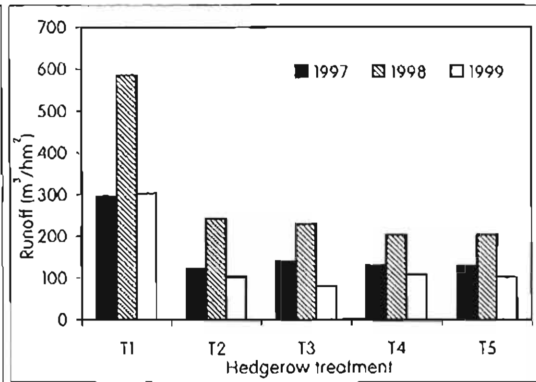

Figure 2: **Runoff at Tanguanyao site**[1]

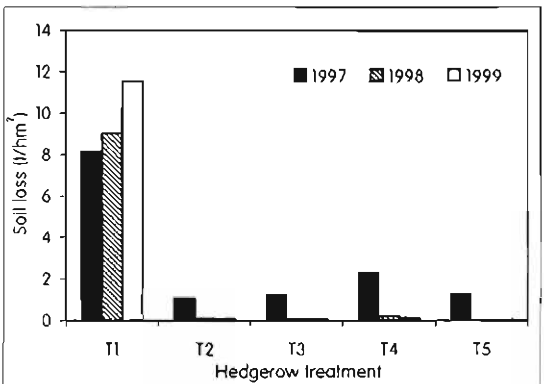

Figure 3: **Soil loss at Masangping site**[1]

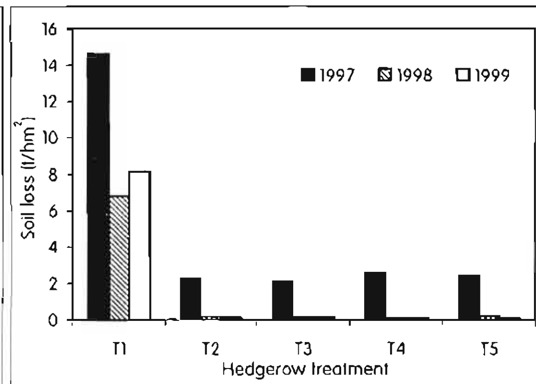

Figure 4: **Soil loss at Tanguanyao site**[1]

The soil loss is shown in Figures 3 and 4. The contour hedgerows were very effective in reducing soil erosion. Compared to farmers' practice, soil loss in plots with contour hedgerows was down to 2-5% of that from control plots 3-4 years after hedgerow establisment at both project sites. The effects of the contour hedgerows on controlling soil loss increased with time after hedgerow establishment.

Maintenance of hedgerows can gradually lead to the formation of terraces after several years' normal cultivation in the alleys. The slope gradients of alleys in each plot at two project sites measured in 1998 are shown in Table 2. The gradient of alleys in plots with hedgerows reduced from 17° to around 7°after seven years of cultivation at the Tanguanyao site, and from 23° to around 11° at the Masangping site after five years of cultivation. It is believed that the bio-terraces will be thoroughly formatted after a few more years of cultivation, the results confirmed that this kind of bio-terrace is easy to establish and manage, and is more stable than engineered terraces.

Table 2: Gradient changes of alley slope after hedgerow establishment

Site	T1 (Control)	T2	T3	T4
Tanguanyao (after 7 years)	17°12'	6°28' - 10°	6° - 8°25'	8°18' - 11°
Masangping (after 5 years)	23°	10° - 12°32'	9°50' - 12°20'	12°30' - 13°

[1] hm = ha (ed)

Ningnan County is located in the hot and dry valley of the Jinsha River with a typical monsoon climate; most runoff and soil loss occur in the rainy season from May to October. The temporal distribution of runoff and soil loss in control plots during the monsoon season in 1999 is presented in Table 3. At Tanguanyao, more than 80% of the runoff and more than 90% of soil loss occurred from June to August. At Masangping only 40% of the runoff occurred from June to August, and 60% from September to October; but 78% of total soil loss occurred from June to August.

Table 3: Temporal distribution of runoff and soil loss in control plots

Site	Period	Runoff (m^3/ha)	Soil loss (t/ha)	Soil loss/runoff
Tanguanyao	May	11.81	0.237	2.01%
	Jun.	78.62	3.055	3.89%
	Jul.	80.02	1.971	2.46%
	Aug.	93.57	2.404	2.57%
	Sep.	34.65	0.426	1.23%
	Oct.	4.73	0.062	1.31%
Masangping	May	0	0	–
	Jun.	60.13	2.77	4.61%
	Jul.	87.34	3.64	4.17%
	Aug.	81.13	2.63	3.24%
	Sep.	176.39	1.43	0.81%
	Oct.	163.87	1.06	0.65%

Agrochemical analysis indicated that erosion accelerates nutrient loss. Table 4 compares the nutrient contents of topsoil and erosion soil and shows that the total nitrogen and organic contents of the sediments at the two sites were between 2.5 and 4.2 times those of topsoil. This result clearly implies that a large amount of nutrients are lost to soil erosion.

Table 4: Comparison of nutrients of topsoil and erosion soil

Site		Sediment	Topsoil	Ratio
Tanguanyao	Total N (%)	0.143	0.053	2.3
	Organic matter (%)	3.272	0.780	4.2
Masangping	Total N (%)	0.172	0.069	2.2
	Organic matter (%)	5.236	1.912	2.5

Conclusions

The results demonstrate the effectiveness of contour hedgerows in soil conservation in the subtropical region. Maintenance of hedgerows can lead to formation of terraces after several years' normal cultivation in the alleys. This kind of bio-terrace is easy to establish and manage, and is more stable than engineered terraces. The contour hedgerow system shows great potential for conserving water and soil on sloping agricultural lands. It is recommended that contour hedgerow technology be applied in subtropical areas of the Chinese Himalayan region if proper hedgerow species are selected.

References

Kiepe, P. (1995) *No Runoff, No Soil Loss: Soil and Water Conservation in Hedgerow Barrier System*. Wageningen: Wageningen Agricultural University

Narain P.; Singh R. K.; Sindhwal N. S.; Joshie P. (1998) 'Agroforestry for Soil and Water Conservation in Western Himalayan Valley Region of India: 1. Runoff, Soil and Nutrient Loss.' In *Agroforestry Systems*, 39(2): 175-189

Palmer, J. (1997) *Sloping Agricultural Land Technologies (SALT): Nitrogen-fixing Agroforestry for Soil and Water Conservation*. Manila: MBRLC

Partap, T.; Watson, H.R. (1994) *Sloping Agricultural Land Technology (SALT): A Regenerative Option for Sustainable Mountain Farming*. Kathmandu: ICIMOD

Effects of Contour Hedgerows of Nitrogen Fixing Plants on Soil Fertility and Yields of Sloping Croplands in a Dry Valley of the Jinsha River, China

Sun Hui, Tang Ya, Wang Chunming, and Chen Keming
Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu, China

Introduction

The contour hedgerow system is an agroforestry model in which nitrogen-fixing trees and shrubs are planted closely in double rows between alleys along contour lines in association with annual crops, pastures, or livestock, in some form of spatial arrangement or temporal sequence. The system has also been called 'alley cropping' (Kang et al. 1990; Nair 1993), and has been investigated extensively in tropical regions since the 1980s. It has been developed as an alternative soil conservation and fertility management technique with low external cash, labour, and chemical fertiliser requirements. Contour hedgerow intercropping can provide the physical barriers needed for water and soil conservation, and a biomass source for continuous supply of nitrogen and organic matter.

The contour hedgerow system was introduced to China in the early 1990s because of its potential value in establishing sustainable farming based on local resources. This paper reports the results of a long-term experiment sponsored by the Chengdu Institute of Biology, Chinese Academy of Science, ICIMOD, and the Government of Ningnan County to examine the impact of contour hedgerows on soil fertility and crop production in the Hengduan Mountains of south-western China.

Materials and Methods

Site description

The study was carried out at two sites: Tanguanyao and Masangping. Tanguanyao is located in Pisha Town of Ningnan County, southwest Sichuan; its elevation is 1150m, and it represents a low elevation agro-ecological area in the dry valley of the Jinsha River. A ustic ferrisol (Chinese Soil Taxonomy Research Group 1995) with an organic matter content of 8.0 g/kg and total nitrogen of 0.41 g/kg in 1991 was used for this study. Masangping is located in Liutie Township of Ningnan County at 1450m, and represents the middle mountain agro-ecological area of this region. The soil has a clay-loam texture, and had an organic matter content of 11.1g/kg and total nitrogen of 0.53 g/kg in 1994.

Experimental Design (Field and Laboratory Methodology)

Fifteen soil erosion plots (five treatments with three replicates) were established at Tanguanyao and Masangping in 1995 and 1996, respectively. The five treatments used were (1) control (farmer's up and down practice without hedgerows and with fertiliser); (2) T2 (*Leucaena leucocephala* hedgerow + crops without fertiliser); (3) T3 (*Leucaena leucocephala* hedgerow + crops with fertiliser); (4) T4 (*Tephrosia candida* hedgerows +

crops with fertiliser); and (5) T5 (*Leucaena leucocephala* hedgerows + mulberry trees + crops with fertiliser).

Peanut was grown in all the plots at Tanguanyao from 1995 to 2000 except that maize was grown in 1998. Maize was cultivated from 1995 to 2000 at Masangping, except that peanut was grown in 1998. Superphosphate was used on peanut, and urea on maize in the fertilisation treatments at the two sites at a rate of 30 kg/ha. The soil used for the trial was 30-210 cm deep and classified as an ustic luvisol (Chinese Soil Taxonomy Research Group 1995).

Soil sampling and nutrient analysis

Topsoil (0-30 cm layer) from all the plots was sampled after harvest of the crops at the end of the rainy season. Soil samples were ground to pass through a 1-mm sieve to determine organic matter, total N, available P, available K, cation exchange capacity, exchangeable Na (natrium), K (potassium), Ca (calcium), and Mg (magnesium). Organic matter was determined by the wet digestion procedure; total nitrogen was determined after digestion by the micro-Kjeldahl method; available K by the ammonium acetate extraction method (Jones 1973); available P by the Olsen method (Oslen 1954); and CEC by CH_3COONH_4 exchange. The soil exchangeable base was determined by CH_3COONH_4 exchange and atomic absorption spectrophotometer/flame photometer after CH_3COONH_4 exchange.

Results and Discussion

Changes in organic matter (OM)

As shown in Table 1, the organic matter (OM) content of plots with contour hedgerow treatments exceeded that of controls by 87% to 132% at Tanguanyao (9 years after hedgerows established), and by 81% to 155% at Masangping (6 years after hedgerows established). The results indicated a favourable effect of contour hedgerow intercropping on the improvement of soil organic matter.

Table 1: Organic matter content under different treatments (g/kg)

Site	Year	Control	T2	T3	T4	T5
Tanguanyao	1991	8.00	8.00	8.00	8.00	8.00
	1996	7.75	7.76	8.12	9.36	8.95
	1997	7.18	9.08	9.48	9.37	8.61
	1998	6.59	9.89	10.99	9.20	8.87
	1999	6.80	10.34	12.00	9.68	9.48
	2000	5.34	10.91	12.42	10.18	10.00
Masangping	1994	11.10	11.10	11.10	11.10	11.10
	1997	12.99	18.22	17.52	15.61	20.21
	1998	11.16	15.76	15.80	13.91	15.23
	1999	9.32	15.71	15.01	13.10	14.46
	2000	6.74	16.69	17.21	13.88	10.40

Changes in total nitrogen (TN)

At both sites, total N in hedgerow intercropping plots increased considerably compared to the controls (Table 2) by 85%-292% at Tanguanyao, and by 104%-181% at Masangping.

The hedgerow system can increase total N in an alley because large amounts of prunings are used as mulch and the nitrogen content in hedgerow prunings is relatively high.

Table 2: Total nitrogen content under different treatments (g/kg)

Site	Year	Control	T2	T3	T4	T5
Tanguanyao	1991	0.41	0.41	0.41	0.41	0.41
	1996	0.56	0.75	0.74	0.77	0.84
	1997	0.61	1.14	1.26	1.34	1.07
	1998	0.68	1.19	1.29	1.42	0.98
	1999	0.67	1.28	1.35	1.45	1.04
	2000	0.41	1.51	1.57	1.61	0.76
Masangping	1994	0.53	0.53	0.53	0.53	0.53
	1997	0.47	0.91	0.84	0.79	0.82
	1998	0.46	0.92	0.97	0.77	0.80
	1999	0.45	0.92	1.07	0.79	0.80
	2000	0.43	1.15	1.21	0.88	1.07

Changes in available P

The available P contents of hedgerow treatment plots were higher than controls at both sites, and available P content of hedgerows plus P fertiliser was higher than that of hedgerows without P fertiliser or controls (Table 3). However, long-term observation of the trend in available P is necessary.

Table 3: Available phosphorous content under different treatments (mg/kg)

Site	Year	Control	T2	T3	T4	T5
Tanguanyao	1998	3.62	3.96	4.04	3.40	3.98
	1999	3.66	3.12	3.78	3.88	3.72
	2000	1.42	1.35	3.74	2.61	2.33
Masangping	1998	1.84	3.34	2.22	2.38	2.68
	1999	1.34	2.67	2.16	2.06	2.96
	2000	0.68	1.83	2.24	2.52	2.74

Changes in available K

The available K under hedgerow treatments increased continuously or remained nearly constant, whereas it decreased in controls (Table 4). In 2000, available K in the hedgerow plots increased by 84%-183% compared to controls at Tanguanyao, and by 56%-77% at Masangping. This shows that pruning can improve the content of exchangeable K in topsoil efficiently under the hedgerow inter-cropping system. Hedgerows also develop deep root systems that may take up leached and available K from the deep soil beyond the root systems of crops. The total K of *Leucaena leucocephala* and *Tephrosia candida* prunings (dry matter) was 29.1 g/kg and 17.1 g/kg, respectively, the K absorbed by hedgerows may be returned to alley topsoil through pruning decomposition.

Table 4: Available potassium content under different treatments (mg/kg)

Site	Year	Control	T2	T3	T4	T5
Tanguanyao	1997	242.1	259.6	241.9	230.1	276.5
	1998	190.3	338.6	373.2	200.2	246.8
	1999	156.5	349.5	378.8	262.0	244.0
	2000	139.9	397.3	313.0	277.1	258.4
Masangping	1997	222.0	267.4	259.2	273.2	358.0
	1998	216.3	315.7	379.9	290.3	304.6
	1999	214.9	383.2	333.4	345.0	318.6
	2000	207.8	366.9	339.4	336.5	324.9

Changes in cation exchange capacity (CEC)

The CEC of hedgerow treatments was generally higher than that of controls (Table 5), but the difference was not statistically significant. Further research and long-term observation is needed to understand the causes of the changes in CEC.

Table 5: CEC under different treatments (mg/kg)

Site	Year	Control	T2	T3	T4	T5
Tanguanyao	1997	123.7	144.0	135.3	139.0	141.3
	1998	108.0	105.5	99.0	109.0	123.0
	1999	91.0	97.5	98.0	104.0	106.0
	2000	75.5	93.4	106.1	97.02	102.8
Masangping	1997	151.5	155.7	202.6	158.7	181.6
	1998	115.0	120.0	126.0	121.0	134.0
	1999	108.0	111.5	106.0	110.0	107.0
	2000	101.5	129.7	155.1	138.9	130.8

Changes in exchangeable bases of topsoil

Soil recalcification is very common because of the dry and hot climate. The hedgerow system seems to have had no effect on the recalcification that took place in topsoil at Tanguanyao. However, recalcification seemed to be strengthened by the hedgerows at Masangping. Exchangeable Mg and K were also increased under the hedgerow system at the two sites, whereas there was no difference in exchangeable Na between hedgerow systems and controls.

Table 6: Exchangeable bases in topsoil under different treatments (mmol/kg)

	Sites	Control	T2	T3	T4	T5
Exchangeable Ca	Tanguanyao	64.53 ns	69.75 ns	68.58 ns	77.64 ns	65.00 ns
	Masangping	82.06 b	76.72 b	109.20 a	86.92 b	94.29 ab
Exchangeable Mg	Tanguanyao	21.52 b	24.92 ab	28.51 a	26.59 a	25.25 ab
	Masangping	32.01 b	46.14 ab	57.51 a	44.63 ab	46.39 ab
Exchangeable K	Tanguanyao	2.67 b	4.01 a	3.91 a	3.60 a	2.84 a
	Masangping	6.97 b	16.85 a	15.02 a	13.08 a	13.81 a
Exchangeable Na (ns)	Tanguanyao	1.68	1.75	1.46	1.84	1.52
	Masangping	1.88	1.64	1.92	3.08	2.71

Note: Figures in the same row followed by the same letter(s) are not significantly different at *p* ? 0.05 by the Duncan Multiple Range Test.

Crop yields under different treatments

Except for T5, the overall average crop yields in hedgerow intercropping plots between 1996 and 2000 increased by 10-23% compared to controls at Tanguanyao, and by 23-70% at Masangping (Table 7).

The criterion most widely used to assess the desirability of contour hedgerows is the effect of this practice on crop yield. The crop yields under T5 declined by 25-32% compared to controls at the two sites; this was due to shading by the trees interplanted in the alleys. But the income from mulberry was much more than the loss of 25-32% of crop yield.

In 2000, the peanut yield increased by 27% in T3 in Tanguanyao, and the maize yield by 54% in T3 at Masangping. At Tanguanyao, the peanut yield in hedgerow plots without fertiliser (T2) decreased by 11%, while at Masangping crop yields in hedgerow plots without fertiliser increased by 43%. This might imply that P from prunings could not meet the

Table 7: Crop yields under different treatments (kg/ha)						
Sites	Year	Control	T2	T3	T4	T5
Tanguanyao	1996(peanut)	2846	3144	3287	3474	2922
	1997(peanut)	1926	2236	2733	2086	1276
	1998(maize)	5030	5573	7463	7445	4808
	1999(peanut)	3280	3900	3830	3920	2040
	2000(peanut)	1850	1640	2360	1510	450
	Average*	2476	2730	3053	2748	1672
Masangping	1996(maize)	1390	1503	2097	1623	1733
	1997(maize)	1210	1550	1930	1570	806
	1998(peanut)	872	1055	1089	973	853
	1999(maize)	2780	2930	4510	3080	2470
	2000(maize)	3110	4470	5910	4310	1330
	Average**	2123	2613	3612	2646	1585

*,**: Crop yields in 1998 not included because of different crops

peanut's requirement, but N from prunings could meet the N requirement of maize. As for T4, the decrease in peanut yield at Tanguanyao and increase in maize yield at Masangping could partly be attributed to *Tephrosia* growing better at Masangping than at Tanguanyao. On average, the crops intercropped with and shaded by mulberry trees yielded 48% less peanut and 34% less maize than the controls in two sites. However, the cost of yield loss can be compensated from sericulture.

Discussion

Both above ground parts (such as prunings and leaf litter) and underground parts (such as fine roots turnover and root residues) have impacts on OM and nutrients in alley soil. In the *Leucaena* hedgerow system, 8-14 t/ha of prunings were applied as mulch or green manure into the alley annually, which equals to 3.2-5.6 t/ha of dry matter, containing 133-234 t/ha of nitrogen, 93-163 kg/ha of potassium, 9-16 kg/ha of phosphorous input into its companion alleys. From this perspective, soil organic matter, total nitrogen, and available K are sustainable under hedgerow systems. OM and TN rose fast during the first several years and then improved slowly or fluctuated partly due to the decomposition and addition rates reaching a balance, which may lead to maintaining soil OM and TN at a certain level.

However, soil P is controversial. On the one hand, acidic soil has a high P-fixing capacity, and although legume prunings have a high content of nitrogen and potassium, their phosphorous content is rather lower. In this study, available P was improved by the hedgerow systems, which may be due to the slightly acidic or neutral soil in the study areas having a lower P-fixing capacity. The high rate of OM addition through prunings helps to improve available P.

The results indicate that though hedgerow systems could maintain production of annual crops, the nitrogen and phosphorous supplied by prunings cannot meet the requirements for maximum yields. Middle-level fertilisation is necessary to further improve crop yields.

Future Implications

Contour hedgerows of N_2-fixing plants could keep sloping croplands from deteriorating and efficiently maintain or improve soil nutrients such as organic matter, total nitrogen, and available K. Production of food crops is also improved compared to conventional cultivation. In the long run, the system helps to strengthen food security and environmental sustainability in mountain areas with high populations and diminishing arable land.

As to extension and application of the system to promote sustainable development and food security in mountain regions of China, it is necessary to strengthen demonstration and research work that considers local conditions and resources, and to supply more options to local farmers. Such efforts will require studies of farmers and different models in different regions to meet their needs.

The relationships between the dynamics of soil nutrient pools and hedgerow above and below ground biomass should be quantified in the mid- and long-term. Woody hedgerow species differ from herbaceous manure in the rate and time of addition of organic materials to soil. Hedgerows provide far more lignified materials than herbaceous manure crops, which affects the mineralisation rate of organic carbon and nutrients in organic matter. Hedgerow roots influence soil (especially deeper soil layers), OM, and nutrients all year round. For example, the underground parts of hedgerows are estimated to provide nitrogen at a rate of 25-102 kg/ha per crop season (Saninga et al. 1995). However, their biomass and function are far from clear. More systematic research on underground parts will help to elucidate the functions of hedgerows in the system.

References

Chinese Soil Taxonomy Research Group (1995) *Chinese Soil Taxonomy* (Revised proposal). Beijing: Chinese Agriculture Publisher

Jones, J.B. (1973) 'Soil testing in the United States.' In *Comm. Soil Sci. and Plant Annual*, 4: 307-322

Kang, B.T.; Reynold, L.; Atta-Krah, A.N. (1990) 'Alley Farming.' In *Advances in Agronomy.* 43: 315-359

Nair, P.K.R. (1993) *An Introduction to Agroforestry*. Dortrecht (Netherlands): Kluwer Academic Publishers

Olsen, S.R. (1954) *Estimation of Available P in Soil by Extraction with Sodium Bicarbonate.* USDA Circ. 939. Washington DC: USDA

Saninga, N,; Vanlauwe, B.; Danso, S.K.A. (1995) 'Management of Biological N_2 Fixation in Alley Cropping Systems: Estimation to N Balance.' In *Plant and Soil*, 174: 119-141

Sloping Agricultural Land Technology for Hillside Farms in the Chittagong Hill Tracts, Bangladesh

S.K. Khisa
Chittagong Hill Tracts' Development Board (CHTDB), Khagrachari, Bangladesh

Introduction

The Chittagong Hill Tracts (CHT) region, situated in the south-east of Bangladesh, consists of three hill districts: Khagrachari, Rangamati, and Bandarban. Its total land area is about 13,191 sq.km (1.32 million ha), 90% of which are sloping lands, about 6% valley bottom lands, and the remaining 4% covered by villages, rivers, and townships (Khisa 2000). Soils of the region are brown to dark brown, well-drained, loamy sands to silty clay in texture low in base cations, and with acidity values from pH 5.0 to 6.0 (Brammer 1986).

'Jhum', or shifting cultivation, is the dominant farming system in the region. The cultivation cycle has now been reduced to 2-3 years [from 9 to 15 years, ed] and is considered unsustainable; a 'jumia' farmer can now barely obtain 3-4 months of food sufficiency from jhum as a result of the land degradation caused by loss of topsoil, reduced soil fertility, and development of aluminium, manganese, and iron toxicities (Arya 1999). Recognising the value of conserving soil resources for economic growth and poverty reduction the Chittagone Hill Tracks Development Board (CHTDB) with the cooperation and support of ICIMOD, has introduced sloping agricultural land technology (SALT) and other appropriate technologies in the CHT under a collaborative network involving five countries (Bangladesh, the People's Republic of China, India, Nepal, and Pakistan) called Appropriate Technologies for Soil Conserving Farming Systems (ATSCFS). This paper presents the experiences of tests, demonstrations, and extension of SALT and other appropriate technologies under the ATSCFS programme in CHT, Bangladesh.

Materials and Methods

On-farm tests and demonstration of contour hedgerows were carried out at Alutila in Khagrachari District following methodological guidelines outlined in Partap and Watson (1994). Nineteen nitrogen fixing trees/shrubs (NFT/S) and three grass species were tested to select suitable hedgerow species, seven showed good potential. They were cut at regular intervals to assess their performance in terms of growth, tolerance to pruning intensities, and biomass production. Fifteen erosion plots consisting of five treatments and three replications were established to assess the effects of hedgerows on controlling soil loss, runoff, and improving soil fertility (T1: farmers' practice without hedgerows but with fertiliser; T2: farmers' practice with *Leucaena* hedge, but without fertiliser; T3: farmers' practice with *Flemingia* hedge, T4: farmers' practice with *Indigofera* hedge; T5: perennial cash crops with *Indigofera* hedge). Changes in the physical properties of soil in plots with hedgerows and without hedgerows were also studied following simple testing methodologies (MBRLC no date). Extension activities through training and provision of

Table 1: Characteristics of recommended hedgerow species

Species	Seed source	Propagation material and its availability	Seed germination	Growth in the field	N- fixation	Pruning tolerance	Coppicing ability	Biomass production	Drought/ fire tolerance	Uses
Flemingia congesta	Philippines	Seed (available)	Good	Fast	Yes	Yes	Good	High	Yes	GM, EC, AF
Indigofera tysmanii	Local	Seed (available)	Good	Fast	Yes	Yes	Good	High	Yes	E.C., GM, FW.
Desmodium rensonii	Philippines	Seed (available)	Good (hot water treatment)	Fast	Yes	Yes	Medium	High	Yes	EC, GM, AF.
Gliricidia sepium	Local	Seed (available)	Seed (hot water treatment)	Fast	Yes	Yes	Good	High	Yes	GM, EC, FW
Leucaena diversifolia	Phillippines	Seed (available)	Good	Slow	Yes	Yes	Good	Medium	Yes	EC, GM, AF, FW
Vetiveria zizanioides	Local	Rhizome (available)	n/a	Fast	No	Yes	No	Medium	Yes	EC, GM, AF
Thysanolaena maxima	Local	Rhizome (available)	n/a	Fast	No	Yes	No	High	Yes	EC, GM, AF, FW, CC.

GM = green manure, EC = erosion control, AF= fodder, FW = firewood, CC = cash crop seeds/seedlings were carried out in cooperation with local government and non-government organisations (NGOs).

Results and Discussion

Screening and identification of suitable hedgerow species

Of the 22 hedgerow species tested, 5 NFT/S species (*Leucaena* spp, *Flemingia* spp, *Indigofera tysmanii*, *Gliricidia sepium*, and *Desmodium rensonii)* and two grass species (*Vetiviera ziznoides* and *Thysanolaena maxima)* were proven to be suitable hedgerow species. The characteristics of the recommended hedgerow species are shown in Table 1. The contour hedgerows were effective in controlling runoff and soil erosion (Table 2) and also improved the soil's physical properties (Table 3). The control plots had higher runoff and soil loss than plots with hedgerows.

On-farm Demonstration of SALT and Other Appropriate Technologies

Four SALT models (I,II,III, & IV) modified and adjusted according to the topography of the site were initially developed and later converted into mainly SALT-III (forest crops, fruit trees, and some portion with annual crops) and SALT-IV (fruit trees and cash crops like ginger, turmeric, and aroids). Other appropriate technologies include the use of leguminous cover crops (LCCs), bio-engineering control of landslides by broom grass hedge and planting of bamboo cuttings, gully control by check-dams and vegetation, and rainwater harvesting with cross-dams. Landslides have been effectively controlled by hedgerows of *Thysanolaena maxima* (Khisa et al. 1999) and by planting bamboo cuttings of *Bambusa vulgaris.* Gully erosion is controlled by check-dams with bamboo walls and planting of *Erythrina indica*, *Lannea* spp, and napier grass. Bio-fencing with *Durantha glumerella* and *Lantana camera* has been found very useful and successfully demonstrated. Composting with cut weeds and grasses and the use of composts has been demonstrated. Use of LCCs for the enrichment of soil with biomass of cover crops with *Mimosa invisa*, *Mucuna pruriens*, and *Calopogonium mucunoides* is being studied. Stall feeding of livestock, introduction of urea molasses block (UMB), and bee-keeping were not successful for various reasons.

Table 2: Soil displacement and deposition (cm) recorded by erosion pin method

Reading level[1]	Treatments				
	T1[2]	T2	T3	T4	T5
Above hedgerows (30 cm)	-1.81	3.54	5.85	4.31	5.50
Below hedgerows (30 cm)	-1.91	-1.95	-2.73	-1.25	-2.79

[1]Mean readings of 15 hedge lines, 3 replications of each treatment
[2]Recorded at the same level as for hedgerows

Table 3: Physical properties of soil in SALT vs non-SALT plots (1999)

Test	SALT	Non-SALT	Ratio
Ground cover (%)	75.0	25	3:1
Earthwork castings (gm)	441.0	150	3:1
Percolation rate (m/sec)	2.4	3.5	1:1.6
Infiltration (m/sec)	0.7	3.4	1:5
Surface runoff (m)	3.5	7.6	1:2

On-farm Test

The results show that contour hedgerows can be very effective in reducing runoff and soil erosion. Three years after establishment of contour hedgerows on steep slopes (40-55%) at the test site, soil loss was reduced by 60 - 80% and runoff by 50-65%.

The chemical properties of soil in 2001 compared with baseline data from 1995 did not change significantly except for a decline in soil organic matter (SOM). Decline in SOM may be due to insufficient biomass being incorporated in the alleys; insufficient biomass produced by the hedgerows, particularly by *Leucaena* spp; and/or the planting of rice or corn in the alleys of test plots in the rain-fed conditions without any rotation with leguminous crops.

These results suggest that crop rotation of cereals with leguminous crops and promoting leguminous cover crops in the alleys to supplement the pruning material from hedgerows needs to be considered for soil nutrient enrichment.

Extension and Awareness Activities

The impact of extension activities is significant in raising the awareness of soil-conserving farming practices like establishment of contour hedgerows. At the time of writing, 688 people including upland farmers, local leaders, extension staff of agricultural departments, and selected NGO leaders have been trained on SALT. One thousand upland farmers settled under the Upland Settlement Project (2nd phase) have been motivated to adopt contour hedgerows in their agroforestry plots, but with limited success. Farmers' adoption rate is about 50%, mainly because of difficulties in establishing and managing the hedgerows. The Soil and Watershed Management Centre at Bandarban and the Bangladesh Forest Research Institute, Chittagong are now carrying out studies both on-station and on-farm at Bandarban regarding the suitability of different hedgerow species and their impacts on reducing runoff and soil loss as well as improving the productivity of sloping lands. The Hill Agricultural Research Station at Khagrachari of the Bangladesh Agricultural Research Institute has been demonstrating agroforestry models using pineapple as hedgerows.

SALT has been included in the curriculum of B.Sc (Hons.) in Forestry courses at the Chittagong University, Chittagong. The significance of SALT has been widely recognised by participants in a number of local workshops and public consultative meetings arranged by such agencies as the Sustainable Environment Management Programme of UNDP. The National Environment Management Action Plan (Danish International Development Agency) stressed the importance of contour hedgerows. Vernacular literature and video films on SALT have been developed and disseminated to local farmers.

Conclusions

The ATSCFS programme in CHT served as a catalyst for increasing awareness of SALT and other appropriate technologies. It has identified agro-climatically suitable hedgerow species and obtained preliminary but useful results showing that contour hedgerows can effectively reduce runoff and soil erosion. It has raised the interest of local farmers in the use of contour hedgerows, over 50% of trained farmers have established such hedgerows and increased the capacity of government and non-government organisations to establish hedgerows. Other appropriate technologies like water harvesting by cross-dams, on-farm composting, use of leguminous cover crops (LCCs) to increase soil organic matter (SOM), and landslide control with broom grass hedge have been identified as effective and relevant tools for hillside farming along with SALT.

However, wide adoption of these technologies by the upland farmers in CHT depends on providing them with land ownership, without which they will not be interested in investing in the husbandry of their lands. Consistent support and extension services by government and non-government organisations, making suitable hedgerow seeds/seedlings available, and more demonstrations of site-specific on-farm SALT models in different parts of CHT are needed. Incorporation of leguminous beans or pulses as relay/rotation/intercropping, or growing of LCCs for nutrient enrichment or increasing SOM in the soil, needs to be studied further and demonstrated for improving the fertility and productivity of hillside farms in CHT.

References

Asian Development Bank (2001) *Chittagong Hill Tracts Region Development Plan,* ADB TA# 3328-BAN, Executive Summary, Draft Final Report for ADB, March, 2001. Manila:ADB

Arya, L. M. (1999) *Agricultural Research and Development in the Chittagong Hill Tracts: Ecological Perspectives, On-site Assessments, Analysis, and Recommendations.* Joydepbur: Bangladesh Agricultural Research Institute, Agricultural Research Management Project

Brammer, H. (1986) *Reconnaissance Soil and Land Use Survey: Chittagong Hill Tracts (1964-65).* Dhaka: Soil Resources Development Institute

Khisa, S.K.; Alam, M.K.; Siddiqi, N.A. (1999) 'Broom Grass (*Thysanolaena maxima*) Hedge: A Bioengineering Device for Erosion Control and Slope Stabilization'. In *Proceedings of the First Asia-Pacific Conference on Ground and Water Bioengineering for Erosion Control and Slope Stabilization, April 19-21, 1999,* pp 172-177. Manila: International Erosion Control Association

Khisa, S.K. (2000) *Options for Improving the Productivity of Sloping Agricultural Lands in Chittagong Hill Tracts, Bangladesh: Experiences of Project on Appropriate Technologies for Soil Conserving Farming Systems.* Paper presented at the regional workshop on ATSCFS held, Chengdu, China in 2000

MIBRLC (no date) *Sloping Agricultural Land Technology (SALT) Test Results,* Bansalan (Philippines): Mindanao Baptist Rural Life Center/ARLDF

Palmer, J. (1996) *Sloping Agricultural Land Technologies (SALT) Nitrogen Fixing Agroforestry for Sustainable Soil and Water Conservation.* Bansalan (Philippines): Mindanao Baptist Rural Life Center (MBRLC)

Partap, T.; Watson, H. R. (1994) *Sloping Agricultural Land Technology (SALT): A Regenerative Option for Sustainable Mountain Farming,* ICIMOD Occasional Paper No, 23. Kathmandu: ICIMOD

The Role of Agricultural Mechanisation in Achieving Food and Nutritional Security and Generating Employment

R.K.P. Singh, K.K. Satapathy, and N.D. Verma
ICAR Research Complex for NEH Region, Meghalaya, India

Introduction

In the context of tremendous technological developments and population explosion, the world experiences a cruel paradox that while in some regions there is affluence and excess production of food, the greater part is subject to widespread poverty and subsistence feeding, malnutrition, unemployment, and lack of purchasing power. Many states of India are subject to these conditions despite the availability of abundant natural resources like land and water, favourable climate, and traditionally good vegetation.

During the last four decades, agricultural production in India has increased almost four-fold, and it now exceeds 200 million tonnes each year. However, there is need for another significant breakthrough in farm technologies in some agriculturally backward states like Bihar, Orissa, Assam, and other north-eastern states, so that even farmers having small landholdings can achieve food and nutritional security. This can be done through adoption of improved technologies and mechanisation in agriculture and allied sectors.

Mechanisation and Agricultural Productivity

India has adopted a selective mechanisation policy. Mechanisation primarily took place where traditional practices failed to achieve timeliness of operation. Equipment and machinery for seedbed preparation, sowing, irrigation, plant protection, and threshing have become more popular as compared to other operations. The number of tractors, power tillers, diesel engines, sprayers, electric motors, threshers, and so on has increased substantially during the last three decades, and correspondingly the availability of farm power per unit area has also increased. Similarly, during this period the demand for agricultural machinery has increased substantially to a level of Rs.300 billion annually (Rs.200 billion for power units and crop production equipment and Rs.100 billion for post-harvest equipment). The entire demand is met through indigenous production.

As global competitiveness and labour wages are steadily rising, it is imperative to bring appropriate mechanisation together with skilled operators to achieve high productivity. Farm power availability is a major constraint to agricultural productivity and needs to be increased from the current level of 1.15 kW/ha to 2.00 kW/ha. The increase can only come from electro-mechanical power sources. Table 1 shows that the share of animate power sources on Indian farms is reducing gradually and in 1997 accounted for 23% of all power used as against 97% in 1951. There has been a concomitant increase in the share of mechanical and electrical power sources. The availability of farm power and machinery has greatly helped to increase food production. Agricultural mechanisation in Punjab, Haryana, western Uttar Pradesh, and some parts of Tamil Nadu, Andhra Pradesh, Gujrat, and Madhya Pradesh has grown faster than elsewhere. Therefore, productivity levels in those areas are also higher than the national average. This higher productivity is due to an increased area under irrigation, use of high doses of fertiliser, high yielding variety seeds, and higher availability of farm power. In developed countries like the USA, UK, and Japan, the farm power availability per hectare is three to five times that of India. Within India, farm power availability in Punjab is about 3.25 kW/ha as against the national average of 1.15 kW/ha.

Table 1: Power availability on Indian farms by source

Year	Total power (hp)	Animate (%)	Mechanical (%)	Electrical (%)
1951	0.25	97.4	2.1	0.5
1961	0.31	94.9	3.7	1.4
1971	0.36	79.2	16.3	4.5
1981	0.63	48.2	32.3	19.5
1991	0.92	34.5	34.7	30.8
1997	1.15	22.7	43.5 (27.3)*	33.8

* Figure in parentheses is mobile power
Source: Alam (2000)

The increase in availability of mechanical and electrical power at Indian farms has helped to reduce the cost of operation. Table 2 shows that the cost of mechanical and electrical power sources per unit time is much less than that of animate power sources.

Table 2: Economics of different power sources for agriculture

Source of power	Average power (hp)	Initial cost (Rs/hp)[1]	Running cost (Rs/hp.hr)[1]
Human	0.1	-	63.0
Bullock	0.5	6,000	19.0
Stationary oil engine	5.0	4,000	7.0
Electric motor	5	3,500	5.0
Power tiller	10	10,000	12.0

[1]In 2000, US$ 1 = IRs 45 approx.

Mechanisation in North-east India

Agriculture in the north-eastern hill region of India is still primitive. Most of the agricultural operations are labour intensive and performed manually. Farm tools are of traditional types (Table 3). Though existing tools are well suited to the current types of operation, they give low output and very high drudgery. Use of mechanical power is very limited. Therefore, introduction of improved technology in the existing farming system demands selective use of mechanisation.

Table 3: Commonly used farm implements in the North-eastern states of India

Name of implement	Power source	Purpose
Dao	human	Used for cutting forest, trees etc
Dibbler	human	For dibbling seed under zero tillage conditions
Spade	human	Digging of soil, preparation of seed bed, weeding bunds, etc.
Local plough	bullock	Ploughing and puddling
Leveller	bullock	Levelling of ploughed land
Peg tooth harrow	bullock/human	Puddling in wetland conditions
Knives/sickle	human	Harvesting of crops
Bamboo basket	human	Storage and transportation of food grain
Counterpoise foot pounder	human	Milling of paddy

Agriculture in hill regions demands machines that are small in size, light in weight, and have the capacity to perform the maximum number of operations. Machines should be able to operate on narrow terraces and in deep valley lands. The lightweight power tiller can be a very useful machine for hill areas because it can be used for ploughing, puddling, weeding, harvesting, and threshing operations with the help of suitable attachments and accessories. Manually driven machines like the wheel hoe, multipurpose weeders, seed drills, and pedal paddy threshers are well adapted to hill areas.

Post-harvest Technology for Nutritional Security and Employment Generation

At present, India produces about 425 million tonnes of food each year; this figure will double in a decade or so. However, foodstuffs are perishable and semi-perishable. In the absence of proper post-harvest technology and infrastructure, their perishability gets exploited by demand and supply factors, and market forces, thus depriving the growers of remunerative prices and possible additional income and employment generation through value added processing.

It is estimated that about 10% of food grain, 25-30% of horticultural produce, and 10-5% of animal based products are lost due to the lack of appropriate post-harvest technology for handling, transport, storage, and so on. This loss is estimated at approximately Rs.700 billion annually. In addition, farmers have to sell raw products without adding value to the products. At least half of this loss could be prevented by using appropriate post-harvest technology and associated equipment. Thus, there is a great need for promoting appropriate post-harvest technology to reduce losses, add value to the products, and generate income and employment in the rural sector.

Conclusion

In the future, agricultural implements and machinery will play a great role in increasing productivity, reducing the unit cost of production, minimising harvest and post-harvest losses, and adding further value to agro-processing industries. Improvement in agricultural mechanisation in the north-eastern region of India will make agriculture and rural life more rewarding, less arduous, and attractive enough to retain rural educated people.

Bibliography

Alam, A. (2000) 'Rising Energy Intensity.' In *The Hindu Survey of Indian Agriculture*, 2000: 181-191

Opportunities and Options for Income Generation and Transition in Mountain Agricultural Systems

Pigeonpea : A Potential Multi-purpose Crop for the Mountains of Southern China

K.B.Saxena[1], Zong Xuxiao[2], Yang Shiying[3], Li Zhenghong[4], and Zhou Chaohong[4]
[1]International Crops Research Institute for the Semi-Arid Tropics, Patancheru (AP), India
[2]Institute of Crop Germplasm Resources, Chinese Academy of Agricultural Sciences, Beijing, China
[3]Institute of Crop Germplasm Resources, Guangxi Academy of Agricultural Sciences, Nanning, China
[4]Research Institute of Resource Insects, Chinese Academy of Forestry, Kunming, China

Introduction

About 90% of the land in southern China is covered with mountains and most of it is arid. The agriculture in such areas, characterised by low and unstable yields, depends primarily on short and erratic rainfall. Efforts are being made to identify a plant species that is capable of conserving soil nutrients and water, and that could grow well in the harsh environment to provide food and fuel to human beings, and fodder and feed to animals. This search has resulted in the selection of a food legume crop, popularly known as pigeonpea (*Cajanus cajan* (L.) Millsp). Pigeonpea was introduced to China about 1500 years ago from India, but its cultivation was abandoned due to poor adaptation and unacceptable seed quality traits. To overcome these constraints, new germplasm was introduced from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT).

Besides highlighting the characteristic traits of pigeonpea, this paper discusses its role in the development of mountain regions where people lack adequate nutrition.

The Pigeonpea Plant

Pigeonpea is a short-lived, perennial legume, often cultivated by smallholder dry land farmers as an annual crop. Pigeonpea is primarily consumed as dry split peas ('dhal'), and its immature seeds are cooked as a vegetable that can also be processed for canning and freezing. The drought tolerance, perenniality, and fast ratooning traits make pigeonpea an ideal plant for providing food, fodder, and fuel. Pigeonpea is outstanding in the depth and lateral spread of its root system, which enable it to tolerate drought. Its deep root system not only breaks the plough pans but also helps in recycling nutrients. Pigeonpea can adapt to a wide range of soil types from gravelly stones to heavy clay loams of close texture and high moisture content. Farmers often grow pigeonpea on poor soils where they have problems growing other food crops.

Soil Amelioration and Conservation

Pigeonpea provides several benefits to the soil. Being a legume, it fixes nitrogen. The leaf fall at maturity not only adds to the organic matter in the soil, but also provides approximately 40 kg N ha^{-1} (Kumar Rao et al. 1981). Pigeonpea seems to have special mechanisms to extract phosphorus from the soil to meet its needs. The recovery of ecology in hill areas is not easy due to prevailing climatic and soil conditions, high population pressure, and the difficulties in finding a fast-growing forest tree species. These problems have bothered the forestry department for many years. Some shrub species such as *Phyllanthus emblica* (Linn), *Dodonaea viscosa* (L.), and *Tephrosia candida* (DC.) now used for afforestation grow slowly and have little or no economic value. In contrast, pigeonpea not only performs well in these degraded soils but also grows faster to cover the bare land. The crop is easily adopted by farmers due to its multiple uses. Therefore, pigeonpea holds great promise for afforestation in China. At present, there are more than 700 ha of forest land planted with pigeonpea for soil conservation in Yunnan province alone. It has also been selected as an afforestation species in major government reconstruction projects such as 'Protection of Forest in the Upper-middle Reaches of Yangtze River', 'Protection of Forest in Lancang Jiang River', and 'Protection of Natural Forest'.

Fodder and Feed

In Guangxi province, the rural economy relies heavily on animal husbandry. Availability of quality fodder and feed throughout the year is essential. At present the provincial government is spending considerable resources to import maize and rice from other provinces and international markets to feed the livestock. On the other hand, large mountain areas lie fallow because they are unfit for growing crops. At present, the animal population in the province is about 8 million, and to increase it further the government has decided to reduce emphasis on feeding animals grain and to increase the population of fodder-eating animals such as goats, cattle, and buffalo. To achieve this, they have launched a special 'Million Goat Project' in Hechi Prefecture in which the population of goats will be increased to one million within a target period of three years. To meet the anticipated needs for fresh quality fodder, pigeonpea has been identified as it grows well in the area and provides good quality of fodder under dry conditions. Its ability to allow 3-5 fodder cuttings makes it a very useful crop for stall feeding also. An evaluation of new pigeonpea varieties in Langan County showed that ICPL 93047 produced 54 tonnes per ha of fresh and 29 tonnes per ha of dry fodder in a year in five cuttings (Shiying et al. 1999). This experiment also showed that pigeonpea can grow well during winter when the normal fodder supply is adversely affected. Goats and cattle prefer dry pigeonpea forage to green matter. It is estimated that in Guangxi province alone about 6.5 million ha of waste mountain slopes are available for exploitation by crops like pigeonpea.

As a feed, pigeonpea grain is primarily fed to pigs, chicken, cattle, and goats. Boiled seeds are used to prepare feed mixtures with other ingredients for pigs, while raw seeds are fed to chickens. Fuji et al. (1995) reported that pigs fed a meal mixed with 6%-12% pigeonpea gained 78 g per day of meat, with a ratio of meat mass to feed input of 3.5:1.

Other Uses of Pigeonpea

Firewood

Pigeonpea produces a large amount of biomass and after harvesting seeds for feed, the plants are cut and used for fuel. On average, one hectare of pigeonpea produces about 6-10 tonnes of fuelwood. According to Yude et al. (1993), the quality of pigeonpea fuel wood is excellent; 1 kg of wood yields 4350 kCal of energy.

Forestry products

Pigeonpea plants are preferred for inoculating of lac insects (*Kerria lacca* Kerr.) because they grow faster and allow harvesting of lac resin a year ahead of other hosts. Jianyun and Yun (1998) conducted studies on the processing technology of plywood bond using pigeonpea glue. The results showed that the bond strength of the plywood ranged from 1.28-1.92 M Pa and that it was higher than that of soybean glue.

Adaptation of New Introductions

The new pigeonpea introductions from ICRISAT had good adaptability in different agro-ecological zones of Yunnan and Guangxi provinces. Besides high seed yield (2-3 t ha^{-1}), these lines matured early (<150 days), had resistance to major diseases, and produced good quality seeds. Some lines grew faster and produced the higher biomass essential for fodder and fuel production. The trials also showed that pigeonpea is ideally suited for soil conservation in unproductive degraded rainfed lands, and that the plants covered the ground within 6-8 months.

The major constraint in this endeavour is the identification of suitable varieties for different agro-ecological zones. In some areas, freezing temperatures injure the plants. In a recently concluded study in Yunnan Province, pigeonpea grew successfully in environments with minimum temperatures falling as low as -1 °C. Some genotypes also tolerated temperatures down to -4 °C, but only for a limited period. At present, screening of germplasm is targeted to identification of freezing-tolerant cultivars. The high level of adaptation of the new pigeonpea germplasm in degraded and fragile soils, its utility in environmental conservation, and its quality fodder have generated interest among farmers, scientists, extension workers, and policymakers in China. The area under pigeonpea has risen from zero in 1998 to 2000 ha in 2000. In 2001, pigeonpea is expected to be grown on 10,000 ha, and the government plans to extend pigeonpea cultivation to 250,000 ha by 2005. Serious efforts are being made jointly by ICRISAT and local governments to overcome the major production constraints and to promote pigeonpea for the development of hill areas of southern China.

References

Fuji, L.; Zenghong, L.; Jie, Y.; Kunxian, C. (1995) 'Study on Feeding Pigeonpea Seed to Pigs.' In *Fodder Industry*, 16 (7): 29-31

Jianyun, Z.; Yun, W. (1998). 'A Preliminary Study on Producing Plywood Bonded with MD-1 Pigeonpea Glue.' In *China Forest Industry*, 6: 7-8

Kumar Rao, J.V.D.K.; Dart, P.J.; Matsumoto, T.; Day, J.M. (1981). 'Nitrogen Fixation by Pigeonpea.' In *Proceedings of the International Workshop on Pigeonpeas (Vol. 1)*, pp 190-199. Patancheru: ICRISAT

Shiying, Y.; Yuxi, L.; Chenbin, C.; Shichun, L.; Hunchao, L. (1999) 'Observations on Introduced Pigeonpea.' *Guangxi Agricultural Science*, 6: 309-310

Yude, C.; Kaiwei, H.; Fuji, L.; Yuanjie. (1993) 'The Potential and Utilisation Prospects of Three Kinds of Wood Fodder Resources in Yunnan.' In *Forestry Research*, 6 (3): 343-350

Domesticated Non-timber Forest Products as the Major Sources of Livelihood for Hill Tribes in Marginal Mountain Farms of Nepal

V.H. Pandit[1], G.B. Thapa[2] and R.P. Neupane[2]
[1]Nepal Agroforestry Foundation, Kathmandu, Nepal
[2]Asian Institute of Technology (AIT), Pathumthani, Thailand

Introduction

Poverty in Nepal is widespread in the more remote areas of the hills and mountains. The poorest households in these areas have very small landholdings. There are also marginalised and very poor populations of ethnic minorities and certain occupational caste groups. Almost one-fourth of the household population in the study area were Chepang, indigenous hill tribes, who substitute their foods by gathering non timber forest products (NTFPs; Gurung 1995). In the middle hills of Nepal, nearly 55% of people have less than adequate food (CBS 1996).

NTFPs are one of the potential sources of income for marginal mountain farmers; they have many uses, can increase household income, and are suited to the mountain environment (Edwards 1996, Chandrasekharan 1998, Pandit 1999, Neupane 2000, Putz 2000). NTFPs can be grown under marginal conditions, and they are more suited to fragile hill ecologies than logging. Harvesting high-quality timber from natural forests is generally not as profitable as other more intensive and short-term forest uses, since substantial opportunity cost capital is locked up in trees and the land on which these trees are growing (Putz 2000). The present study attempts to generate much-needed information with particular reference to a small watershed, Galaudokhola in the middle mountains of Nepal. The study is based on the results of a field survey carried out in 2000.

Study Area

The study area can be divided into three elevational or ecological zones: the lower (418 - 800 m), middle (800 - 1239 m), and upper Galaudokhola (1239 - 1900 m) according to contrasting biophysical and socioeconomic characteristics. There are 1,820 households with an average of 6.5 members per household (Table 1).

Table 1: Sample size and household size by elevation zone

Elevational zone	Villages	Total households	Sample size	Average household size	
				Male	Female
Lower (418-800m)	Sisapani, Keurini and Bhadaure	517	73	3.56	3.01
Middle (800-1239m)	Basnetgaon, Gangrang and Subdandagaon	739	62	3.65	2.89
Upper (1239-1800 m)	Tarke and Chilaunekharka	564	41	3.32	3.20
Total		1820	176	3.51	3.03

Source: Field Survey, 2000

Livelihood Security of Marginal Mountain Farmers

There are six ethnic groups (Tamang, Chepang, Brahmin, Newar, Magar, and occupational castes) in the area. The Tamang and Chepang are concentrated in the upper zone, and the remainder in the middle and lower zones (Table 2). For generations the Chepangs had a semi-nomadic way of life. They lived in caves and practiced shifting cultivation together with hunting and gathering. With a gradually increasing population and a declining forest area, these people have adopted permanent cultivation (Gurung 1995). Their landholdings are very small, located mainly on steep slopes with poor quality soils, and are utilised for rainfed crops like maize and millet. Most of the better lands, like paddy, at lower elevations have been occupied by other ethnic groups belonging to the upper class who have been practicing permanent field crop cultivation for many generations.

Table 2: Distribution of households and land holdings by ethnicity

Ethnic group	Number of households			Average landholdings (ha/household)			
	Lower Zone	Middle zone	Upper zone	Irrigated lands	Rainfed uplands	Marginal lands	Total
Tamang	1	2	12	0.31	0.62	0.26	1.19
Brahmin	33	30	4	0.45	0.42	0.14	1.01
Magar	5	19	0	0.38	0.51	0.21	1.10
Newar	12	5	0	0.43	0.69	0.28	1.41
Chepang	1	6	25	0.20	0.31	0.17	0.68
Occupational castes	21	0	0	0.11	0.36	0.09	0.56

Source: Field survey, 2000

Contribution of Domesticated NTFPs to the Household Economy

Adopted as a strategy for securing a livelihood from very small landholdings, growing assorted species of NTFPs on marginal lands has contributed considerably to the local economy. Table 3 shows the average annual household incomes from the sale of different products.

Table 3: Sources of income by elevation zone

Zone	Average annual income (US$) from different sources per household					
	NTFPs**	Off-farm*	Livestock Products*	Crops*	Spices**	Total
Lower (418-800 m)	63 (14)	152 (34)	74 (16)	136 (30)	29 (6)	454
Middle (800-1239 m)	68 (27)	49 (19)	44 (17)	54(21)	39 (15)	254
Upper (1239-1800 m)	112 (50)	48 (22)	18 (8)	25 (11)	21 (9)	224
Average/household	76 (23)	91 (28)	50 (15)	81 (24)	31 (9)	329

Source: Field survey 2000

Note: numbers in parentheses indicate the percentage contribution from each source

*F-test significantly different at the 0.05 level

**F-test significantly different at the 0.01 level

There is a clear tendency from lower to upper zones for the relative share of household income attributable to NTFPs to increase. In the upper zone, NTFPs account for about half of all household income, in the lowest zone, only 14%. Land in the higher elevations is not very suitable for growing crops so settlers grow more NTFPs. The annual average income from NTFPs by ethnic group is shown in Table 4. Brahmins and Newars live at the lower elevations and possess relatively better quality lands, some of which are used for as many as three crops annually. Living close to a highway, they also have access to non-farming employment opportunities as supplementary sources of household income. Therefore, Brahmins and Newars have paid little attention to domestication of NTFPs, as reflected in the 9% and 11% of annual household income, respectively, that they derive from NTFPs (Table 4).

Table 4: Annual average income by ethnic group

Ethnic group	Income (US$)/household					
	NTFPs**	Off-farm**	Farm crops**	Animal**	Spices **	Total
Tamang	119 (43)	20 (7)	85 (32)	15 (5)	36 (13)	275
Brahmin	47 (9)	92 (19)	214 (43)	63 (13)	80 (16)	496
Magar	117 (28)	51 (13)	177 (44)	41 (10)	20 (5)	406
Newar	100 (11)	315 (34)	340 (37)	124 (14)	37 (4)	916
Chepang	93 (44)	56(25)	42 (19)	15 (7)	12 (5)	218
Occupational Castes	49 (15)	59 (18)	154 (47)	40 (12)	29 (9)	331

Source: Field survey 2000
Note: numbers in parentheses indicate the percentage of household income from each source
** F-test significantly different at the 0.01 level.

Altogether, 10 variables ranging from household size to income from field crop cultivation were included in a correlation model (Table 5). One of the variables, ethnicity, was initially qualitative and converted into a quantitative value using the weighted value method following the prevailing social system, which has classified ethnic groups into upper and lower castes.

Table 5: Correlation of selected variables with income from NTFPs

Variable	Correlation coefficient
Household size	.286**
Number of women	.300**
Illiteracy	.248**
Ethnicity	-.257**
Paddy land	.078
Rainfed crop land	.144
Marginal land	.526**
Large livestock	.145
Small livestock	.232**
Income from crops	-.005

Source: Field survey 2000
** Correlation significant at the 0.01 level

Of all the variables included in the analysis, household size, number of women, illiteracy, ethnicity, size of marginal landholdings, and small livestock herd-size were significantly correlated with the earnings from NTFPs. All variables but ethnicity were positively related. Marginal landholding had the highest correlation coefficient, meaning that income from domesticated NTFPs increases with increasing size of marginal landholdings. Since this type of land is not suitable for field crop cultivation, farmers have made efforts to grow assorted species of NTFPs.

Conclusion

Farmers who have small landholdings tend to utilise their better quality lands to cultivate cereal crops and their marginal lands to grow NTFPs, which earn them some cash income. However, the intensity of NTFP domestication and amount of income derived depend on the household size in general, and the number of women present, in particular. NTFPs are important sources of cash income, particularly for very poor people with small landholdings. In the study area, ethnic groups like the Chepangs and Tamangs who live mainly at the higher elevations, have benefited significantly by selling NTFP species grown on their marginal lands that are not suitable for cultivation of cereal crops. In the middle and lower elevations, where most people belong to the higher castes, NTFPs have played a relatively small role in household economies due to the combined effect of lack of skill in processing NTFPs and the relatively higher amounts of cereal crop production on better quality lands located on gentle slopes.

References

Chandrasekharan, D (1998) *NTFP, Institutions, and Income Generation in Nepal, Lessons for Community Forestry.* ICIMOD Discussion Paper Series MNR 98/1. Kathmandu: ICIMOD

CBS (1996). *Nepal Living Standards Survey Report, Main Findings Volume 2.* Kathmandu: HMGN, National Planning Commission Secretariat

Edwards, D.M. (1996) 'The Trade in Non-Timber Forest Products from Nepal'. In *Mountain Research and Development,* 16(4): 383-394

Gurung, G.M. (1995) 'Chepang Culture and Economy: A Cross Road'. In Bhattarai T.R.; Pradhan S.; Ghimire G. (eds) *Chepang Resources and Development*, pp. 26-35. Kathmandu: SNV

Neupane, R.P. (2000) *Prospects of Agroforestry Promotion in Hills of Nepal.* PhD Dissertation. Thailand: Asian Institute of Technology, Rural Development, Gender and Resources Program

Pandit, B.H. (1999) 'Forest User Group Networking in Kabhre Palanchok and Sindhu Palanchok District'. In *Today National and International Magazine*

Putz, F.E. (2000) 'Commentary Economics of Home Forestry'. In *Ecological Economics,* 32: 9-14

Butterfly Farming: An Off-Farm Income Option for Mountain Farming Communities - Experience from Pakistan

M.A. Rafi, M. Irshad, and M.A. Matin
Integrated Pest Management Institute, NARC, Islamabad, Pakistan

Introduction

An integrated approach is needed for conserving, upgrading, and using the natural resources in mountains. Off-farm activities can be used to maintain specific mountain ecosystems. Butterfly farming in marginal mountain lands may be a potential option for income generation in the HKH.

Concept of Dynamic Butterfly Farming

Butterflies are of great aesthetic, ecological, historic, recreational, and scientific value. The international demand for tropical butterflies is great and each year millions of them are sold throughout the world. The butterfly trade market previously based on dead and papered specimens from tropical countries, has developed into a live market with the advent of improved international delivery services over the past two decades. Many buyers are scientists engaged in research on the ecology, ethnology, evolution, and conservation of butterflies. Other buyers include individuals who like expensive curios that incorporate butterflies (Collins and Morris 1985). Increasingly, butterflies are used to decorate less-expensive items such as purses, trays, and other common objects.

Over the last two decades, butterfly farming and live butterfly houses have become popular in many countries (Dean 1999; McNeely 1988).The Stratford Butterfly Farm in England imported more than 500,000 live butterfly pupae during 1998 and sales are increasing 10%-15% per year (TSBF 2001). The butterfly business is also flourishing in many other countries and regions.

Butterfly Farming

Butterfly farming is based on the utilisation of various species of plants that serve as food for butterfly larvae. A half-acre garden under fine nylon mesh can be planted with 500 food plants, including some flowering plants for adult diet. After a pair of butterflies is released inside it, the female will lay most of her eggs on the host plants within a few days. The larvae hatch and start feeding on the plants. The larvae will then pupate, and the pupae can be exported or kept for further captive breeding. Depending on the climate, a butterfly house can be a glasshouse or a simple mesh-covered cage inside which butterflies live wild. Apart from decorative spring waters, creeks, and fish ponds, the many flowers and larval host plants grown create the impression of a natural habitat with lots of colourful butterflies darting around from flower to flower.

Potential of Butterfly Farming in the HKH

Butterfly farming and butterfly houses are gaining popularity in many countries, and there are many opportunities for butterfly farming in the HKH, which is rich in butterfly fauna.

For example, studies on the butterfly fauna of Pakistan revealed 453 species (Rafi et al. 2000 and 2001a). Rearing techniques have already been developed for some butterflies (Rafi et al. 1999), but these need improvement. *Papilio demoleus* has been reared for 25 generations in cages, showing that these butterflies can be reared if certain prerequisites are provided (Rafi et al. 2001b).

Tourism

Butterfly houses are very good tourist attractions, especially if located in areas that already have large numbers of tourists. Most butterfly houses feature a restaurant, coffee shop, and a souvenir shop for extra customer service. In the souvenir shop, a great variety of the butterfly products already described can be sold. These parallel businesses often contribute the majority of income, while the butterfly house itself is merely an attraction with only small earnings from its low entrance fees.

Conservation of Nature

Butterfly farming is one of the most environmentally sound ways to utilise and preserve nature, and a number of butterfly farming projects have been supported at various locations worldwide. It is a conservation effort that has also been endorsed by the Lepidoptera Specialist Group of the International Union for Conservation of Nature and Natural Resources (IUCN). However, it has not yet become a significant factor in the mountains of Pakistan.

Socioeconomic Benefits

The product is a high value, low-volume crop that brings needed supplementary income to the people of rural areas. Butterfly farming is a business to which villagers quickly adapt. The farming of butterflies by rural communities will provide a potential alternative livelihood to many families, resulting in better purchasing power, in turn leading to increased spending or consumption, thus increasing production in other fields of the economy.

Compared with any other farming industry, butterfly farming requires less effort or land, and it involves minimal costs to the producer. Butterflies do not require the equipment or financing of a conventional farm; little capital is required except for purchasing a few square meters of fine nylon mesh for a breeding cage.

Women in rural Pakistan traditionally work in the house, a situation perfectly suited to rearing of butterflies. Butterflies can be nursed continuously in a protected environment, ensuring a high survival rate and a potentially higher earning to the farmers. The farming of butterflies does not demand any special educational skills, except a practical hand and a good deal of dedication. This means that even uneducated rural women will be able to participate and contribute to a new, unique export commodity.

Bibliography (not necessarily cited in the text)

Collins, N.M.; Morris, M.G. (1985) *Threatened Swallowtail Butterflies of the World,* the IUCN red data book. IUCN: Gland & Cambridge

Dean, M. (1999) 'Butterfly Excursions'. In *Flower & Garden Magazine*, November 1999
Dulude, J. (2000) 'Butterflies Aren't Free (Costa Rica is Largest Butterfly Exporter)'. In *Latin Trade*, 2000
Inskipp, T.; Wells, S. (1979) *International Trade in Wildlife*. London: Earthscan
McNeely, J.A. (1988) *Economics and Biological Diversity*. Gland: IUCN
Pyle, R.M. (1981) 'Butterflies: Now You See Them', *International Wildlife*, 11 (1): 4-11
Rafi, M.A.; Matin, M.A.; Khan, M.R. (1999) 'Number of Generations and Their Durations of Lemon Butterfly, *Papilio demoleus*, in Barani Ecology of Pakistan'. In *Pakistan Journal of Scientific Research*, 51 (3-4): 131- 136
Rafi, M.A.; Khan, M.R.; Irshad, M. (2000) Papilionid (Swallowtails) Butterflies of Pakistan. *Pakistan Agricultural Research Council / University of Azad Jammu and Kashmir.* Islamabad: Gul Awan Printer
Rafi, M.A.; Mishkatullaha, Khan, M.A. (2001a) *Butterfly Fauna of Pakistan*. Unpublished manuscript
Rafi, M. A., Matin, M. A. and Naqvi, N. H. (2001b). 'Survivorship Analysis of *Papilio demoleus* L. (Lepidoptera: Papilionidae) in Semi-natural Condition.' In *Helios (Collection of Lepidopterological articles), Moscow Sovetsky Sport,* Russia, 2: 117-122
TSBF (2001) The Stratford Butterfly Farm URL: http:// www.butterflyfarm.co.uk/
Unno, K. (1974) 'Taiwan's Butterfly Industry.' In *Wildlife*, 16: 356-359

Agroforestry Interventions for Improving Livelihoods of Subsistence Farm Households in the Hills of Nepal

R.P. Neupane and G.B. Thapa
School of Environment, Resources and Development, Asian Institute of Technology, Pathumthani, Thailand

Introduction

Farmers in the hills of Nepal practice subsistence agriculture in miniature, fragmented landholdings. Declining soil fertility has resulted in declining yields of major staple crops and has been a serious land management constraint for sustaining agricultural production in the hills (Schreier et al. 1995; Vaidya et al. 1995). Hill farmers have increasingly been confronted with a dwindling supply of forest fodder due to increasing livestock population, depleting forest resources, and restriction on free fodder collection and livestock grazing. This paper assesses the potential role of agroforestry in promoting sustainable livelihoods in marginal mountain farms under the agroforestry project initiated by the Nepal Agroforestry Foundation (NAF).

Materials and Methods

The study involved three hill Village Development Committee (VDC) areas: Kumpur, Salang, and Nalang in Dhading district. More than 90% of the farmers in the district practise subsistence agriculture, with cultivated landholdings averaging 0.6 ha (CBS 1996). Livestock production is a key component of the farming system, averaging 5.1 livestock units (LSU) per household. Information on agroforestry was collected from a sample of 223 farm households (82 'project' and 141 'non-project') selected randomly from the wards of these VDCs.

Besides the household survey, soil samples were collected from project and non-project areas in Kumpur and Nalang. A total of 18 soil samples (10 project and 8 non-project) were collected randomly from the 0-20 cm deep plough layer. Samples were drawn from 10-12 different spots within the selected plot, were thoroughly mixed to form a composite sample and then analysed for eight soil properties: pH; organic matter (OM); total nitrogen (N); available phosphorous (P); available potassium (K); and sand, silt, and clay textural classes.

Results and Discussion

Soil fertility

Bari (rainfed upland) soils from project areas had higher amounts of OM, N, silt, and clay than non-project soils, and khet (irrigated land) soils from project areas had higher amounts of OM, N, P, and K (Table 1). This indicates the positive contributions of agroforestry to soil fertility. Bari soils had higher levels of P and K than khet soils ($p < 0.05$). Similarly, levels of OM content and N were significantly higher in khet (irrigated land) than bari (rainfed upland) soils ($p < 0.05$).

Table 1:Summary of soil test results by type and use of land						
Soil type	Bari (n=10)			Khet (n =8)		
	Project	Non- project	F-value	Project	Non- project	F-value
pH	6.47	6.66	1.394	6.44	6.47	0.052
OM (%)	1.53	1.02	1.006	2.35	2.04	0.200
N (%)	0.073	0.048	0.985	0.115	0.10	0.172
P (kg ha^{-1})	69.43	87.39	0.480	46.77	30.88	0.219
K (kg ha^{-1})	154.06	158.72	0.023	150.2	94.08	2.269
Sand (%)	37.33	50.90	1.945	26.95	28.25	0.009
Silt (%)	39.33	28.00	2.341	50.00	49.50	0.002
Clay (%)	23.33	21.10	0.277	23.05	22.25	0.052

n = the number of composite samples; OM = organic matter; N = nitrogen; P = phosphorous; K = potassium

The practices of intensive fodder, firewood, and pole extraction had little impact on soil OM content. The problem of declining OM was more serious in bari than in khet. In bari, the problem was more acute in parcels located farther from homesteads.

Spatial distribution of farmland parcels and agroforestry species

The number of farm parcels per household ranged from 1 to 9, with an average of 4. On average, households owned more bari (2.9/household) than khet (0.9/household) parcels, and bari parcels were located closer (8 minutes) to the home than khet parcels (30 minutes).

Farmers managed land parcels differently depending on their size, distance from the home, and production potential. Available manure was applied more to parcels located closer to home, and these were also managed better. Consequently, the distant parcels have been gradually marginalised and their yields have decreased over the years. The cropping intensity for both bari and khet parcels was higher in project than non-project areas. Similarly, the cropping intensity was higher in bari parcels closer to homesteads (gharbari) parcels than those at a distance (Table 2). The parcels located near homes had higher yields than those located farther away. Similarly, concentration of agroforestry species was higher in parcels located closer to the farmhouse.

Table 2: Characteristics of landholdings and land parcels			
Characteristics	Project (n=82)	Non-project (n=141)	Total (n =223)
Average land holding per household (ropani[1])	**14.2**	**16.30**	**15.50**
gharbari (homestead upland)	3.73	4.20	4.10
bari (dry upland)	5.20	8.10	7.00
khet (irrigated lowland)	4.70	3.50	3.90
home garden	0.17	0.10	0.13
kharbari (upland not used for field crops)	0.38	0.39	0.39
Average parcels per household	**3.30**	**4.10**	**3.80**
gharbari	0.88	0.98	0.94
bari	1.38	2.27	1.94
khet	1.00	0.81	0.88
Average distance from the house (minutes)			
gharbari	00	00	00
bari	7.13	7.90	7.60
khet	26.00	34.20	30.70
Average household size (number of persons)	**6.20**	**6.70**	**6.50**

Source: Field Survey 1998
n = number of samples; [1] 20 ropani = approx. 1 ha

Further, the average numbers of fodder trees, shrubs, fruit trees, and grasses planted and protected on bari were significantly higher ($p < 0.01$) for the project than non-project plots. Similarly, the number of firewood and bamboo species belonging on project land were significantly larger ($p < 0.05$) than for non-project land (Table 3). In addition to the species grown along the edges and sides, the project households had planted improved fodder species on khet terrace risers and bunds maintaining lower heights to minimise the negative effects of shading. Non-project households had only planted along the edges of khet plots.

Table 3: Average number of agroforestry species in bari and khet plots

Type of species	Bari			Khet		
	Project	Non-project	F-value	Project	Non-project	F-value
Fruit trees (*n*)	71(85)	12(136)	7.895**	29 (20)	16 (17)	0.567
Fodder trees (*n*)	32(155)	16(354)	10.74**	27(36)	15(20)	1.916
Shrubs (*n*)	76(104)	23(156)	7.533**	67(22)	73(9)	0.016
Fuelwood trees (*n*)	35 (90)	18(182)	4.225*	15(28)	22(18)	0.804
Grasses (bhari)	52 (57)	08(107)	10.36**	80(18)	20(12)	1.151
Medicinal herbs (*n*)	37 (17)	27(22)	0.309	02(02)	02(2)	1.419
Bamboos (*n* bushes)	04 (40)	01(56)	5.443*	11(08)	01(4)	1.310

* Significant at the 0.05 level; ** Significant at the 0.01 level.
Figures in parentheses are number of parcels. 1 bhari is about 40 kg

Farmers reported that they were motivated to undertake agroforestry by the income obtained by selling mulberry cuttings and NB 21 grass slips to the Nepal Denmark Watershed Management Project and other organisations, as well as diversifying their income though using mulberry leaves for silkworm rearing.

Conclusion

The promotion of agroforestry contributed to increased productivity, improved soil fertility, diversified income, and better use of marginal farmlands to improve livelihoods in the hills. The gradual decline in the cropping intensity and production capabilities of distant parcels owing to inequalities in inputs and management requires urgent attention to minimise further marginalisation. The planting of a higher number of agroforestry species is due to the NAF's motivation, extension, training, and the availability of planting materials, which implies an important role for institutions.

References

CBS (1996) *Statistical Pocket Book*. Kathmandu: HMG/N National Planning Commission Secretariat, Central Bureau of Statistics

Schreier H.; Brown, S.; Shah, P.B. (1995) 'Identification of Key Resource Issues: Discussions and Recommendations.' In Schreier, H.; Shah, P.B.; and Brown, S. (eds.) *Challenges in Mountain Resource Management in Nepal: Processes Trends and Dynamics in Middle Mountain Watersheds*, pp. 247-252. Kathmandu: ICIMOD

Vaidya, A.; Turton, C.; Joshi, K.D.; Tuladhar, J.K. (1995) 'A System Analysis of Soil Fertility Issues in the Hills of Nepal: Implications for Future Research.' In Schreier, H.; Shah, P.B.; Brown, S. (eds.) *Challenges in Mountain Resource Management in Nepal: Processes Trends and Dynamics in Middle Mountain Watersheds*, pp. 63-80. Kathmandu: ICIMOD

Assessing Rural Community Livelihoods in the Mountain Terraces of Yemen

A. R. Y. Ebrahim
Mountain Terraces Project, International Centre for Agricultural Research in Dry Areas (ICARDA), Yemen

Introduction

Yemen is one of the least developed countries in the world and is a low-income, food deficit country. Agriculture contributes 23% of GDP, employs 60% of the work force, and provides a livelihood for rural residents, who represent 76% of the population. Fragile and highly variable natural resources of land, water, and biodiversity are major challenges facing the development of the agricultural sector.

Yemen has limited arable land, and 72% of that total area is already cultivated. Man-made terraces account for about 35% of this land. For centuries, Yemeni farmers have developed indigenous techniques for harvesting water and constructing mountain terraces. These and other community-based practices have enabled the long-term sustainability of agriculture in Yemen over many centuries. Prior to the oil boom of the 1970s, most Yemenis had no economic alternatives to intensive, subsistence-level agriculture.

The complex landscape of the Yemeni mountains has developed from human management of the natural resource base, resulting in an interdependence between the farming systems that have evolved and the natural resources of these mountain slopes. For this reason, integrated analysis of the biophysical and socioeconomic factors affecting the use of natural resources is necessary. The extent and rate of terrace degradation must be estimated and quantified, in order to identify priority areas for intervention.

While the Yemeni farmers' innovations and development of local technical knowledge are apparent in production systems developed over many centuries, their participation in identifying problems and testing land conservation practices has been limited. Because natural resources management invariably involves different stakeholders in a village, involvement of these stakeholders in identifying natural resource management problems and their solutions is paramount.

This project aims to fill these gaps by building on existing research and conducting empirical participatory research to identify and evaluate land conservation practices. While this project builds on the findings and experience of earlier research in the mountains of Yemen, there are three important guiding principles: (a) effective stakeholder participation at individual, community, and policy levels; (b) immediate impact on the livelihood of participating rural households; and (c) integrated analysis of natural resources management within a community context.

Study Approach

The Participatory Rural Appraisal (PRA) method was followed involving land users and communities in each watershed. Detailed guidelines were developed for community characterisation and for collecting a land information database in a GIS framework. The aim was to gain understanding of the communities in the research sites (watershed) and the land resources, and relate that to land use, terrace conditions, and maintenance.

The PRA approach was implemented from November 2000 to March 2001. The activities involved in generating data were: (1) meeting with farmers to explain the objectives, the procedures, and to gain their confidence for participation; (2) group discussions with farmers at the village level; (3) interviews with individual farmers; (4) field observations; (5) mapping of various land resources by knowledgeable farmers; (6) use of farmers' criteria to assess the status of terraces, well-being of the community/households, soil fertility, and crop production; and (7) ranking of the problems and priorities by the farmers.

A preliminary community-level land information database was developed; and micro-watershed sites, communities living at these sites, and resources utilised were identified.

Annual rainfall in the study areas ranges from 200 mm to 1000 mm. Three sites were selected, one each in the Northern Highlands, Middle Mountains, and Southern Uplands.

Results

The complex landscape of the Yemeni mountains consists of steep slopes, terraced croplands, rangelands, and patches of trees. Irrigated production takes place along the banks of the wadis that dissect the mountains. Rain fed agriculture in mountainous areas was developed centuries ago based on intricate systems of man-made terraces. The terraces are built to safely withhold rainwater, and the surplus water is carefully diverted to stone-paved outlets or carried away by sophisticated underground conduit systems. Rainwater harvesting is based solely on gravity. Irrigation from seasonal post-rain springs is also practiced on confined nearby fields, but due to low flows these are widely used for domestic purposes. Terraces contribute to both soil and water conservation on sloping land. The process of soil erosion downslope is greatly slowed due to retention and collection of runoffs on terraces.

The traditional terrace farming system provided the best possible resource utilisation, optimising available water and minimising land degradation. Rain fed farming is practised on about 35% of the total land area, mostly on terraced land, due to scarcity of groundwater.

Rapid urbanisation, population increases, increased role of markets, and increased employment opportunities in non-farm sectors led to a massive rural-urban migration, particularly among adult males. Subsidised food supplies and higher non-farm incomes reduced dependence on the land for food and income. Farmers' attitudes and behaviours changed due to several factors that impact their livelihoods. Lack of government support and proper technologies are the major constraints contributing to low production and increased poverty. These factors have changed the traditional values that had been the basis for community cohesion and management of community land resources, this had led to terrace abandonment and accelerated resource degradation. Large water flows over the terraces occur after heavy showers, leading to heavy soil erosion and allowing uncontrollable overland flow from upper terraces throughout the watershed to reach the wadi.

Soil erosion due to land abandonment and lack of regular maintenance has caused degradation of terraces in the highlands, and valuable agricultural land is lost every year. The degradation of terraced lands in the mountains has serious consequences on the production systems downstream. Lack of maintenance of individual terraces could result in the knocking over of other terraces downslope, increased run-off damaging wadi banks, and flash floods affecting the spate irrigation systems in lowlands areas.

Conclusion

The degradation of the terraces in the Yemeni Mountains is now well documented. If the current trends continue, Yemen may permanently lose a significant portion of its productive land to soil erosion due to lack of maintenance of traditional soil and water conservation systems. The threat that the degradation of terraces in the highlands poses to rural household food security and welfare and to national economic development has been clearly recognised. Development of cost effective soil and water conservation practices, productivity enhancing technologies, and identification of policy and institutional options that enable the adoption of these technologies and practices is needed.

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Drip Irrigation for Cash Crop Production: Results of a Trial in the Jhikhu Khola Watershed, Nepal

B. Prajapati-Merz[1], G. Nakarmi[1], and N. P. Bhandari[2]
[1]International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
[2]Horticulture Centre, Panchkhal, Nepal

Introduction

The warm sub-tropical climate in the lower parts of the Jhikhu Khola Watershed (JKW) is suitable for vegetable production – the average monthly temperature ranges from 5 to 33 °C, and rainfall averages about 1200 mm each year (Merz Dhakal and Dangol 2000). The typical rainfall pattern, in which about 80% of the annual rainfall occurs from June to September, leaves the rest of the year virtually dry. Further winter rainfall is sparse and very unreliable. During the dry period some farmers extract water from the Jhikhu Khola and its tributaries to irrigate potato and tomato fields. The parcels on rainfed agricultural lands do not have access to irrigation water and therefore remain fallow. Other farmers who have access to springs cultivate cash crops, mainly tomatoes, on small upland plots through bucket irrigation.

The People and Resource Dynamics in Hindu Kush-Himalayas Project (PARDYP) of ICIMOD, in collaboration with the Horticulture Centre Panchkhal of HMGN, Department of Agriculture, set up a trial in February 2000 to demonstrate an alternative irrigation system (drip irrigation) at the Horticulture Farm at Tamaghat in the spring season. The aim was to study the comparative advantages of drip irrigation techniques over conventional irrigation systems

Materials and Method

Two plots of similar size (12 X 12 m) were established side-by-side, one each for the drip system and the bucket system. An improved variety of bitter gourd (white long), which has a good market price, was selected for the trial.

A locally fabricated drip irrigation unit able to perform with a low water head was selected, and a medium-sized system installed in one of the plots. For installation details refer to Nakarmi, Prajapati-Merz; and Jha (in press). For the bucket irrigation method applied in the second plot, a 20 litre plastic bucket was used to haul water to the plot. Water was poured onto individual plants with the help of a 0.5l plastic jar, so that each received about 0.5l water at a time.

Results and Discussion

Bucket versus drip irrigation methods

The efficiency of the bucket method was extremely low. When equal amounts of water were provided, the bucket plot routinely appeared drier than the plot under drip irrigation. Therefore more water was applied to the bucket-method plot, often two to three times more than that applied to the drip irrigation plot. The higher water input was necessary to compensate for water losses mainly from evaporation and surface run off. The monsoon rainfall provided adequate water from the 14th week, and no irrigation water was required from then onwards.

Labour for Crop Management

The bucket irrigation plot required 200% more labour than the drip plot. Though an equal effort was needed for land preparation and to put up the supporting sticks, about 33% more effort was needed to weed the bucket plot, and 600% more effort to irrigate it. It took about 20 minutes to apply 40l of water to the drip plot (10 minutes to fill the tank, 10 minutes to empty the tank), while it took about 50 minutes to apply the same amount of water to the bucket plot. The overall crop management cost was three times more with the bucket method.

Water Application versus Yield

The total amount of water used in the plot irrigated under the bucket method was 6330 litres, nearly three times higher than that in the drip plot, 2240 litres. The cumulative production from plots under drip and bucket methods were 612.1 kg and 638.8 kg, respectively. This is a difference of 4%, but the real difference in production was only 2%, because 2 out of 96 plants in the drip plot were actually sterile (male) plants, which did not fruit. The plot under bucket irrigation consumed three times more water but the total yields from each plot were not significantly different. This implies that bucket irrigation is less efficient and wastes precious water.

Because of the onset of pre-monsoon rain from the start of the flowering of the plants, however, this study did not elucidate the complete effects of the two irrigation systems.

Cost-Benefit Analysis

An analysis of benefit was conducted on the basis of the expenditure for seedlings, chemical fertiliser, actual cost to purchase the irrigation system, and the labour cost for crop management (field preparation, irrigation, weeding, and putting up supporting sticks). The labour cost was calculated at the rate of Rs 100[1] per day. The source of income was the fruit production from the plots. During the study, the price of bitter gourd fluctuated between Rs 12 and 18 per kg, thus it was calculated at the rate of Rs. 15 per kg. Total expenditure for the drip plot was Rs 2712, against an income of Rs 9182, yielding a net profit of Rs 6470. The expenditure for the bucket plot was Rs 2972, against an income of Rs 9582, yielding a net profit of Rs 6610.

Setting up the drip plot involved an initial capital cost of Rs 1450. Because this system has a useful life of at least five years (according to the IDE), an actual cost-benefit analysis is possible only on the basis of five-year data. Nevertheless, it seems a net profit of about NRs 6000 can be made from a plot of 144 m^2 by growing bitter gourd.

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[1] In 2001, NRs 73 = US $ 1 approx.

Conclusion

In cultivation of bitter gourd, the drip irrigation system has several benefits over bucket irrigation because the water application in the former method is substantially lower owing to minimum losses to evaporation, surface runoff, and deep infiltration. Moreover, time to irrigate the plots is reduced, thus reducing the labour cost for crop management. The trial indicated that under conditions of limited access to water, small-scale farmers with small budgets can improve their incomes using drip irrigation systems to grow bitter gourd.

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References

Merz, J.; Dhakal, M.P.; Dangol, P.M. (2000) 'Comparison of Climatological Balances for the Jhikhu Khola and Yarsha Khola Watersheds, Nepal'. In Allen, R., Schreier, H., Brown, S., Shah, P.B. (eds) *The People and Resource Dynamics Project: The First Three Years (1996-99)*. Kathmandu: ICIMOD

Nakarmi, G.; Prajapati-Merz, B.; Jha, P.C. (in press) *Alternate Water Management: A Case Study from Kubinde Gaun, Jhikhu Khola Watershed, Nepal*, Paper Presented at the International Conference on Sustainable Management of Natural and Human Resources for a Better Quality of Life in South Asia, Kathmandu, Nepal, October 14-17, 2000

Apple Farming Productivity Concerns of Mountain Farmers and Pollination Issues

U. Partap
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Declining Productivity

Cultivation of cash crops such as fruits and vegetables is increasing in several pocket areas of the Hindu Kush-Himalayan region as a consequence of diversification in mountain farming (Partap 1995; 1999). Apple is the leading cash crop in several areas of the HKH region, where it accounts for 60% to 80% of total household income. Over 140 hill and mountain districts of India, Pakistan, Bhutan, China, and Nepal grow apples on sloping and marginal land in temperate environments covering about 367,000 ha. The annual production of apples in the HKH region is over 2.5 million tonnes, which helps bring about US$500 million each year to farmers and others involved in apple farming and marketing (Partap and Partap 2002a). However, for the past decade farmers have been complaining about declines in apple production despite all agronomic inputs and orchard management practices including irrigation, fertilisers, and pesticides. Most farmers feel that productivity has declined by about 50% (Partap T. 1998; Partap and Partap 2000).

Our studies revealed that inadequate pollination is a very important factor in this decline in apple productivity (Partap and Partap 2001). A few apple farmers in India and China are aware of it and are trying to manage it using different approaches including honeybees (Partap and Partap 2002). But most farmers and institutions in the Hindu Kush Himalayan region have little knowledge of this crucial factor limiting the productivity of their cash crops such as apples, other fruits, and vegetables. This paper reports the findings of investigations about the apple pollination problem, its causes, and its impact on crop productivity.

Field studies examined the pollination problem in apple growing valleys of the HKH region. The studies investigated pollination-related productivity problems in the apple crop and farmers' management practices in Himachal Pradesh (India), Maoxian County (China), Thimphu and Paro valleys (Bhutan), Balochistan and northern areas of Pakistan, and western Nepal. Information was collected using a well-structured pre-tested survey questionnaire indicating various parameters related to the apple pollination problem and its impact on productivity.

Factors Responsible for Inadequate Pollination

Poor proportions of appropriate pollinizers in orchards are an important factor responsible for inadequate pollination of the apple crop. Almost all commercially important varieties of apple are self-incompatible, and therefore to produce fruit they require pollen from other compatible pollinizer varieties. The present surveys revealed that due to the market demand for one preferred variety of apple, farmers failed to plant appropriate numbers of pollinizer trees in their orchards. Another equally important factor is inadequate populations of pollinating insects in apple growing areas. The populations of natural insect pollinators are declining owing to alterations in their food and nesting habitats caused by shrinking natural forests and grassland ecosystems, increased areas under cross-pollinated crops and varieties, and excessive use of pesticides on a new generation of cash crops. In addition drops in temperature and rainfall during the apple flowering season have resulted from global climate change, and this also adversely affects apple pollination by affecting pollinator activity.

Pollination Management Practices of HKH Farmers

Increasing the pollinizer proportion

In Himachal Pradesh in India, farmers have started planting pollinizer trees in their orchards to increase the proportion of pollinizer varieties. Realising that grafts produce flowers earlier than the newly-planted trees, farmers are grafting pollinizer varieties onto the commercially premium varieties. Until the grafted branches or newly planted pollinizer trees start flowering in a few years, farmers have devised short-term solutions called 'bouquet pollination'. The farmers make a bunch of small flowering branches of pollinizer called 'bouquets', put these in plastic bags filled with water, and hang them on the trees of commercially premium varieties.

Increasing the number of pollinators

To increase the number of pollinators in their orchards, farmers in Himachal Pradesh are using honeybee colonies of *Apis mellifera* and *Apis cerana* for pollination. A system of renting and hiring bee colonies is evolving quickly. At present, it is largely the Department of Horticulture and a few private beekeepers that rent bee colonies to apple farmers. The current cost of renting an *Apis cerana* or *Apis mellifera* colony for apple pollination is US$18 per colony (US$ 11 as security and US$ 7 as rent). Only a few farmers keep their own colonies for pollination. Other farmers have created a heavy demand for honeybees for pollination, and beekeeping entrepreneurship is evolving to meet it.

Hand pollination

Farmers in Maoxian county of China pollinate their apple crop by hand instead of using friendly insects like honeybees. Hand pollination has become a common practice and it is a massive exercise in a 60 km long valley in which every family member, man, woman, or child, is involved. In Maoxian County, hand pollination is a community effort in most of the villages, and a number of labourers are employed for this purpose. They are better termed 'human bees', because they do the work that could be done by using honeybees. The practice of using honeybees is surprisingly absent from the farmers' repertoire, even though migratory beekeepers are found in the area. A cost-benefit analysis of hand pollination reveals that it is an expensive, laborious, and time-consuming method of pollination. Using bees to pollinate these apple trees would be eight times cheaper. The fast-improving economy of the area will make hand pollination an increasingly costly option for farmers.

Why would Maoxian farmers not use honeybees for pollination? The investigations revealed a lack of awareness about the use of honeybees. The research and development institutions never promoted the use of bees in the first place, so the farmers did not know about it. Migratory beekeepers did move their bee colonies into this valley, and they expressed reluctance to rent their colonies unless farmers stopped excessive use of pesticide sprays on their apple crop.

Promoting Honeybees for Pollination

There are different ways to manage pollination. These include the use of honeybees, hand pollination, and rearing non-*Apis* pollinators and using them for pollination. Among these, the use of hand pollination is prevalent in Maoxian County. Even though hand pollination is the most reliable method of ensuring pollination, it is an expensive, laborious, and time-consuming method. Therefore, it will not be sustainable in the long term, largely because of increasing labour costs. Another method is the management and use of non-*Apis* pollinators such as bumblebees and solitary bees. Various species of bumblebees and solitary bee species of *Amegilla, Andrena, Anthophora, Ceratina, Halictus, Megachile, Nomia, Osmia, Pithis,* and *Xylocopa* are important pollinators of apple flowers in the HKH region. Many of these pollinators can be reared on a large scale and managed for the pollination of apple and other crops. At present, species of *Osmia* (*O. cornuta* and *O. cornifrons*) are being reared and used for apple pollination on a large scale in Japan. However, in the HKH region there is a lack of expertise and neither government institutions nor private entrepreneurs are engaged in rearing and managing these insects for pollination purposes. Therefore, popularising the option of pollination by rearing and using non-*Apis* pollinators in the HKH region will take several years.

Giving due consideration to all these facts, the most practical approach will be promoting the use of honeybees for pollination. Experimental research has proven that pollination by honeybees increases fruit set, enhances fruit quality, and reduces fruit drop in apple (Dulta and Verma 1987). Honeybees are also the most efficient pollinators among insects because they can be managed in sufficient number and show flower constancy (Free 1964, 1966; McGregor 1976). The hive-kept species of honeybees, *Apis cerana* and *Apis mellifera,* are of great value because these can be managed and moved to the orchards where and when necessary. Our cost-benefit analysis of various methods of pollination reveals that pollination using honeybees is a cheaper and more effective way of pollinating apple and other fruit crops than any alternative.

Need for Strengthening Research and Extension Systems

The use of beekeeping to pollinate crops is a new effort in the HKH region. Even though beekeeping is common, farmers in most of the pollination problem areas are not aware of the value of honeybees for pollination. The practice of using honeybees for pollination is limited to a very few areas because in the past beekeeping awareness and promotion were focused only on honey production. Neither the policies nor institutions ever supported development of beekeeping from a crop pollination service viewpoint. There are only isolated examples like that of Himachal where special efforts have been made by government agencies to strengthen the research and extension systems to enable them to promote beekeeping for crop pollination. Governments in other countries of the region need similar initiatives.

Conclusion

The preceding discussion clearly shows that like soil, water, and nutrients, crop pollination has become one of the factors limiting apple productivity. Recognition of the pollination problem is relatively new in the region, and needs due attention at this early stage. Apple is only one example of a number of cash crops grown by HKH farmers that require management of pollination for better production and quality. Vegetable seed production is another sector where pollination management is essential. The preferred solution lies in promoting honeybees for pollination. Thus, there is need to change the focus of beekeeping from conventional honey production to crop pollination.

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References

Batra, S.W.T. (1997) 'Solitary Bees for Orchard Pollination.' In *Pennsylvania Fruit News,* April 1997

Dulta, P.C.; Verman, L.R. (1987) 'Role of Insect Pollinators on Yield and Quality of Apple Fruit'. In *Indian Journal of Horticulture*, 44:274-279

Free, J.B. (1964) 'Comparison of the Importance of Insect and Wind Pollination of Apple Trees.' In *Nature,* 201: 726-727

McGregor, S.E. (1976) *Insect Pollination of Cultivated Crop Plants.* Washington, DC: USDA

Partap, T. (1995) *High Value Cash Crops in Mountain Farming: Mountain Development Processes and Opportunities*. MFS Discussion Paper Series No. 95/1. Kathmandu: ICIMOD

Partap, T. (1998) 'Agricultural Sustainability Challenges in Upland Areas of Semi Arid and Humid Asia'. In *Proceedings of the Study Meeting on Sloping Land Agriculture and Natural Resources Management*, pp 39-84. Tokyo: Asian Productivity Organisation

Partap, T. (1999) 'Sustainable Land Management in Marginal Mountain Areas of the Himalayan Region'. In *Mountain Research and Development,* 19: 251-260

Partap, U. (1998) 'Successful Pollination of Apples in Himachal Pradesh'. In *Beekeeping and Development,* 48: 6-7

Partap, U. and Partap, T. (2001) 'Declining Crop Production and Worried Himalayan Farmers: Solution Lies in Promoting Honeybees for Pollination'. In *Issues in Mountain Development 2001/1*. Kathmandu: ICIMOD

Partap, U. and Partap, T. (2002) *'Warning Signals from the Apple Valleys of the HKH: Productivity Concerns and Pollination Problems.* Kathmandu: ICIMOD

Partap, U., Partap, T., and He, Y. (2000). *Pollination Failure in Apple Crop and Farmers' Management Strategies in Hengduan Mountains, China.* Paper presented at the Eighth International Pollination Symposium, July 10-14, 2000, Mosonmagyarovor, Hungary

Partap, U.; Partap, T. (1997) *Managed Crop Pollination: The Missing Dimension of Mountain Agricultural Productivity.* MFS Discussion Paper Series No. 97/1. Kathmandu: ICIMOD

Partap, U.; Partap, T. (2000) 'Pollination of Apples in China'. In *Beekeeping and Development*, 54: 6-7

The Role of Economic Trees[1] in the Mountain Farm Economy: A Case Study of Apple Cultivation in Maoxian County, Sichuan Province, China

Bao Weikai, Tang Ya, and Chen Jianzhong
Chengdu Institute of Biology, Chinese Academy of Sciences, P. O. Box 416, Chengdu, Sichuan 610041, P R China

Introduction

Apple is one of the most important fruits in China and around 3.3 million ha are currently under apple cultivation, accounting for over half the apple cultivation area in the world. Apple is one of the most important economic trees in the mountains of China. Although apple yield in Sichuan Province accounts for only 3-5% of the country's production, it has been a very important source of livelihood for people in the apple cultivation areas, mainly the Hengduan Mountains, where Maoxian County accounts for 18% of the province's apple crop area and 16% of its yield. Until the mid-1990s apple farmers in Maoxian had benefited considerably from converting cereal crop lands to apple farming, but since then have been suffering from low prices and reduced incomes. This paper will analyse the development process, identify existing problems of apple cultivation in Maoxian, and expound its role in the rural economy and possible ways to maximise its benefits.

Biophysical and Socioeconomic Backgrounds

Maoxian, a Qiang-nationality autonomous county, is located on the south-eastern fringe of the eastern Tibetan Plateau. It lies in the transitional zone from the Sichuan Basin to the high and cold Northwest Sichuan Plateau, between 102°56' and 104°10'E longitude and 31°25' and 32°16'N latitude, covering an area of 4,064 km^2. The population is about 105,000, of whom around 88% are engaging in various agricultural activities. Agricultural land totals only 10,607 ha, or 2.61% of the total land area. The per capita agricultural land is 0.1 ha, and each farming household has, on average, around 0.45 ha of crop land. The agricultural lands are mainly distributed in the valleys of the Minjiang River and its tributaries.

The warm temperate climate is characterised by low rainfall and a long dry season. The mean annual temperature is 11°C. The annual sunshine duration exceeds 1557 hours, and the annual solar radiation is 100,900 cal cm^{-2}. The mean annual precipitation is about 495 mm but the annual open evaporation is 1,356 mm. Drought is a major factor affecting agricultural production, especially in valleys.

The main food crops include maize, potato, naked barley, winter wheat, and so on, but crop farming has been minimised in the valleys. Maoxian is also an important vegetable production base for Chengdu, the capital city of Sichuan. The main vegetables include Chinese cabbage, cabbage, tomato, green and red pepper, lettuce, and garlic. The main economic trees include apple, walnut, huajiao (*Zanthoxyllum bungeanum*), pear, and plum.

[1] Economic trees are defined as those that produce a cash crop other than timber.

Because most of the former crop lands in valleys have been converted to cultivation of economic trees or vegetables, grains are imported, mainly from the Sichuan Basin.

Impact of Apple Farming on the Rural Economy and Land use

Apple trees were introduced to Maoxian for the first time in 1935. Though Maoxian was identified in 1963 as China's most suitable area for apples, it was after 1985 that apple cultivation extended to a large area, as a result of rural reform. Most of the agricultural land along river valleys has now been converted to apple cultivation. From 1996 onwards the area and yield have been more or less constant.

A survey of 80 households in five villages indicated that expected high income from apples was the reason for 64% of households to convert initial to apple farming. Another 15% of households followed this first group in adopting apple farming, meaning that around 80% of the farmers eventually converted their land to apple growing in order to gain more cash income. Though the income from maize in Maoxian is highest among food crops, exclusive cultivation of apple yields 5-10 times more income per hectare than maize (Bao et al. 1999a).

Transformation from cereal crop farming to apple cultivation has contributed considerably to livelihood improvement. Increased cash income has been the key factor contributing to this. Both survey and statistical data reveal that farmer's per capita income increased with the expansion of apple cultivation. Apple income contributed 60-70% of the household income, which clearly indicated the important economic role of apple cultivation.

The extension of apple cultivation has caused obvious changes in crop patterns. Most of the crop land in river valleys has now been planted with apples. Because it takes at least five years to get benefit from apple trees, maize, potatoes, and vegetables were also planted on the crop land, forming apple-based intercropping systems. By the late 1990s at least 20 apple-based intercropping types were identified (Bao et al., 1999a, 1999b). Because more income is obtained from apple-vegetable intercropping than from either monocropping of cereal crops or combined fruit tree and cereal crop intercropping, apple-vegetable intercropping has replaced most of the other models. According to the Maoxian Agricultural Bureau, the area under apple-vegetable intercropping increased fourfold from 1980 to 1992. As a result, the cultivation of wheat, rapeseed, maize, and potato had decreased considerably. Another change resulting from the development of apple cultivation is increased cultivation of green manure; while cultivation of green manure has decreased in other areas of Sichuan, in Maoxian it increased by 30% between 1980 and 1992 .

The Roles of Different Institutions in Developing Apple Cultivation

Education has played a role in apple cultivation. The survey indicated that families having less education had difficulty both in adopting new technologies and practices and in modifying existing technologies and practices, and the apple yield and cash income were therefore lower than for more educated families. Differences in management were also observed in the field, and these differences affected production in terms of both quantity and quality.

Surveys and interviews of farmers and government officials revealed that although the development of apple cultivation in Maoxian had been largely the result of individual initiative, national policy nevertheless played a crucial role. The rural reform characterised by the household responsibility system was the key contributing factor influencing large-scale apple cultivation, because it allowed farmers to decide what to plant on their own land. The slow development of apple cultivation in the 1960s and 1970s has been attributed to prevalent agricultural policy that only allowed cultivation of cereal crops.

However, the role of local government, research institutions, and extension agencies has been limited since the start of large-scale apple cultivation in the 1980s. Although in the 1960s extension services played an important role in introducing various apple varieties to the region, in the past 40 years significant extension services have not been available to apple farmers, although a fruit tree station was established in 1978. Research institutions have contributed to apple development in identifying Maoxian as a suitable area for apple cultivation, and devising the master plan for apple development, pest control, promoting apple-vegetable intercropping systems, modifying crop-apple cultivation systems, and improving the management of apple orchards. The apple-vegetable and crop-apple intercropping systems have been widely adopted by local people and have proven to be important in sustaining their incomes since the late1990s, when income from apple declined considerably.

To build on these successes, the services of these institutions need to be improved greatly. Lack of access to information about markets and improved varieties has led to declining incomes among apple farmers as prices have declined and better apple varieties from other parts of China and abroad have become available in markets. Government, extension, and research institutions should have played a crucial role in advising the apple farmers to change to new varieties with better market potential. Nevertheless, despite declining incomes farmers are continuing to plant apples and in some cases using this to replace old varieties with new varieties. No farmers have planned to return to food crop farming because of the low income from cereal crops. Most apple farmers have started growing vegetables in apple orchards, which has become another important income source for local people.

Existing Problems and Strategies for Improving Apple Farming

The most important problem has been the declining price. On average, the percentage of household income attributable to apples declined from 70-80% in 1997 to around 30% in 2000, although the area under apple cultivation has remained constant. Declining income removes incentives for improving crop management, which has led to reduced yield, and in some cases the uprooting of apple trees. The most important contributing factor for this has been the failure to replace old varieties with better ones in a timely manner. In the past decades, neither farmers, government, research, or extension institutions regarded the replacement of old varieties with newer ones to be important, and it was too late to react when the existing varieties had already lost their markets. Large-scale apple cultivation in China took place in 1987 and introduced improved varieties with better marketing potentials. Improved apple varieties have been available in the market since 1992 and more production is expected in the near future. As a result, the demand for Maoxian apple has been decreasing sharply since 1992. Another problem in Maoxian is lack of an appropriate marketing mechanism and development of fruit processing capacity. No marketing network has been established in the past 30 years. As a result, apple farmers have been forced to sell their products at low prices. The farmgate price in 2000, for example, was only 0.4-0.6 RMB[1] per kg although apples sold at 2-3 RMB per kg in markets within about 120 km, implying a huge profit for middlemen. Lack of appropriate management was the third problem. Apples in the region are entirely hand pollinated and over fruiting is common, but farmers are unwilling to thin fruits, which leads to poor quality and low market potential. As a result of the above, the Maoxian apple has been excluded from the mainstream market.

Mountains are rich in different niches, and many niches may not be suitable for food crop cultivation. Evidence has shown that economic trees like apple may be among those crops to suit local niches and provide good income sources. Cultivation of cash crops suitable to local conditions can improve rural economies and livelihoods in mountains considerably. Compared to cultivation of annual crops, cultivation of perennial economic trees also has other positive effects on local agricultural environments, including acting as windbreaks, microenvironment mitigation, increased efficiency in utilising solar radiation, and soil and water conservation (Bao 1998,1999). However, the transformation from food crop farming to economic tree farming provides not only opportunities for income generation but also risks and challenges. The potential risks in such transformations have been largely neglected by research institutions, extension institutions, local government, and local farmers. The opportunities of today may become the constraints and risks of tomorrow. This case study indicates that with the gradual saturation of markets, new ideas, improved technologies and management, and improved quality become crucial for sustainable development of economic trees. There is an urgent need to change from concentrating on improving productivity to improving quality. Both improved and traditional technologies must be used to achieve this goal. More important, varieties with good market potential should be introduced to replace the present varieties. A market network should be established to help achieve a satisfactory selling price.

References

Bao W. K. (1998) 'Energy Balancing in Fruit Tree Interplanting Crops Systems in the Upper Reaches of Minjiang River'. In *Eco-Agriculture Research,* 6 (3):39-42

Bao W. K. (1999) 'Optimal Adjustment on Fruit Tree-crop Intercropping System (IV): Nutrition Management and Adjustment Measures'. In *Chinese Journal of Ecology*, 18(4): 31-35

Bao W.K.; Chen Q.H.; Liu Z.G. (1999a) 'Productivity Dynamics and Optimal Adjustment of Nine Interplanting Communities in Dry Valley in the Upper Reaches of the Minjiang River'. In *Chinese Journal of Applied and Environmental Biology,* 5(2): 136-141

Bao W.K.; Chen J.Z.; Qiao Y.K. (1999b) 'Eco-agricultural Construction at Dry Valley in the Upper Reaches of the Minjiang River'. In *Eco-Agriculture Research,* 7(2):66-68

[1] In 2000, US $ 1 = RMB (Yuan) 8.28 approx.

Issues for Marginal Farms and Potential for Development

Issues and Options for Marginal Farms in the Hindu Kush Himalayas: A Study in Himachal Pradesh (India)

C. S. Vaidya and R. Singh
Agro-economic Research Centre, H.P. University, Shimla (HP), India

Introduction

With the increasing problems of population pressure, soil erosion, and degradation in Himachal Pradesh, the management of marginal farms and lands has gained in importance. There has been an increase in the proportion of marginal farms, defined as holdings of less than one ha, from 58% of all farms in 1970-71 to 64% 20 years later.

This study evaluated livelihood strategies based on fruit and off-season farming and highlighted the issues and options for the development of marginal farmers in the state. Apples and off-season vegetable production were selected as two viable options for marginal farms and were analysed in detail. The study confined itself to activities that have been commercialised in the state. These can form the basis for diversifying production activities on marginal farms with an eye to commercialisation.

Himachal Pradesh can be divided into four agro-climatic zones. In Zone I (low-hills), where agro-climatic conditions are sub-tropical, most activities are not very profitable. In Zones II (mid-hills) and III (high-hill temperate wet), activities like fruit, off-season vegetables, floriculture, and mushroom production are highly profitable. Zone IV (high-hill temperate wet) can be commercially exploited for off-season vegetables and seed potato production. Zones II and III have seen the most diversification and commercialisation. From these agro-climatic zones, one district was selected for each activity. The district Shimla was selected for apple production and off-season vegetable production. The study pertains to the calendar year 2000.

Vegetable system

Despite the area's being quite progressive and well known for vegetable production, the productivity of different crops was generally below the experimental yield obtained on research farms. The yield gap was 5.3% for tomatoes, the main vegetable crop of the area. The pattern of input use for the tomato crop is quite close to the recommended level of inputs, resulting in tomato productivity that is close to the experimental level. There were substantial differences, however, between the experimental and farmers' field-level productivity in the cases of other crops. The highest gap observed was for French beans, 78% lower because this crop is grown as an intercrop with maize. The gap for peas was 67%. The productivity gaps for other vegetable crops ranged from 30 to 40%.

Fruit System

The main emphasis in the fruit growing area has been on apple production. Other crops are not significant, and on many farms a complete monoculture of apples has been the result. This, combined with factors like agro-climatic conditions, has resulted in substantially lower productivity. The lowest gap between farm and experimental productivity was for maize – 23% lower. In other crops it varied between 50 and 70%. No values are available for the experimental yield of apples and hence no gaps could be calculated, but horticulturists say that the present yield is very low and can be increased by at least 50% to 60% with proper pre-harvest management of the crop.

Economics of Crop Cultivation

The emergence of the present livelihood strategy of the area is an outcome of various factors. Among these, profitability is the main consideration.

Returns from crops in the vegetable system

The highest net returns ($2766/ha) are obtained from cultivation of tomatoes, followed by cauliflower and cabbage. These returns appear to be quite high, but when the actual cropping patterns are factored in, net returns are reduced to $593/ha, with an input:output ratio of 2.63. Each dollar invested on the farm gives a return of 2.63 dollars. Theoretically, the present cropping pattern on a hypothetical farm of one hectare would yield a net profit of $1602.

Returns from crops in the fruit system

The net returns realised on the farms in the fruit growing area are very meagre except for apples and potatoes. The net return from maize is only $79/ha, and from wheat and barley a mere $4 and $18, respectively. These low returns are more than offset by the returns from apple and potato cultivation, which yield net returns of $2497 and $516 per ha respectively, with input:output ratios of 1:3.7 and 1:1.6. Apple is the main source of income. The total net returns per farm on the apple farms are $1344/ha, with a very high input:output ratio of 3.7. Theoretically, the present cropping pattern on a hypothetical farm of one hectare would yield a net profit of $1793, a substantial income.

It appears that the farmers are enjoying good returns in both the areas. This is true, if a comparison is made with the other areas of the state lying in other agro-climatic zones or even with many pockets of the same zone. Despite this, there still is scope for increasing the net returns by improving the productivity of the crops grown.

Development of Horticultural Infrastructure

In the growth and marketing of agriculture/horticultural commodities, development of infrastructure is essential. In this context, the state took a number of policy initiatives for the development of infrastructure related to horticulture. These can be broadly divided into three categories: production facilities, dispersal facilities, and institutional facilities.

Production facilities

The state has set up 113 nurseries to supply fruit plants of different varieties, and 736 private nurseries are also registered for this purpose. A network of 209 distribution centres under the control of the Department of Horticulture, HPMC, Himachal Pradesh Agro-Industries Corporation, and Himachal Pradesh Marketing Federation (HIMFED) supplies insecticides and pesticides to farmers. Fertilisers are supplied from various outlets by the Primary Agricultural Cooperative Societies (PACS), Department of Agriculture and Horticulture, and others at subsidised rates.

Dispersal facilities

The state has set up five cold storage units with a capacity of 8000 tonnes within the state, and three with a capacity of 8256 tonnes outside the state. At present there are four grading houses with a capacity of 15,000 tonnes, and five grading-cum-packing houses with a capacity of 5000 tonnes. Processing plants with a capacity of 40,000 tonnes have also been set up in the state.

Institutional support

The Himachal Pradesh Marketing Corporation (HPMC) was established in 1975 to provide facilities like cash marketing advances, packing material (cash/kind), forwarding assistance, transit warehouses, cold storage facilities, market intelligence, and so on. A corrugated fibreboard carton manufacturing plant has been set up at Gumma in Shimla district. The rate of subsidy under the scheme for incentives to weaker sections varies from 25% for small farmers and 33.3% for marginal farmers, to 50% for scheduled caste/scheduled tribe farmers, farmers in backward areas, and IRDP farmers for fruit plantations. The maximum subsidy is $67 per family.

Vegetable Development Programmes

As for other crops, incentives are available for the purchase of inputs for vegetables. Under the scheme, a 50% subsidy is available on the purchase of all inputs other than fertilisers, to the members of scheduled castes, scheduled tribes, families identified under the Integrated Rural Development Programme, and those located in backward areas. A subsidy of 33% is available to marginal and small farmers. The subsidy varies between 25 and 75% depending upon the scheme, target group, and the area of operation.

Programmes and schemes like the 'Intensification of Vegetable Cultivation through Project Approach', 'Production and Supply of Vegetable Seeds' (Central Sector Scheme), 'Foundation and Certified Seed Production of Vegetables' (Central Sector Scheme), and so on are available for the development of vegetable cultivation in the state. Other schemes cater to all field crops without making any distinction for vegetables. Such schemes include the Minikit Programme and the Scheme for Green Houses and Training.

Issues in Apple and Vegetable Production

The following issues and comparative advantages for apples and vegetable production emerged from the study.

Labour

Apples and off-season vegetables are labour-intensive crops. The scarcity of labour constrains the extension of apple and vegetable cultivation to additional lands. The technical nature of production and marketing makes the availability of skilled manpower mandatory. It is not only the quantity of labour that matters, the quality aspect is equally important.

Capital and credit requirements

The capital requirement for both these crops is significantly higher than for other field crops. Vegetable farmers often resort to borrowing from non-institutional sources, as the procedure for lending in banks is quite long and cumbersome. In the case of apple, capital requirements are fulfilled from both institutional and non-institutional sources.

Inputs

Farmers with insufficient capital are forced to use lower than the recommended levels of inputs. Many times this also happens as a result of due to ignorance. Another factor is the low availability of such inputs.

Extension services

Although there are various agencies involved in extension services, many farmers do not have access to their services. Those who have received some training complain that there is almost no follow-up.

Marketing

The marketing of apples and vegetables is a highly technical and risky task, especially during periods of bumper production. The effect of bumper production of vegetable is seen immediately in the next production season in the form of lower area allocation. But, this is not the case for apple, whose area allocation cannot be altered so quickly.

Market intelligence

Many of the risks of marketing can be avoided if appropriate market intelligence is available. The quality of the market intelligence is inadequate in various respects: it can be late or misleading and is also not available for many markets. Thus, the farmer has no other option but to send his produce to the conventional market.

Women's participation

Despite the high involvement of women as labour, their role in the decision-making is slight. They have very little role in marketing produce.

Risk and uncertainty

Apples and vegetables, being perishable products, have an inherent risk associated with their production. The changing weather cycle, and incidence of disease, and infections can result in lower than normal yields. Marketing risk arises out of the ever-changing scenarios at the market, poor infrastructure, and substandard packing and grading.

Favourable Factors and Advantages

The following factors have been identified as instrumental in making apple and off-season vegetable production successful.

Agro-climatic compatibility

One of the main reasons for the success of these activities has been their compatibility with the agro-climatic conditions. In other words, the niche provided by such conditions has been successfully tapped and put to the benefit of a large number of farmers.

Efficient use of land resources

The land resources of the fruit growers are larger, and they have made more comprehensive use of land. It is possible to use land not suitable for crop cultivation as apple orchards. This was seen in both the areas. Although farmers with orchards have made more rigorous use of land, they have a tendency towards monoculture as the apple orchards replace most of the field crops.

Profitability

Apple and off-season vegetable cultivation could not have formed the main livelihood strategies of the farmers in many parts of the state, had they not been associated with a high level of profitability compared to traditional field and other crops. Profitability motivated the farmers to adopt these activities.

Crop productivity

The use of inputs was observed to be below the recommended levels and this led to lower productivity of vegetable and other crops. However, the productivity of tomato, the main crop, was almost equal to the recommended level.

Literacy

Although initially the spread of activities was mainly due to agro-climatic compatibility and profitability, the real spread and refinement in production and marketing techniques came with the increase of literacy rates in these areas.

Infrastructure

The development of infrastructure, especially in the form of rural roads, along with the spread of these activities, played a very crucial role. The successful adoption of these activities is largely a result of road infrastructure development in the state.

Policy initiatives

Cherishing the dream of making the state the apple state of India has led to very favourable policy initiatives for development.

Markets and demand

These activities were able to become the main livelihood strategies of some areas because of the availability of well-established markets. This played a crucial role in the initial stages, and its importance has not diminished despite the fact that distant markets are also being exploited and farmers have started using the Internet for the sale of apples. The commodities produced are in perennial demand in the state as well as in other parts of the country. At present, the demand is met by other hill states like Jammu & Kashmir and Uttaranchal, but there is still a market for Himachal produce.

Issues and Options for Improving Livelihoods of Marginal Farmers in Uttaranchal

G.S. Mehta
Giri Institute of Development Studies, Aligunj, Lucknow, India

Introduction

Uttaranchal is one of the more underdeveloped states of India. Agricultural and associated activities, including animal husbandry and fishing, form the economic base and the main sources of livelihood and employment. However, increasing population, decreasing arable land due to increasing landslides and soil-erosion, decreasing natural resources required to sustain agricultural production, and the decreasing quality of lands due to increasingly scarce water for irrigation have increased the problems of sustaining the livelihoods of farming households, particularly for marginal farmers.

Emerging Situation of the Farming System

Land use pattern

A detailed enquiry revealed that the utilisation of land for the production of crops is very low, and decreasing at 0.2% per annum due to land degradation which makes farming communities unwilling to engage in agricultural activities that give low returns. The tendency to leave land fallow is increasing as land fertility decreases. At the same time, due to over-exploitation of forests by both local people and organised timber thieves, the land under forest cover is decreasing. Consequently, the land classified as barren and cultural waste has been increasing significantly in almost all mountain and hill areas. The land problems have caused shifts in the occupational structure of employment and led to increasing out-migration of the male labour force outside the state.

Production system

The productivity rates of major crops in hill districts were examined for at least a decade. A significant shift in the cropping pattern was seen in both plains and hill areas, but to a higher extent in hill areas. Utilisation of available land for the production of high-value commercial crops such as fruits, pulses, and off-season vegetables is increasing consistently, while land under the cultivation of low-value traditional food grains such as paddy, madua, wheat, and barley has been decreasing in hill areas.

Land distribution and utilisation

Cultivated land accounts for only around 13% of the state's total geographical area. The farmers own very small amounts of cultivable land, a sizeable part of which is not being utilised for either 'kharif' (summer) or 'rabi' (winter) crops, because the land has been degraded and to a large extent lost its productive capacity. Farmers keep the land fallow in alternate years to regain fertility. Of the total land available to the farmers, over 64% (90% in hill areas and 24% in plains areas) does not have irrigation facilities. In such circumstances, every category of farm in Uttaranchal can be considered as marginal and small.

There are 754,000 operational holdings in the state, of which 97% are marginal and small farms. The average land area per cultivator is only 0.6 ha (0.5 ha in hill areas and 0.9 ha in plains areas).

Over the years, landholdings have become fragmented due to the increasing population and numbers of households. Consequently, the numbers of small and marginal farms are increasing rapidly. Every year, the operational land area decreases by 0.2%, while the numbers of holdings increase by 0.3%. The increase in the numbers of marginal and small farms results from the fragmentation and sub-division of the highest categories of farms. The pressure of cultivators on the farming system is increasing at a much faster rate than the growth of population, and more sharply in hill areas than in plains areas. During the past decade, the average amount of cultivated land per cultivator has decreased from 1.4 ha to 0.6 ha, an annual decline of 5.8%.

Options for Improving Livelihoods

Given the problems of the existing farming system and various constraints to increasing the productivity of different field crops, diversification of the farming system by shifting the available land from the production of low-value food crops to hi-value commercial crops could be an important option for sustaining the livelihoods of marginal and small farmers. Shifting available land from growing traditional food crops to cultivation of fruits and vegetables has been instrumental in terms of both employment generation and increasing incomes. Utilisation of one hectare of land for cultivating fruits provides 77% more employment and 58% more income than the cultivation of agricultural crops (Mehta 1997).

Uttaranchal state has a great potential for growing different kinds of off-season vegetables, flowers, ornamental plants, mushrooms, and medicinal and tea plants in its different climatic zones. Temperate fruits such as apples, pears, peaches, plums, apricots, cherries, and walnuts are grown at elevations from 1000m to 3000m; and crops such as citrus, mangoes, litchi, banana, guava, papaya, strawberry, and different local fruits at elevations ranging from 300m to 1400m.

Fruits: area, production, and productivity

In Uttaranchal, 188,000 ha are under the production of different fruits, 15% of the total cultivated area. The land area for fruits increased by 132% between 1984/85 and 1998/99, the total production of fruits increased from 330,000 tonnes to 520,000 tonnes or 58%, and productivity per hectare increased from 2.3 tonnes to 2.8, or 20.4%. Apple is the most important fruit crop grown in the state and is cultivated on 55,000 ha, nearly 30% of the total area of all fruits. Farmers owning both small and large landholdings have become quite aware about the economic use of their available land. In some areas nearly 63% of fruit growers have expressed a desire to diversify and expand the size of their orchards by additional planting of different varieties of fruits. Farmers not currently engaged in growing fruits would also like to do so, but the problems of marketing represent a major constraint in diverting their land from the cultivation of traditional low-value crops to the plantation of fruit trees (Mehta 1988).

Vegetables: area, production, and productivity

Uttaranchal possess advantages over the plains areas in terms of producing a variety of seasonal vegetables, particularly potato and tomato, and the land area under vegetables has been increasing consistently. Between 1984/85 and 1996/97, the land area of vegetables increased from 46,000 to 90,000 ha, an average of 3,700 ha added each year mainly for potato and the productivity of all vegetables together increased from 6.1 tonnes/ha to 9.1 tonnes/ha.

These facts clearly indicate that farmers are increasingly shifting their available land into the production of different vegetables instead of growing traditional crops. Increasing returns from vegetables has influenced them to adopt various improved technologies, which have increased the productivity rates of different vegetables over the years. If this successful trend is sustained, the growing problem of poverty among marginal and small farms can be substantially reduced. However, at present, lack of proper marketing facilities and the absence of post-harvest technologies and storage facilities are serious constraints to a more rapid and systematic development of vegetable cultivation.

Marketing Arrangements and Support Services

The advance or pre-arranged sale of orchard crops is the most prevalent marketing arrangement in the state. It favours fruit contractors rather than fruit growers, as the contracted prices are usually significantly lower than market prices. At the same time, fruit grown in remote and less accessible areas does not find a convenient market. Collecting fruits from these areas is difficult even for contractors.

The emerging marketing problems could be solved by organising fruit growers to form cooperative societies and developing fruit markets and marketing centres in different fruit growing areas. This would also prevent perpetuation of the inequitable linkages prevailing between fruit growers and contractors. Marketing arrangements would need to ensure sale of fruits at remunerative prices and to make available crop-credit from banks and other financial institutions. A network of cooperative societies, including primary credit societies, would probably be the most effective system for these purposes.

In addition to these initiatives, it would be necessary to provide easy access to support services such as seeds, fertilisers, production techniques, improved agricultural services and methods, and marketing infrastructure in order to increase yield levels and minimise the risks involved in the shift from food-centred subsistence production to niche-based commercial production.

Measures for Meeting the Opportunity Cost of Shifting Land

Intercropping

Fruit trees require five to six years to develop before they can bear fruits and earn income. Therefore, the shift from the production of food grains to the plantation of fruits would initially mean hardship for farmers, particularly those owning very small pieces of land. Farmers should be encouraged and helped to carry out intercropping on land where fruit trees are grown. Suitable high-value commercial crops should be identified by carrying out research on the quality and suitability of soils for growing particular crops. A study by Karane (1996) showed that raising soybeans during the kharif season and peas in the rabi season successfully complemented pecan nut trees. Inter-cropping between fruit trees with oil seeds and local varieties of pulses has been quite successful over a period of four to five years in most orchards in Nainital and Almora. In fact, the value of pulses and oil seeds grown as intercrops is estimated to be much higher than the value of traditional crops grown on the same land. Nevertheless, Mehta (1996) estimated losses of 20% to 35% on production of agricultural crops as a result of intercropping with fruit trees in some areas. The yield will of course be relatively lower than cultivating food crops without fruit trees, but at least some food requirement will be met.

The Task Ahead

Mobilisation of public support for the diversification of farming systems by shifting land to the production of fruits and vegetables will not be a difficult task. Farmers are very keen to bring changes to the farming system and are making great efforts in this regard even without any proper support from either local institutions or the government. However, farmers possessing small landholdings are hesitant to adopt changes because of the high production and market risks. If this is not addressed properly, it could deprive farmers even of the limited subsistence they now derive from food crops.

References

Karane, K. D. (1996). 'Technologies for Improving Productivity of the Hill Agricultural System in Uttarkhand.' In Valdia K. S. (ed.) *Uttarkhand Today*. Almora: Almora Book Depot

Mehta, G.S. (1988) *Uttarkhand: Potential of Development*. New Delhi: Indus Publishing Co

Mehta, G.S. (1996) *Economics of Growing Apples in India*. Netherlands: University of Tilburg, Development Research Centre

Mehta, G.S. (1997) *Development Experiences and Options in a Hill Region: The Case of Uttaranchal, U. P., India,* Discussion Paper Series No. MEI 97/4. Kathmandu: ICIMOD

Impact of Accessibility on Issues and Options of Marginal Farms in the Nepalese Mountains

K. Gautam
Department of Agriculture, Kathmandu, Nepal

Introduction

In 56 out of 75 districts of Nepal, local food production is not adequate to meet the demand. The food deficit districts include 16 in mountain areas, 26 in hill areas, and 5 in the Terai (MDD 2000). Food insecurity and poverty are the key concerns of the mountain and hill farmers of Nepal because of the limited choices and options available for production of foodgrains on marginal lands.

Aside from small landholdings and various aspects of marginality, the root causes of food insecurity and poverty in the hill and mountain areas include the accessibility of services, markets, and goods. This paper will assess how the accessibility factor has impacted the livelihoods of marginal land cultivators. The paper is based on the findings of a study of three different sites: Charkhu of Okhaldhunga, Marpha/Tukuche of Mustang, and Madanpokhara village of Palpa district.

Impact of Accessibility on the Identification of Issues of Major Farms

Food security characteristics

The food security characteristics were analysed on the basis of food production as well as trade available from the land cultivated. In Palpa district, the Small Farmer Development Programme (SFDP) was launched 20 years ago to improve the livelihood of farmers. Under this programme various activities were launched through different NGOs and INGOs. Therefore the situation in this district has been improved and is different to that in the other areas. The marginal farms of this area are considered as a model for the hill regions of Nepal.

In terms of food security, 48% farms in the Okhaldhunga district had food sufficient for less than 3 months, followed by 24% in the range of 3-6 months. Only 5% of farms produced a surplus. The main cause of such small food surpluses is the lack of accessibility to markets, goods, and services (Table 1).

In the case of Palpa, which has relatively better accessibility to markets, services, and goods, the food security situation of the marginal farms was better: 57% of farms had a food surplus, while only 5% of farms were secured for less than 3 months.

No farm in Mustang produced surplus food, but at the same time no farm produced food sufficient for less than three months. About 40% of farms were within the range of 6-9 months food security, and 25% of farms produced food sufficient for 12 months.

Table 1: Food security status

Food Sufficiency Period	Okhaldhunga (%)	Palpa (%)	Mustang (%)
Surplus	4.8	57.1	0
12 months	9.5	9.5	25.0
9-12 months	14.3	9.5	17.8
6-9 months	0	19.1	39.3
3-6 months	23.8	0	17.9
< 3 months	47.6	4.8	0

Source: Field Survey, 2000

Sources of Income

In Okhaldhunga cereal grains contributed 68% of income, followed by orchards and livestock. This is due to the inaccessibility of markets, services, and goods. In Palpa, where accessibility is better, off-season vegetables accounted for 55% of income, followed by poultry. In Mustang, cereal grains contributed 19%, followed by livestock at 13%. Livestock are used to transport goods from the Mustang and Beni markets. The share contributed by apple orchards was only 8%, due to the transportation problem (Table 2).

The other source of income is migration. Most Okhaldhunga people who migrated did so to join the Indian or British armies, while Palpali people aimed for government service within the country. In Mustang, at least one member from each sampled household had migrated to Japan or the U.S.A. The marginal farmers share in the income earned from migration.

Table 2: Sources of income

Income Source	Okhaldhunga (%)	Palpa (%)	Mustang (%)
Cereal grain	68.3	7.5	19.2
High value crops	0.2	55.1	1.4
Orchards	1.6	7.7	8.2
Poultry/livestock	7.2	14.4	12.7
Other	22.7	15.2	58.7

Source: Field Survey, 2000

Impact of Accessibility on Marginal Farms

Okhaldhunga

Only one innovative farmer was found in the Okhaldhunga district sample village. This success story is presented in Box 1 to indicate the options available to marginal farms.

Palpa

In Palpa district, there are many innovative farmers as a result of the accessibility of goods, markets, and services and the influence of the small farmer programme. Farmers in these villages were trained in terraced management of sloping land under the Tinau Watershed Management Project launched by Swiss Technical Assistance (SATA). Before this project was implemented, the main cropping pattern on marginal land was maize/millet, wheat, or oilseeds, all rainwater based. The gross income from maize/millet - wheat was only about Rs.3,000[2] per 'ropani' (0.05 ha) of land. But now farmers are earning more than Rs.15,000 from the same land with the help of irrigation through polythene pipes.

BOX 1: **An Enterprising Farmer**

During the survey, we found one entrepreneurial farmer who maximised the income from marginal land and the available water resources: He was Raj Bahadur Magar. Mr. Raj Bahadur Magar owned only 0.25 ha of land and rented 1.17 ha of 'khet' (irrigated land). His own land is 0.10 ha upland and 0.15 ha khet. From this 0.25 ha land he formerly produced only five quintal[1] of paddy, maize, and millet, which was not sufficient for 3 months for his four-member family. But he went to the District Cottage Industry Office and received training for making furniture from bamboo. Even though promotional activity is poor, he now earns about Rs. 3000 a year from making bamboo furniture. In the same way he visited the Agriculture Service Center (ASC) at Rumjatar and obtained a minikit of vegetables for a kitchen garden. He produced some green vegetables and sold them to the nearby Rumjatar market and earned Rs. 1000 with little effort. He again visited the ASC and asked staff to visit his area and make suggestions for his bari use. In his bari he formerly produced only maize and millet, but now he produces green garlic, onion, and fresh vegetables like cabbage, rapeseed, and cauliflower for the Rumjatar market, and earns Rs. 10,000 per year from vegetable production. Now his food sufficiency has increased to 6 months. His success in income earning from crop changes on bari inspired his brother Mr. Pushpa Bahadur Magar to also start garlic production. Other farmers of marginal land are also thinking of changing their cropping patterns where irrigation is available to allow vegetable production.

Mustang

The case study presented in Box 2 shows clearly how inaccessibility is a major constraint for land utilisation and crop diversification.

Thus, if different services, goods, and markets are accessible, the marginal farmers will try to use them by diversifying their crops, changing land management, and investing in livestock and poultry rearing. Depending on various factors, in conditions of good

BOX 2: **Apples in Mustang**

Mustang district has a high potential for apple cultivation. Each and every household has some apple trees. However, farmers are unable to divert their land to apple orchards because they cannot transport the fruit to the markets in Pokhara and beyond. Mr. Karna Bahadur Thakali, an innovative farmer in Marpha, says that the 75 trees he owns could produce 8250 kg of apple. Last year he transported four tonnes (50%) using his own four horses, and earned Rs.50,000. If proper accessibility were developed, he and his friends would be able to sell 75% of their production and earn more money. Road accessibility is needed because the production pockets are located in up-Pakho, only a few farmers have converted low land into apple orchards. If accessibility were improved, farmers would use the lowland area for apple orchards and import the needed cereal grain. The average net output per hectare from cereal grain is 2700 kg, with a value of about Rs. 16,900, while from apple the 30,500 kg produced would fetch Rs. 100,000 in local markets and nearly Rs.200,000 in outside markets.

[1] 1 quintal = 100 lbs or 100 kg. ed
[2] In 2000, NRs 72 = US $ 1 approx.

accessibility a moderate farm size would be 0.5 ha in Palpa and 1.5 ha in Okhaldhunga. For horticulture based farming, a moderate farm size would be 0.75 ha.

Conclusions and Recommendations

Marginal farmers are productive in terms of cropping intensity, but not necessarily in terms of yields. This is due to the lack of access to inputs that would raise productivity, to technology, and to markets.

To improve the food security of marginal farmers, the output of crops grown on marginal lands under marginalised conditions should be increased. New technologies are mostly only available for irrigated land. As yet there has not been a major research breakthrough specific to coarse grain like naked barley, buckwheat, barley, and finger millet; and improved seeds are not available.

If the accessibility of goods, services, and markets is increased, then marginal farmers who have marginal land diversify their cropping patterns (as seen in Mahan Pokhara) and start to cultivate high-value crops (as in Okhaldhunga).

Eco-friendly road or ropeway programmes should be identified and made available to farmers who cannot access markets for their high-value crops.

Furthermore, in mountain areas features such as fragility, marginality, lack of accessibility, and internal resource heterogeneity should be taken into account before devising plans for reducing poverty through production opportunities.

References

MDD (2000) *Special Issue Market Information Bulletin*. Kathmandu: Market Development Division, Department of Agriculture

Use of Marginal Land to Improve the Livelihoods of Mountain People: Experiences from Himachal Pradesh

H. R. Sharma[1] and T. Partap[2]
[1]Department of Agricultural Economics, Himachal Pradesh Agricultural University, Palampur (HP) India
[2]Himachal Pradesh Agricultural University, Palampur (HP) India

The mountain ecosystem is characterised by abundant marginal lands that include sloping lands. These lands have been variously called resource poor lands, fragile lands, vulnerable lands, or degraded lands; in data reporting systems, they are reported under different categories like cultivable land, barren and uncultivated land, and pastures. As a result, the mountains have a very small amount of cultivated land. For example, in the HKH region, only 11% of the total geographical land is suitable for cultivation. While the population density per sq. km is very low, it is extremely high relative to the available agricultural land. However, because of varied agro-climatic conditions, reflected in diverse niches, there is a huge potential for growing different high value cash crops on the marginal lands. Experiences in different HKH regions have shown that the adoption of high value cash crops, compatible with the mountain niches, has helped some pocket areas in multiple ways. In Himachal Pradesh this has been achieved first, by converting the abundant marginal land into more productive land and harnessing local niches; second, by maintaining and improving the ecology and environment of the region in terms of soil conservation and increasing soil fertility; and third, by making a qualitative impact on the economic conditions of the people, which helped break the so-called poverty-environmental degradation-poverty cycle. Thus, contrary to popular beliefs and notions, the evidence from these areas suggests that the processes of development and conservation of ecology and environment can be mutually supportive and reinforcing. The present study was undertaken to study the trends in the process of marginalisation of holdings, and the availability of marginal lands for expanding farming in different areas of the state of Himachal Pradesh (HP). The study, drawing on the experiences of fruit farming in the state, highlights the impact of the use of marginal lands on the quality of life, equity, ecology, and environment of the local area. The emerging challenges and the need to evolve new technologies for the productive use of marginal lands are also discussed.

The Marginalisation of Holdings

In HP, small holdings comprise more than 80% of the total landholdings in most areas and districts, including high hill districts. There is a declining trend in the per capita availability of agricultural land, thus increasing the number of marginal/small farmers. The continuous sub-division of holdings in the absence of alternative employment opportunities has accelerated the process of marginalisation of holdings. Over time most of the holdings are becoming economically non-viable and becoming non-marginalised in the production process, endangering the livelihoods of the mountain people. In view of this, the availability of huge areas of marginal land offers a ray of hope if suitable crops that could be grown in these areas can be identified and a technology for growing them evolved (Partap 1998, 1999) The experience of Himachal Pradesh has shown that these lands can be used productively with positive economic and environmental effects. Before reviewing the available evidence, we present the current status of the availability of marginal lands in different areas and districts of the state.

Availability of Marginal Lands

A significant amount of marginal land, which includes cultivable wastes, current fallows, other fallows, and so on, is available for expanding farming and easing the huge pressure on land in both the high hill and low hill areas. In the high hill areas, the marginal land potentially available for farming varied from as high as 11.4% to as low as 1.4%. Another important feature is the availability of a significant amount of land under grasslands, which varied from one-fourth to two-thirds of the total geographical land. In the low hill districts, marginal land that can be made available for farming varied from 3.1% to 19.5%. The land under grasslands was significantly lower in the low hill areas than in high hill areas. In all areas a substantial amount of land under forests would be productively used if the present forest laws were amended to allow the farmers to select forest plantations according to their requirements and to involve them in management and benefit sharing. In brief, a significant amount of marginal land is available for expanding farming.

Table 1 shows the potential for growing different cash crops in different agro-climatic regions of the state. While crops like vegetables, off-season vegetables, and floriculture require good quality irrigated land, fruits and medicinal plants can be grown on unirrigated sloping marginal lands. The studies carried out by the Institute of Himalayan Bio-Resources, Palampur, have shown that a number of aromatic and medicinal plants can be successfully grown in temperate and dry temperate regions of the state where abundant marginal lands are available.

Table 1: Potential for growing high value cash crops in different agro-climatic zones of Himachal Pradesh

	Low hills (350-650 metres)	Mid hills (650-1800 m)	High hills (1800-2200 m)	High hill dry zone (2000-3500 m)
Irrigated Crop Area				
Vegetables	vegetables	off-season vegetables	seed potato, temperate vegetable seeds, off-season vegetables	peas, seed potato, off-season vegetables, vegetable seeds, kuth, saffron, hops, kalazira
Flowers	gladiolus, rose, chrysanthemum, dahlia, bird of paradise	gladiolus, rose, chrysanthemum, dahlia, bird of paradise	tulip, lilies, carnation, daffodil, iris	-
Unirrigated Marginal Land				
Fruit crops	mango, citrus fruits	stone fruits, citrus fruits	apple, kiwi, cherry, almond,	apple, dry fruits, nuts, chilgoza
Medicinal and aromatic plants	*Terminalia chebula, T. bellirica, Emblica officinalis, Cymbopogan nardus, Rosa officinalis*	*Viola* sp, *Nardostachys, Centella asiatica, Origanum vulgare L., Ficus palmata Forsk*	*Polophyllum, Taxus baccata, Angelica glauca, Berberis aristata Dc., Acorus calamus, Picrorhiza, Swertia chirita, Jurinea Nardostachys grandiflora*	*Aconitum ferox, A. heterophyllum, Saussurea costus* (Falc.) Lipsch, *Artemisia* spp., *Dactylorhiza hatagirea, Amebia benthamii, Hippophae* sp,

Source: Compiled by the author in consultation with scientists of IHBT, Palampur

Use of Marginal Land in Himachal Padesh

The state of Himachal Pradesh has made rapid strides in fruit farming and has acquired the status of fruit bowl of the country. The state's development strategy has been considered a model for other hill and mountainous states. The adoption of a development strategy in conformity with mountain specificities has been the single most important factor in triggering the process of sustainable agricultural development. The strategy focused on providing a sound physical and institutional infrastructure. Empirical studies have documented the diverse effects of the spread of fruit farming on the economy and environment. More precisely, studies have shown how fruit farming, which mostly uses marginal and sloping lands, has affected the quality of life, equity, and ecology and environment of the local people and area. The results of one such study conducted in the Kullu Valley of Himachal Pradesh that compared the economic and ecological effects of fruit farming with those of subsistence crop farming are presented here.

To begin with, we compared the livelihood options and their contribution towards total household incomes in the fruit farming region with those of the subsistence-farming region. Household incomes in the fruit farming region were nearly double those in the subsistence farming region. Further, while there was not much difference in the configuration of the livelihood options in the two regions, their importance differed significantly. For example, fruit farming contributed more than two-fifths of the household income in the fruit farming region as compared to less than one-fifth in the subsistence-farming region. Likewise, the contribution of crop production was much less in the former compared with the latter region. Options like agricultural labour and non-agricultural labour were not important in the fruit farming region, whereas they contributed a significant proportion of household income in the subsistance region. In brief, the livelihood options in the fruit farming region, most of which is on marginal and sloping lands, were far superior to those in the subsistence region.

The high quality livelihood options have made significant contributions to improving the quality of life of the people in the fruit farming region areas like health and nutrition, human resource development, access to basic amenities, and general economic status. Although some poverty remained in the fruit farming region, it was much less than the 30% found in the subsistence farming region.

The impact on equity, one of the essential conditions for ensuring sustainable agriculture, was studied in terms of different indicators, some conventional and some non-conventional (Table 2). The degree of inequality, including gender inequality, was much lower in the fruit farming region than in the subsistence farming region. The high degree of gender

Table 2: Implications for equity: some indicators

Indicators	Fruit farming	Subsistence farming
Male wage (agriculture) (US $/day)	1	0.87
Female wage (US $/day)	0.87	0.71
Income distribution (Gini ratio)	0.37	0.40
Female literacy (%)	43	34
Male literacy (%)	61	54
Percentage of female participation in households' decision making	90	40
Percentage of females with secondary and higher level education	41	13

equity is also reflected in the flexible sexual division of labour. Women now perform a number of activities that were earlier considered as male prerogatives, and they enjoy more freedom than their counterparts in the subsistence farming region.

The implications of fruit farming for ecological and environmental sustainability were studied in terms of different indicators like livestock population, investment in agriculture, crop yields, and cropping patterns. A number of features have significant positive implications that augur well for ecological and environmental sustainability. For example, the decline in the livestock population accompanied by improvement in breeds and the switch to stall feeding has resulted in higher milk yields and higher availability of farmyard manure (FYM). Likewise, the improvement in the quality of life has lessened the pressure on forests as sources of fodder and fuel wood. Another important indicator is that 30-40% of household income is being invested to improve and conserve natural resources like soil and water. These indicators and the process of change underlying them refute the notion that there is inherent incompatibility between development and environment. The evidence shows that the abundant marginal lands can be productively utilised with a significant positive impact both on the economy and the environment.

Conclusions and Challenges

To recapitulate, the mountains and hills are facing an acute scarcity of agricultural land because of increasing population pressure. The lack of alternative employment opportunities and continuous sub-division of land holdings is rendering most of the holdings non-viable. In their desperate bid to maintain subsistence levels of agriculture, farmers have extended cultivation to steep slopes, leading to falling yields, rapid environmental degradation, and ultimately, endemic poverty and impoverishment. The whole process is manifested in the so-called poverty–environmental degradation–poverty cycle. This has posed a serious problem in ensuring sufficient livelihoods for the mountain people. Happily, however, a significant amount of marginal land currently reported under fallows, cultivable wastes, barren, and uncultivable land is available for productive use if suitable crops that can be grown on these lands are identified and the technology for growing them evolved. Experience has shown that wherever options are available to the farmers of such lands, they have been used productively to make significant improvements in the livelihoods, and this has also had a positive ecological and environmental effect. However, R & D efforts focusing on these lands have not received much attention. This poses a serious challenge to the scientists, technologists, and policy makers seeking to use these lands more productively.

References

Partap, T. (1998) *Marginal Lands and Marginalised Farmers in the Hindu Kush-Himalayan Region: Challenges and Opportunities*, Paper presented at the International Conference 'Mountains 2000 and Beyond', held at Wildbad Kreuth/Federal Republic of Germany, June 21-23, 1998

Partap, T. (1999) 'Sustainable Land Management in Marginal Mountain Areas of the Himalayan Region.' *Mountain Research and Development Review*, 19(3): 251-260

Sharma, H. R. (1996) *Mountain Agricultural Development Processes and Sustainability - Micro Evidence from Himachal Pradesh, Indian Himalayas*, Discussion Paper Series No. MFS 86/2. Kathmandu: ICIMOD

Transition in Land-use Conditions of Marginal Farms in Mountain areas of Nepal

N. Khanal
Central Department of Geography, Tribhuvan University, Kathmandu, Nepal

Introduction

Mountain farming is undergoing several stresses as a result of shrinking landholdings, increased farming on marginal lands, increasing soil erosion and declining farmland fertility, inadequate food production, and degradation of support lands. The scarcity of crop land has serious implications for food security. However, there are ample opportunities for using marginal and sloping lands in sustainable ways if appropriate technological and management choices are made. Mountain areas in the Himalayas have relatively abundant but under utilised marginal land that can be opened to certain types of mountain agriculture. A variety of potential niches and production systems can be developed to make such farming ecologically and economically sound. It is essential to assess the geography and people, particularly the land use patterns, to develop appropriate strategies for technological and management interventions.

This study seeks to identify various types of marginality and access to spatial infrastructure, and the processes of land use and land cover in the Madi watershed.

Methodology

The study was conducted in the Madi watershed area, which forms one of the major tributaries of the Gandaki river in the central part of Nepal. The watershed was divided into three distinct regions based on topography, geology, land use, and accessibility. The upper region is a high mountain landscape characterised by higher precipitation and lower accessibility. The middle region is moderate in terms of topography, precipitation, and accessibility. The lower region has good accessibility. There are three sub-watersheds – Madi, Rudi, and Midim – in the upper region; five sub-watersheds in the middle region; and two sub-watersheds – Sange and Kalesti – in the lower region. At least 40 households from each village or landscape were surveyed.

Data were collected at the household level using a structured questionnaire that included socioeconomic aspects. In addition to the questionnaire, a checklist was prepared to collect information from group discussions.

Results

Marginality and access to spatial structures

Marginality is a complex concept that depends on the prevailing socioeconomic and political systems. Because it can be viewed from various perspectives, there is no widely applicable definition of marginality or marginal farmers. However, attempts have been made to review the classification of farm households and the definition of marginal farmers used to date in the context of Nepal.

Since this study sought to identify the spatial issues of marginal farmers, particularly regarding land use patterns, performance, and processes in the Madi watershed, rather than to define and determine the number of people below the poverty line, the size of landholding was been used to define marginality. Farm households holding less than 0.5 ha were defined as marginal, those with 0.5-2 ha as small, and those with more than 2 ha as medium and large.

Of the 556 households surveyed, nearly 38% were classified as marginal, 51% as small, and less than 2% as large. The proportion of marginal farm households was comparatively high in the lower part of the watershed at 46%, but decreased to 37% in the middle and 33%in the upper part. However, even marginal farm households sometimes rent their land to other small farm households.

A large number of ethnic groups with different cultural backgrounds inhabit the Madi watershed. More than 45% of farmers in the Kami, Damai, Sarki, Darai, and Kumal ethnic groups had marginal landholdings, and this figure was consistent in all parts of the watershed. Traditionally, these occupational caste groups did not possess large landholdings. The percentage of marginal farm households among the Magar and Newar ethnic groups was also higher than the overall average. Newars were traditionally involved in trade and business, so they tend to have small landholdings.

Process of Land Use and Land Cover

The assessment of existing land use and land cover conditions was confined to privately owned land.

Types of land and landholding size

The average size of 'khet' (irrigated) landholdings for the whole watershed was 0.4 ha; 0.3 ha in the lower, 0.4 ha in the middle, and 0.5 in the upper area; and 0.1 ha for marginal, 0.5 ha for small, and 1.1 ha for medium and large households.

The average size of 'bari' (rainfed) landholdings was around 0.4 ha in the lower, middle, and upper areas. Thus average khet holdings in the upper areas were more than bari, and in the lower region less. The lower area is drier, and most of the lower and middle parts of the watershed are rain fed, although the production potential of land in the lower part is higher than that of land in the upper part. Two to three crops a year can be grown in the lower region with provision of water and other agricultural inputs, whereas only one crop can be grown in the upper part because of temperature limits. A large labour force has been employed in converting rainfed bari land to khet land in the upper part, where the availability of water has made this feasible.

The average size of bari landholdings among marginal, small, and medium and large farm households was 0.2, 0.4, and 0.8 ha, respectively. The average size of bari landholdings among the marginal households was more than the average size of khet land in all eco-regions, showing the domination of rainfed crop land among marginal farm households.

'Kharbari' is open land used to grow thatch or to graze animals. The overall average amount of such land among marginal farm households was 0.004 ha; 0.005 ha in the lower, 0.006 ha in the middle, and 0.002 ha in the upper region.

'Korea' is land used for shifting cultivation. This type of land is confined to the upper region; the average size was 0.006 ha, and 0.008 ha among marginal farm households. In the past, this type of land was used to grow crops in three- or five-year rotations. However, this type of cultivation has stopped due to labour shortages resulting from migration of the economically active population and strict prohibition of such activities by the Annapurna Conservation Area Project. Such land could be utilised to grow permanent crops in the future.

Abandoned khet and bari lands, which were used to grow crops in the past, have been left fallow, particularly in the upper region and the ridge slope of the middle and lower regions. The reported average size of such landholdings in the watershed was 0.1 ha, 0.02 ha in the lower, 0.02 ha in the middle, and 0.18 ha in the upper region. Overall, the amount of abandoned land, particularly in the upper and middle regions, appeared to be higher than reported.

Wasteland occupied by landslide debris or sand and gravel brought by the river at flood times is also cultivable. The average size of such landholdings was 0.012 ha: 0.006 ha in the lower, 0.003 ha in the middle, and 0.02 ha in the upper region.

On average, each household owned 0.16 ha of wasteland, 21% of the average crop land area owned. Marginal farm households owned 0.3 ha wasteland on average, 33% of the average crop land area owned by these households.

Land Cover

Crop combination and cropping intensity

Nepalese farmers generally grow more than one crop on each plot, but in this area nearly 28% of the plots owned were under a single crop system; 36% produced two crops, 6% three, and less than 2% more than three. Among marginal households, 26% of plots produce a single crop, among small 29%, and among medium and large households 25%. Marginal households have a higher percentage of plots producing more than one crop than small and medium and large households.

In terms of area, nearly 31% of all cropland was under a single crop system, 36% under a two-crop system, 9% under a three-crop system, and 3.5% under a more than three-crop system. The proportion under a one-crop system ranged from 24% in the lower, to 36.5% in the middle, and 32.2% in the upper area. Similarly, the percentage under a two-crop system ranges from 37.2% in the lower, 35% in the middle, and 35.8% in the upper. The percentage under more than a two crop system is 26.6%in the lower, 13.1% in the middle, and 5% in the upper. The area under a single-crop system among marginal farm households is 29.6%, followed by 43.4% for a two-crop system and 16% for more than a two-crop system. Nearly 10.8% of crop land is left fallow.

The average cropping intensity in the watershed was 140%, which is very low compared to the figures from the National Sample Census of Agriculture in 1991/92 of 177% for hill areas and 161% for mountain areas, but higher than the 123% for hill areas and the 125% for the mountain areas reported by the National Census of Agriculture in 1981/82. Cropping intensity ranges from 154% in the lower to 147.7% in the middle and 129.5% in the upper areas. Cropping intensity among marginal farm households was 154%. Cropping intensity on bari land (157%) was higher than on khet land (123%). Bari land is dominated by a two-crop system of maize and millet, whereas the khet was dominated by a single crop, paddy. In areas along the river valleys where irrigation is available, up to three crops – paddy-wheat-paddy or paddy-wheat-maize – are grown on khet land. But the overall percentage of area under two or more crops in khet land is very low, mainly due to the winter shortage of water for irrigation, particularly in the middle and lower regions.

Horticulture

Commercial production of fruit is a recent phenomenon in this area. In some pockets of the watershed, oranges and other citrus fruits are now grown, but this activity has not yet developed in other parts of the watershed despite being economically and ecologically very sound. The average number of fruit trees or plants grown by each household was very low.

On average, each household in the watershed grew 3.3 orange trees, 12.3 banana trees, 15.3 pineapple plants, 0.3 mango trees, and 0.7 guava. The average number of orange trees ranges from 3.3 in the lower to 5 in the middle and 2.3 in the upper. For banana, the range is from 13.6 in the lower to 29 in the middle and 0.3 in the upper. For pineapple, it is 10.5 in the lower, 42.6 in the middle, and 0.4 in the upper. The average quantity of production is again very low among marginal farm households.

Conclusions

The development problem in this area is not lack of capital but lack of technology and management skills. Future development efforts should be focused in this direction.

A large amount of cultivable wasteland is now under-utilised. If appropriate technology and management skills are provided, these lands could be utilised to improve the economic conditions of farm households. Though the volume of monsoon precipitation is quite high, water is scarce during winter in the upper slopes, particularly in the middle and lower part of the watershed. Rainwater harvesting and management could allow such cultivable wasteland to support permanent crops.

Landholdings are not only small; they are also highly fragmented. Poor farmers lack the right to use abandoned plots, so they encroach upon the forest area. This implies that the rules and regulations of land ownership rights should be reviewed and appropriate rules and regulations formulated to solve this problem.

The production of agricultural crops is not sufficient to provide food security, and the area is in food deficit. Abandoned terraces should be utilised in a sustainable way.

Increasing scarcity of cropland due to rapid population growth is a major challenge in Nepal. Diversities due to spatial variation in altitude, slope, climate, vegetation, and socioeconomic and cultural values and practices of the local people have created a variety of potential niches and production systems in mountain areas. The present level of food production can be raised through intensification and diversification based on the land's production potential. Large amounts of land such as 'kharbari', 'parti', 'bagar', 'gauchar' and 'butyan' exist outside the current area of crop land under different ownership rights – private, community, and government. These 'marginal lands' also have specific niches or comparative advantages that can be harnessed in a sustainable way for productive use, if appropriate technological and management choices are made.

Impact of Leasehold Forestry on Marginal Mountain Farms in Nepal

F. M. J. Ohler
FAO Technical Assistance to Hills Leasehold Forestry and Forage Development Project, Kathmandu, Nepal

Introduction

The concept of community-based leasehold forestry was introduced to Nepal via the Forest Act of 1993, through the Hills Leasehold Forestry and Forage Development Project (HLFFDP). This project has two objectives: raising the incomes of hill families who are below the poverty line, and contributing to improving the ecological conditions of the hills.

Four line agencies are involved in the HLFFDP: (1) the Department of Forests is the lead agency, responsible for the leasing process; (2) the Department of Livestock Services is responsible for technical support to leasehold groups on fodder and livestock development; (3) the Agricultural Development Bank of Nepal (ADBN) provides credit to leasehold farmers; and (4) the Fodder and Pasture Division of the Nepal Agricultural Research Council (NARC) carries out applied research. The project is financially supported by the International Fund for Agricultural Development (IFAD). The Government of the Netherlands funds technical assistance through the Food and Agricultural Organization (FAO) of the UN.

This paper presents a cohesive model for causal linkages from the leasehold forestry project intervention to its impact on marginal mountain farms of Nepal. There is substantial evidence to support this model.

- **Household survey data –** From 1994 to 1999, annual household surveys were conducted, ultimately reaching 256 project and 122 control households. In 2000 a data validation was undertaken, followed by a thorough statistical analysis (Thompson 2000).
- **Group and site information data –** The HLFFDP has systematically collected data from all leasehold groups and sites on an annual or bi-annual basis. The last round of data collection was in 2000, covered 1549 leasehold forestry groups, and was followed by a systematic analysis (Singh & Shrestha 2000).
- **Site-specific impact assessment on vegetation and social development –** In 1994 and 1995 a series of studies was undertaken in new leasehold sites using the International Forestry Resources and Institutions (IFRI) methodology. In 2000, follow-up studies were carried out in two sites to assess the impact of leasehold forestry on vegetation and social development (NFRI 2000 a, b).
- **Comparative studies of women with differing access to forest resources –** In 1999 and 2000 two studies were carried out in which 57 women were interviewed, 20 with access to leasehold forest, 19 with access to community forest, and 18 without access to community or leasehold forest (Douglas & Cameron 2000; Ghimire 2000).
- **Ongoing studies –** such as feeding values of fodder species, and vegetable production by leasehold farmers, HLFFDP annual reports, and staff reports.

Target Group: Marginal Mountain Farms

Subsistence farmers who do not produce sufficient food for their household consumption are defined as marginal farmers. By July 2000, 1549 leasehold forestry groups had been formed, with about 10,500 member households located in 10 districts of the central and western development regions of Nepal, at altitudes ranging from around 400-2000m. Subsistence farming is still the norm in these areas, and household food self-sufficiency is a criterion used by farmers themselves to define poverty or wealth. In the project area there is a clear correlation between the area of cultivated land and household food sufficiency. Households with about 0.25 ha of cultivated land are likely to have around 4 months of food sufficiency; households with about 0.5 ha of cultivated land have around 7 months food sufficiency; households with about 0.75 ha of cultivated land have around 10 months food sufficiency; and households with about 0.9 ha of cultivated land have around 12 months (i.e., year-round) food sufficiency.

The project included three main interventions.

1. **Leasehold group formation and forest handover** – On average about 0.6 ha of degraded forest per family was handed over as leasehold forest, usually for 40 years at no cost.
2. **Training and inputs** – Land-development training was provided to all new leasehold households, with both men and women participating. Standard inputs provided include seeds of grasses and legumes, tree saplings, and planting material. Both the District Forest Office and the District Livestock Office provided training and inputs.
3. **Access to credit** – A special credit facility was provided through the Small Farmers Development Centre of the Agricultural Development Bank of Nepal.

Effects and Impact

The interventions have two direct or primary effects, which lead to three secondary and four tertiary effects, each resulting in certain impacts improving the family welfare and livelihood of the leasehold farmers.

First primary effect: increased fodder availability

Converting a degraded forest into a leasehold forest in the care of a resource-poor farmer's family results in a quick and sustained increase in the vegetative cover of the forest. In newly formed leasehold groups, on average only 32% of the ground is covered by vegetation, this jumps to 50% after one to two years, and then gradually increases to 78% percent in 6-7 year old sites.

Second primary effect: increased quality and productivity of livestock

Access to credit enables farmers to purchase livestock, and they will often opt for an improved breed or more productive type of animal (e.g., milking buffalo instead of cow). A sample of 298 households indicated that the ownership of cows was progressively decreasing, while ownership of buffaloes was increasing, as was the ownership of goats.

First secondary effect: increased time available to women farmers

The first primary effect, increased fodder from leasehold and private land, reduces the time women need to collect fodder. Interviews with women indicate that five years after the leasehold groups are formed, the average time needed to collect fodder is reduced from 3.9 to 1.4 hours per day, a difference of 2.5 hours per day.

Tertiary effect: opportunity to diversify income sources

When women gain 2.5 hours per day, they may take some rest from their heavy workloads, but there is evidence that especially women are more engaged in new income generating activities. According to the household survey, the numbers of household members earning cash income increased by 24% between 1996 and 1999 in leasehold households, compared to a decline of 4% in control households.

A widely observed trend shows that with increased availability of fodder and time, and diversification of income sources, increasing numbers of households start selling fodder, from none in the first year to 16.4% in 6-7 year-old groups.

Tertiary effect: opportunity to attend more meetings, training, and literacy classes

The increased availability of time should also make it easier for women to attend meetings, training, and literacy classes. The leasehold households are from the poorest section of society, with lower than average school attendance and high rates of illiteracy, especially among women. Many leasehold women also report that they got the opportunity to attend literacy classes through mediation of the project.

Second secondary effect: increased stall feeding

Increased availability of fodder makes it much easier for farmers to convert from free grazing to stall feeding. In the case of large livestock, we have observed an important increase in buffalo ownership and a decrease of cow ownership. According to the household survey, 47% of leasehold farmers reported an increased period of stall feeding of goats in 1999 as compared to 1996. However, control households showed a similar, but weaker trend, reporting a 32% increase in stall feeding of goats.

Tertiary effect: reduced pressure on forest vegetation

Increased stall feeding results in reduced grazing pressure on forest and other types of vegetation. Data from the Chitripani and Bhagwatisthan leasehold forests sites indeed show a big increase in diversity of plant species. In Chitripani, plant species diversity in 9 ha of leasehold forest increased from 37 species in 1994 to 58 species in 2000, an increase of 57%. In Bhagawatisthan, plant species diversity in 78 ha of leasehold forest increased from 70 species in 1995 to 130 species in 2000, an increase of 86%.

Tertiary effect: increased manure

Increased stall feeding results in increased availability of manure. However, the project has no precise information on the quantity and quality of manure produced. Increased availability of farm manure should result in increased food production and food sufficiency, and household food security has indeed improved. According to the household survey the period of food security between 1996 and 1999 increased from an average 7.8 months in 1996 to 8.4 months in 1999, while the household size increased from 6.6 to 7.1 persons.

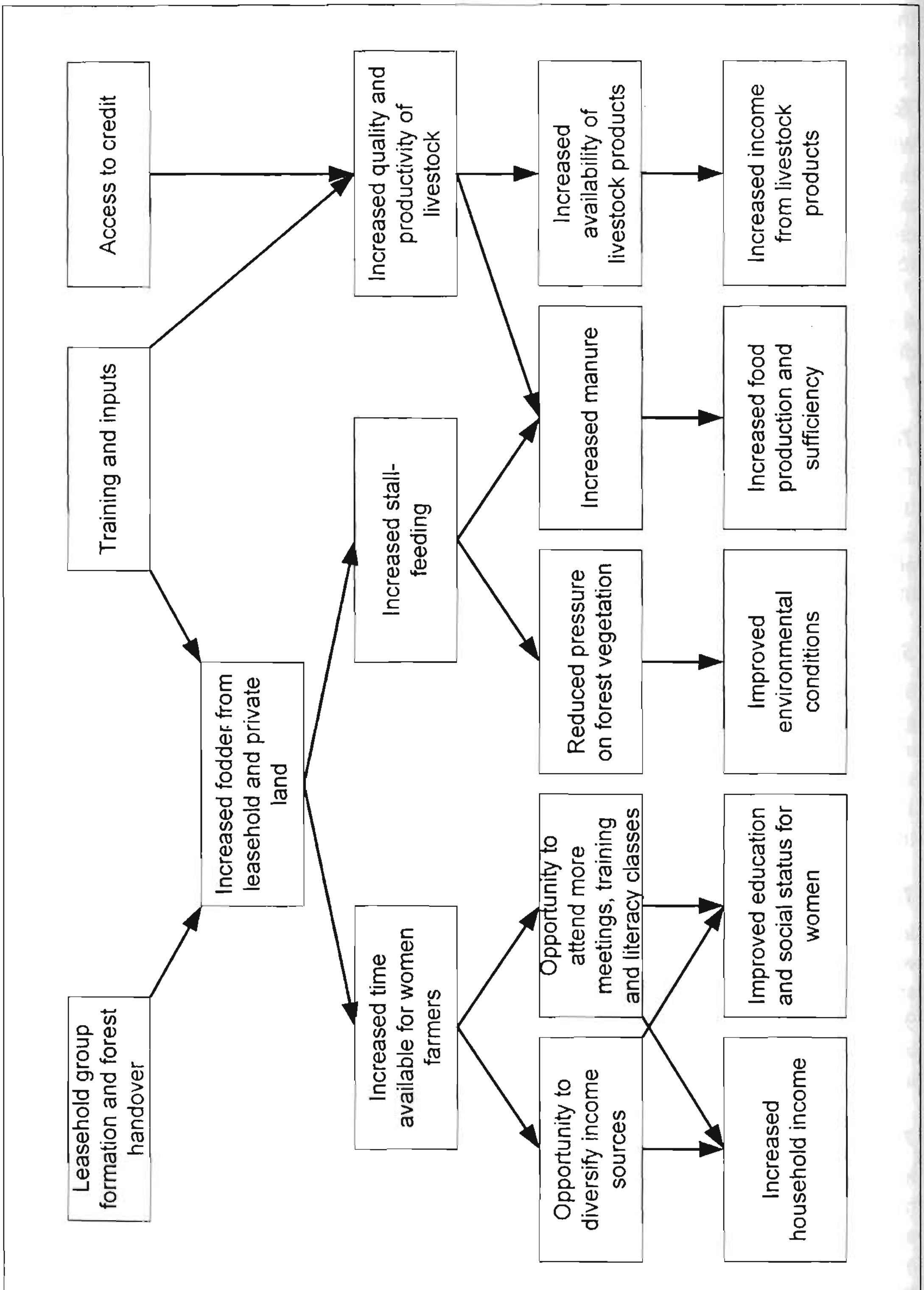

Figure 1: Model from intervention to impact of leasehold forestry on marginal mountain farms in Nepal (based on Ohler 2000 and Thompson 2000)

Third secondary effect: increased availability of livestock products

An increase in the quality and productivity of livestock leads to an increased availability of livestock products, which then should result in increased food sufficiency, and increased income from livestock products. There is strong evidence that the proportion of households generating income from livestock products is gradually increasing. In newly formed leasehold forestry groups, 53% of households earn cash from the sale of goats, as compared to 88% 6-7 years after group formation. Similarly, in newly formed leasehold forestry groups 20% of households earn cash from the sale of buffalo milk, as compared to 41% 6-7 years after group formation.

Model for Linkages from Intervention to Impact

We have seen how the different interventions interact and result in primary effects, and how these primary effects lead to secondary and tertiary effects, each leading to one or more final effects or impacts. With the evidence presented, we can draw up a model of the impact of leasehold forestry on marginal mountain farms in Nepal, based on causal linkages, starting from the projects' interventions (see Figure 1).

Discussion

Leasehold forestry provides forest resources to the poorest households. As a result, more households are able to engage in rearing livestock than before. Reduced grazing as a result of stall feeding leads to positive impacts on the forest and environment.

Leasehold forestry provides tenure security through leases of 40 years on degraded holdings, and motivates farmers to invest in land improvement with a long-term perspective. Leasehold forestry decreases poverty, but it is true that easy access to credit may result in increased dependency on credit institutions.

Leasehold forestry improves the condition of women, especially through saving time in the collection of fodder and forest products. However, this evidence is based on interviews with women who have been members of leasehold forestry groups for more than five years.

Potential of Leasehold Forestry and its Limitations

If leasehold forestry for the poor is limited to the handing over of degraded forest, then the actual area of degraded forest determines the maximum extent of leasehold forestry. However, there are other limiting factors too, in particular altitude and population.

HLFFDP experience shows that at altitudes over 1700m (about 5000 feet), leasehold forestry is problematic for several reasons, as the growth and regeneration of the vegetation is much slower and the production of harvestable fodder is much lower.

The population can be a limiting factor as well, if for example there are large areas of degraded forest without enough (poor) people living in them.

References

Douglas, Z.; Cameron, J. (2000) *The Effects of Differing Access to Forest Resources on the Livelihoods and Capital Assets of Poor Women in Kavre District, Nepal,* Project Internal Document 7/2000. Kathmandu: FAO, Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

Ghimire, K. (2000) *The Effects of Differing Access to Forest Resource on the Livelihoods and Capital Assets of Poor Women in Makwanpur District, Nepal,* Project Internal Document 11/2000. Kathmandu: FAO, Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

NFRI (2000a) *Impact Assessment of the Hills Leasehold Forestry and Forage Development Project on Vegetation and Social Development in Bhagawatisthan Site. Bhagawatisthan (Kavrepalanchowk District),* Nepal Forest Resources and Institutions – research program (NFRI)/ FAO - Project Internal Document 12/2000. Kathmandu: Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

NFRI (2000b) *Impact Assessment of the Hills Leasehold Forestry and Forage Development Project on Vegetation and Social Development in Chitrepani Site. Churiamai VDC – Hetauda Municipality (Makwanpur District),* Nepal Forest Resources and Institutions – research program (NFRI)/ FAO - Project Internal Document 13/2000. Kathmandu: Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

Ohler, F.M.J. (2000) *The Impact of Leasehold Forestry on Livelihoods and Environment,* FAO – Field Document 3/2000. Kathmandu: Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

Thompson, R.H. (2000) *Assessment of the Impact of HLFFDP on Participating Households from the Household Survey Data 1994-99,* FAO - Project Internal Document 10/2000. Kathmandu: Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

Singh, B.K.; Shrestha, B.B. (2000) *Status of Leasehold Groups and Leasehold Sites,* FAO – Field Document 5/2000. Kathmandu: Technical Assistance to the Hills Leasehold Forestry and Forage Development Project

Problems and Potentials of Crop Diversification for Marginal Farmholders in the Dry Mountains of Dingxi County, North-west China

Lin Zhen and J.K. Routray
School of Environment, Resources and Development
Asian Institute of Technology, Pathumthani 12120, Thailand

Introduction

Agriculture is the dominant sector of China's economy and accounts for 54% of GDP. About 72% of the population is directly involved in agriculture, although this number is slowly decreasing due to rapid urbanisation. Since the 1980s, government has taken many measures to develop agriculture . One is the readjustment of the cropping patterns. The basic principle is to develop diversified cropping patterns on the basis of enhanced food crop production. As a result of various efforts, agriculture has grown quickly in the past 20 years. According to the State Bureau of Statistics, the average income of farmers has doubled compared to before the 1980s.

However, agriculture is still underdeveloped in north-west China. Dingxi County is located in north-western Gansu Province where most farmers still perform low-profit farming and engage in a mono-cropping pattern. Some of the farmers are still living below the poverty line. The county is one of the poorest counties in China.

This paper aims to examine existing agricultural practices; to identify problems, gaps, and potentials of agricultural production; and to formulate strategies to promote crop diversification. Participatory and multidisciplinary approaches were used. The focus is restricted to the dry, mountainous regions of Dingxi County of mid-Gansu Province in north-west China.

Study Area

Dingxi county is located in the middle of Gansu Province. The average altitude is 1897m above sea level. It covers an area of 4225 sq.km, 0.9% of the province's land area. The total cultivated land is 114,933 ha, accounting for 27% of the total cultivated land in the county. It includes 20 villages. The county is a typical hilly and mountainous area, with only 14% as plains area. The population in 1998 was 400,000, of whom 89% were farmers.

The climate is very dry. The mean annual temperature is 6.3 °C; July is the hottest month with a mean temperature of 18.5 °C, and January is the coldest with a mean temperature of -7.9 °C. The average frost-free duration is 140 days. Total annual precipitation is 376 mm, about 60% of which occurs in summer, with the lowest rainfall of 8.3 mm in winter. Agriculture is typically rainfed.

There are four types of soil: limestone-based, black stony, yellow loess, and red loam. The soil on mountain tops is severely eroded and no more topsoil is left. Soil erosion, mainly induced by wind, is also severe.

Research Methodology

The study was conducted through reviewing secondary sources of data and interviewing key informants like agricultural officials, extension workers, village heads, farmer's groups, and so on. The secondary data were collected from different sources like the *Statistical Year Book*; various national five-year plans; and reports, documents, and research studies along this line. Problem tree analysis was applied to analyse the cause and effect relationships of monocropping. A potential matrix was used to identify the basic potentials and derived potentials helping to solve the problems. Some descriptive and statistical analyses were also employed.

Results

Existing cropping patterns

The main crops planted from 1995 to 1998 were food crops, they accounted for 83% of the sown farmland (Table 1). Among them, wheat ranked first, followed by potato, local oats, and so on. The total cropping area of cash crops was 11.9% of the total cultivated area. The main varieties were flaxseed and medicinal plants. The ratio of food crops, cash crops, and other crops was: 16.5:2.4:1.

Table 1: Cropping pattern in Dingxi county

	Area planted (ha)	Percentage of total cultivation area	Av. production (kg/ha)
Food Crops	**99,160**	**83.10**	**1214**
Wheat	31,247	26.19	1229
Potato	25,113	21.01	1529
Naked Oats	13,424	11.25	1114
Corn	9660	8.09	1795
Pea	8305	6.96	1354
Millet	4527	3.79	1147
Gruel	1960	1.64	1105
Cash Crops	**14,176**	**11.88**	--
Flaxseed	13,287	11.13	349
Medicinal plants	73	0.06	1115
Others	**5990**	**5.02**	--
Total	**119,327**	100	--

Source: Yearbook of Agricultural Economies of Gansu Province, 1995-1998

The areas for vegetables, grasses, and agroforestry are 267 ha; 14,600 ha; and 52,933 ha, respectively. However, due to poor management, poor soil, and low rainfall, most of the forestry stands are under-stocked and of poor quality, or cannot grow. Therefore, timber production is almost impossible.

Analysis of Problems

This area, like the rest of the province, experiences very low rainfall and long dry periods. The soil is of very low fertility and water holding capacity. Water for irrigation is sparse, and irrigation facilities are insufficient to meet the demand. All these factors have limited agricultural activities to food crops like wheat and potato. Monocropping is a major reason for low production and income. Analysis indicates that monocropping is caused mainly by limited natural resources such as rainfall; poor soil fertility; lack of farming inputs like high yield varieties (HYV), chemical fertilisers, and pesticide/insecticide; and lack of support entities like research, extension, and credit services. These problems are not independent but are interlinked with one another. All these problems have resulted in monocropping and low incomes for farmers (Figure 1).

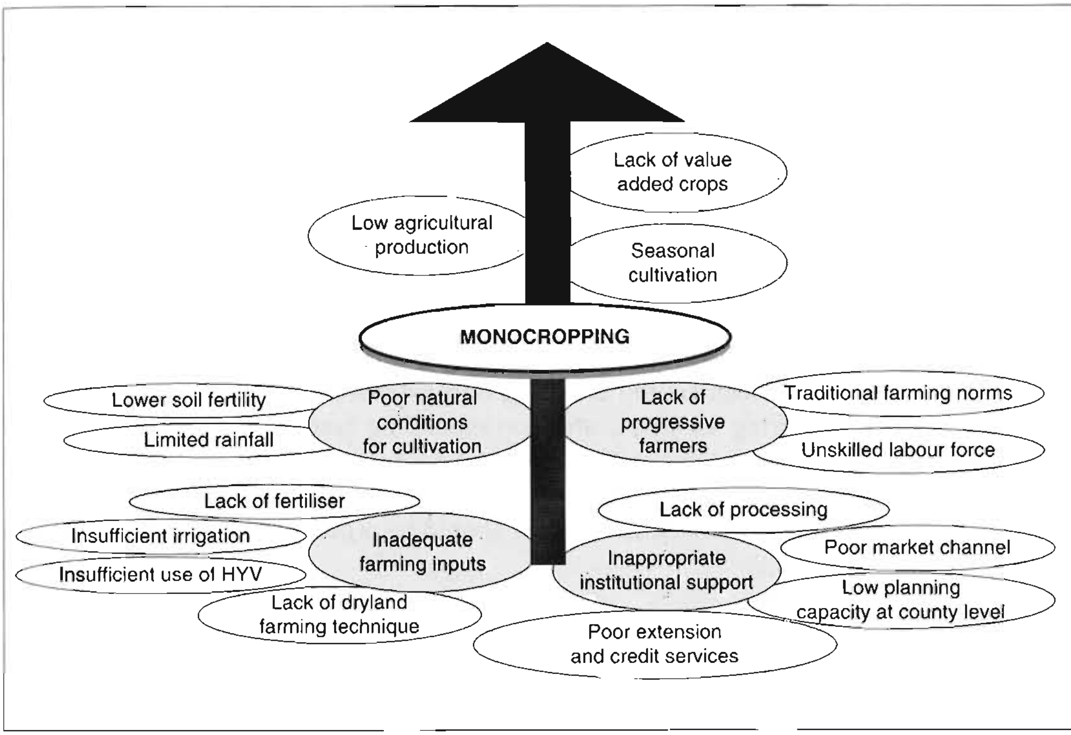

Figure 1: **Causes and effects of monocropping**

Analysis of Potential

Problems always include potentials. The natural potentials are mainly long sunshine duration (69% of the total annual duration), strong solar radiation (15.2 cal/cm^2 monthly during May to August), rich terraces that cover a large area (2533 ha), and larger land holdings (0.20 ha higher than the national figure). Infrastructure potentials are roads, railways, and all kinds of transport facilities; existing agro-markets in each township; and a central market in the county centre. Human potentials are a labour force (200,000 or 56% of the total farmers) and their knowledge of dryland farming. Institutional potentials include new policies, seven existing agricultural schools, 20 farmer's training centres, several research centres and extension stations, and banks and rural credit co-operatives.

One big potential is the sustainable rainfall resource management experience. A project on effective use of rainwater was initiated by the provincial government, and was jointly implemented by several research institutes and local governments. It promotes more efficient use of rainwater through runoff collection techniques, water storage tank construction, devices for lifting and conveying water, micro-catchment water conservation with polythene film mulching, and multi-use crop products and bi-products for livestock.

All farm households have adopted these techniques, which have made both irrigation water and drinking water available for people and animals. Additional benefits include reduced soil erosion, decreased pesticide and fertiliser use, increased options for crop diversity, and increased capacity of women to play a major role in fruit and vegetable management and livestock rearing.

Strategies to Promote Crop Diversification

Enhance governmental support

Government policy for efficient use of agricultural resources like land and water should be stressed to enhance diversified crop production. More grace policy in the provision of short-term credit and loans should be made in the future to support application of inputs like HYV, fertiliser, pesticides, and irrigation. Local government should adopt participatory approaches to make policies more attractive to farmers.

Enhance agricultural research and extension

The main efforts should focus on the breeding and extension of drought- and disease-resistant and early-maturing varieties, and corresponding techniques such as dry land tillage, rainwater harvesting, water-saving irrigation techniques, and soil and water conservation. These techniques should be practical and acceptable to farmers. On-farm services regarding extension of new techniques should be provided to farmers regularly in a timely manner.

Establish effective market networks both inside and outside the county

Most effective local markets can be promoted to small market centres to establish a market network. Local government could invest for this purpose. Local farmer's cooperatives and groups should participate in marketing activities from collection of products to the sale of these products to protect farmer's benefits.

Strengthen the training and education of planning staff and farmers

Better training is needed for extension staff and farmers. The education and training of farmers could be conducted in existing centres. Basic background knowledge and skills can be taught during slack seasons. Specific farming techniques could be promoted during farming seasons through on-site demonstration. Farmer technicians should be responsible for the education and training of farmers. Local government should increase investment for this purpose.

Establish value-added processing enterprises

The enhanced production of cash crops, fruits, grass and forage, and livestock make the establishment of value-added processing enterprises necessary and possible. Starch processing plants using potatoes as raw material, oil processing plants, flax processing plants, and carpet making factories are all potential considerations. The establishment of processing plants could in turn promote crop diversification.

Conclusions

Monocropping in the area limits crop production and farmer income. Crop diversification is an alternative way to enhance production and increase incomes of small farms, and to improve off-farm income. The efficient use of existing potentials and derived potentials, together with the adoption of certain strategies, will facilitate diversified crop production. It must be emphasised, however, that other means such as agro-industry, transportation, and other business are alternative ways to increase the income of small farms.

References

Gansu Academy of Agricultural Sciences (1993) *Research of Dry Land Farming in Dingxi District.* Lanzhou: Gansu People's Press

Jock R. A.; John L. D. (1992) *Risk Analysis in Dry Land Farming Systems*. Rome: FAO

Randhawa, N. S.; Sundaram, K. V. (1990) *Small Farmer Development in Asia and the Pacific.* Rome: FAO

Gender, Empowerment and Community Approaches

Rural Women of the HKH: The Prevalent, Yet Marginalised, Farmers

J.D. Gurung
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

Mountain people rank amongst the most deprived of the world's population, and yet their stewardship of mountain natural resources is closely linked to the sustainability of life in lowland areas. However, the dominant role that women of these mountain areas play in natural resource management, agricultural production, and the well-being and very survival of mountain families, including children, has received little attention.

Few data exist on the situation of mountain women and of gender relations in the Hindu-Kush Himalayan region. Much of the data available in the countries in the HKH region has not been disaggregated by agroecological regions to give information on mountain people, much less by gender. This research was undertaken to address this gap by providing accurate data on mountain women's lives, and by examining policies specifically aimed at women's development and the field level realities that determine the effectiveness of these policies.

The Situation of Mountain Women

Diversity of Gender Relations

In general, isolation has been a feature of most mountain societies, although the trend is declining with the influx of modernisation. Mountain societies tend to have less rigid social structures and hierarchies than societies of the lowlands, where dominant religious ideologies have been more influential in determining social norms and mores. Because of indigenous beliefs and the dominant role of women in livelihood systems in the mountains, mountain women were traditionally afforded more freedom of movement, independent decision making, and higher status than women of the lowlands.

Common Features

Certain features are common throughout the HKH region. Mountain people have historically been marginalised politically, socially, and economically, by the dominant lowland powers and have had little involvement with or control over national level decisions. The significant or even dominant role of women in the sphere of production, as well in the more conventional domestic sphere, is also a common feature. Other commonalties include patriarchy, impacts of environmental degradation, imposition of new values, and poor representation of women's interests at political levels.

Patriarchy

Patriarchy, or the domination by males in society, is prevalent throughout the region. However, the degree of patriarchy varies due to the tremendous diversity of cultures. It is more pronounced in Muslim, Hindu, and Confucian societies, but still exists in Buddhist and Christian societies as well. In parts of Bhutan, Tibet, and some areas of north-east

India, matriarchal communities still exist, though these are increasingly coming under the influence of powerful external forces from lowland societies, including those of Hinduism and Christianity (Gurung 1998).

- Low self-image and self-esteem

From the time of birth, females are repeatedly reminded, in subtle and not-so-subtle ways, of their inferiority. Femaleness is considered to be a lower form of rebirth and a kind of negative force that can bewitch and bring harm to others (e.g., Ortner 1996). In all of the case studies, with the exception of tribal groups of the Chittagong Hill Tracts, women reported lower levels of self-esteem than men and a lower image of women than men in their society.

- Patrilocal residence

The patriarchal system is shaped by patrilocal residence and kinship relationships that force females to leave their natal homes upon marriage and live in unfamiliar surroundings under the control of their husbands' families. Most marriages are still arranged by parents, so the women must establish themselves amongst relative strangers, with little of the family support they enjoyed at home. The difficulties and hardships inflicted by mother-in-laws on new brides are well known in the countries of Nepal and India (ESCAP 1997; NPC Nepal and UNICEF 1996).

- Inequitable inheritance rights

The customary laws throughout much of the mountain region dictate that sons inherit the land and herds of their parents, while women inherit only movable goods such as jewellery and household items. Thus men are the owners of production. Besides the obvious inequity, such customs further hamper women's abilities to expand their livelihood options by denying them credit from financial institutions, as they do not possess the collateral required for loans (Ortner 1996).

Environmental management

- Indigenous knowledge

As the dominant farmers, women have traditionally been the managers of crop germplasm and its diversity, through the testing, preservation, and exchange of seed through informal networks (Gurung, J. 1998). Their special knowledge of the value and diverse uses of plants for nutrition, food security, health, and income provides a balance to the market-oriented pressures that emphasise high yield and uniformity (e.g., Eyzaguirre and Raymond 1995).

- Decreased access to forest and water resources

The diminishment of forest and water resources due to environmental degradation has a marked impact on women, who are responsible for the collection and management of such resources, often forcing them to travel longer distances to meet their households' daily needs. To date, there are very few places where alternative technologies have provided non-traditional sources of cooking fuel or new methods of transporting water.

- Heavy workloads

Women of the HKH region bear substantially more of the domestic and farm responsibilities than their menfolk or their counterparts in the plains. The back-breaking chores of carrying water, fodder, and firewood up and down steep mountain slopes are carried out daily, consuming large portions of the women's day and energy. In some parts of the Uttar Pradesh hills, women's work seems to have reached an inhuman level, leaving observers to ponder on how long women existing on a limited caloric input and often in a pregnant or lactating state can physically continue to bear this load.

- Absent men

Male out-migration for short-term or long-term periods is increasing throughout the region as families struggle to find ways to sustain themselves and their farmlands amidst decreasing crop yields and during periods of scarcity. In many circumstances, major decisions are delayed until the 'household head' returns for his annual visit home. The absence of males does provide women with more opportunities to participate in public life, as when they are able to represent their households in forest-user group meetings in the hills of Nepal.

- Malnutrition

In the ecologically fragile mountain areas, environmental degradation directly affects the quantity and quality of food resources. Due to socio-cultural norms, women and children are most vulnerable to these scarcities, as they receive inadequate amounts and quality of food, perform excessive labour, and have limited access to health services. In Nepal, as many as 80% of women of childbearing age are anaemic, and studies have shown a widespread lack of sufficient protein, vitamin A, iron, and iodine (NPC/UNICEF 1996).

Changing values

- Monetarisation

In most mountain communities, traditional forms of bartering have given way to monetarisation. As women are still involved primarily in subsistence farming activities on their families' own land, they do not earn cash for their hard work. And as roads open up avenues for selling farm products, women are usually left out of the cash transactions that men control. Previously, women had much more control over farm products, which they would barter for household necessities. But due to their limited mobility, lack of ease in dealing with male traders, and low self-esteem, they are usually excluded from today's cash transactions.

- Influx of new values

Even the relatively egalitarian examples of gender relations found in some traditional mountain societies following Buddhist or animist religions are being transformed by the prevailing values belonging to lowland religious, nationalistic, and cultural paradigms. Changes occurring in once remote mountain areas are affecting gender relations in ways that we have yet to fully understand, but the indications are that women's value in their households, communities, and societies is declining as money and outside worldliness are becoming the new indicators of status (Gurung, B. 1998). It is, however, not always necessary that the influx of new values leads to negative consequences for women. New values bring new aspirations; for example, parents in Bhutan are now sending their girl children to school, as they believe education can free them from being trapped at home (Tshering 1998).

Invisibility of women

Although the data clearly show that women are the dominant farmers in the mountain areas, their significant knowledge, management, and even labour in the forests and fields are ignored by the predominantly male-oriented research and extension staff. Because women's contribution to agricultural production is not visible and usually not considered significant by agricultural professionals, their role as managers of agrobiodiversity in the region has gone largely unnoticed. Policies designed with the best intentions in capital cities have not taken the local realities of women's lives into account.

- Links between status of women and children

In remote areas with scarce facilities, women are exposed to high risks associated with childbearing. Working 14-16 hours a day and without the protein, iron, and calories required, women do not obtain the expected weight gain during pregnancy, leading to improper development of the foetus and low birth weights.

Mountain areas have some of the highest infant and maternal mortality rates in the world. These rates are a direct result of poor maternal health and inadequate safe motherhood practices. A letter published in the Kathmandu Post (1998) stated that of 14 medical centres in Nepal able to handle complicated deliveries, only 2 were located in mountain regions.

Bright Spots

Educational Opportunities

One of the most dramatic changes seen at the rural level is the education of girl children. Perhaps due to the campaigns of a few international agencies, girls are now increasingly being enrolled in school. This does not necessarily translate into their attendance at school, due to their responsibilities for childcare, livestock herding, and so on, but even their enrollment indicates a new investment in girl children's lives.

Another aspect of education in the mountains is non-formal education for women. These programmes provide women with basic reading, writing, and accounting skills, and also expose them to new technologies or messages about health and other topics. But the greatest impact may be in their newly found levels of self-confidence and commitment to change things for the better in collaboration with other women of their communities.

Political participation

Statistics show that the representation of women in national political bodies is extremely low in most countries of the HKH region. Although there are very few mountain women holding political positions in national assemblies, increasingly women are voting and taking up positions within local bodies, such as the village panchayats in India. With the democratisation and decentralisation of governing bodies in countries of the HKH region, women with leadership abilities will increasingly take up responsible positions.

Taking the lead

In some mountain communities, women have banded together to address problems of environmental deterioration, economic hardship, and domestic violence. Besides the well-known example of the Chipko movement in the hills of Uttar Pradesh, another form of social organisation indigenous to the Gurung society, the Mothers' Group, has recently received attention. In the hills of Nepal, these groups have mobilised support from projects and tourists to build footpaths, establish fodder/firewood plantations, start day-care centres, set up savings schemes, and so on. Across the hills of Nepal and India, such groups are using their joint power to wage war on alcoholism and domestic violence.

Conclusion

The situation of women in the mountains of the HKH presents a contradictory picture. Women appear to be competent, knowledgeable, independent actors upon whose shoulders the bulk of the responsibility for survival and sustainability of households and communities rests. And yet they are weighed down by distinctive structural constraints, burdened by negative ideologies, lack economic assets, and often are unable to enforce their decisions over even their own labour, bodies, and major life events.

Outsiders who work with women and men of the mountains often assume that they are subject to the same levels of gender inequity as lowland women, and thus impose their own biases on how they are to behave. This attitude is causing mountain women to lose status and value in their own communities.

Development strategies throughout the region have not yet demonstrated the understanding that gender bias is a primary cause of poverty, because it prevents women from obtaining the education, training, health services, legal status, and other abilities and opportunities to combat it. Only when gender bias is reduced and eventually eliminated can the economic and environmental problems of the HKH mountains be solved.

References

Economic and Social Commission for Asia and the Pacific (ESCAP) (1997) *Women in India: A Country Profile.* New York: United Nations

Eyzaguirre, P.; Raymond, R. (1995) *Rural Women: A Key to the Conservation and Sustainable Use of Agricultural Biodiversity*. Paper presented at the Fourth World Conference on Women, Beijing. Rome: IPGRI

Gurung, B. (1998) *Towards an Understanding of Mountains, Development, and Knowledge Processes: A Study of the Mewahang Rai of Eastern Nepal*. Unpublished doctoral dissertation, University of Hawaii

Gurung, J. (1998) *Gender Dimensions in Biodiversity Management: Bhutan and Nepal.* Rome: FAO

NPC/UNICEF (1996) *Children and Women of Nepal: A Situation Analysis.* Kathmandu: UNICEF and National Planning Commission of Nepal

Ortner, S. (1996) 'The Problem of 'Women' as an Analytic Category', In *Making Gender: The Politics and Erotics of Culture.* Boston: Beacon Press

The Kathmandu Post (1998) *Letter to the Editor*, March 13

Tshering, P. (1998) *Report on Situation of Women in Bhutan for the Fact Finding Mission on the Situation of Women in the HKH,* internal report to ICIMOD, Nepal

Enhancing Employment Opportunities for Women through Diversification of Mountain Agriculture

N. Muzaffar
Honeybee Research Institute, National Agricultural Research Centre
Islamabad, Pakistan

Introduction

The trend of male off-farm employment and migration to cities and overseas has increased the responsibility of women in agricultural production. Women in mountain communities have had secondary roles owing to cultural and economic conditions. Women's economic development can be brought about through creating income-generating employment opportunities. This paper proposes some technologies that would suit women by improving their health and nutritional standards while offering quick economic results.

Some Suitable Technologies

Apiculture

Apiculture can be started as a part-time occupation that has many benefits. Bees pollinate cultivated crops and wild plants. Honey generates income. Beeswax generates income. Beekeeping is possible even with limited resources. Beekeeping does not use up land needed for crops. Nectar and pollen are not used by other livestock; only bees harvest these resources. Other local traders benefit by making hives and equipment, and from using and selling the product. Beekeepers have a financial reason to conserve the environment, ensuring that flowers are available and bees are protected. Beekeeping can be done in leisure time. Bee-keeping generates income without destroying habitat. Bees help create and maintain diversity of plants. Finally, honeybees contribute towards increased production of insect-pollinated crops and towards ensuring the continuity and existence of flowering plants in all kinds of fields, including marginal wastelands.

Solar fruit and vegetable dehydration systems

A wide range of fruits and vegetables is available in mountain areas all year round. A considerable portion of these products gets spoiled before reaching consumers, owing to lack of refrigerated transport and cold storage facilities. This causes serious problems of wastage (20-40%) and post-harvest losses. These losses could be minimised if the surplus fruits and vegetables were converted into non-perishable dehydrated products, which can be used or sold during the off-season to fetch better prices. Low cost solar driers can be used.

Cheese and yoghurt

Many mountain farmers who own dairy animals get sufficient milk to meet their day-to-day requirements. The surplus is mostly used to make ghee or 'khoa' (a fatty milk product). These have high cholesterol contents. Cheese has less cholesterol and is an excellent source of nutrition, particularly for children. There is a considerable scope to process milk for cheese production in mountain areas of Pakistan, and it has the potential to generate income through low-level technology.

Sericulture

Women can rear silkworms quite easily. This remunerative enterprise can be set up on a commercial scale as it is closely integrated with the agricultural system. The valuable timber and branches for basket making or fuelwood would provide a good market return.

It has been estimated that one ounce of silk seed can produce 17 to 19 kg of dried cocoons in six weeks, which would give an income of about US$38 (Ahmad and Muzaffar 1993). Expansion of this industry has a potential for economic uplift of women and would also save foreign exchange.

Poultry

Poultry farming offers the quickest, most efficient, and most economical source of good quality protein. Indigenous birds are reared as backyard poultry. They subsist on waste grains or are fed with small quantities of cereal and kitchen waste. Their production is almost entirely a net gain.

Several breeds and crosses of chickens are suitable for poultry farming on a small scale. Cross breeding of local chicken with meat poultry breeds such as Rhode Island Red holds good promise of producing a dual-purpose breed, with improved pure breeds for higher body-weight, egg size, and fecundity of the fowl. Commercial poultry production can be taken up in mountain areas around big cities to get better returns.

Aquaculture

Mountain fishing families are generally poor. They fish both for family consumption and for sale. Small-scale trout farms or hatcheries can be set up on modern lines with arrangements for handling, processing, smoking, salting, drying, and packing.

Raising fish in cages is relatively simple and has several advantages over raising fish in an open pond (Rab and Afzal 1986). Water that is already present in an ordinary farm pond, lake, reservoir, river, or stream can be used, and there are many such resources available in the mountains. Cage culture permits more intensive utilisation of water resources with a low capital expenditure. Recent developments have made cage culture more reliable and easier to operate, especially for women. A multitude of fish products like fish crackers, fish balls, paste, sauce, and dried jellyfish can be produced in small processing establishments.

Mushrooms

Production of mushrooms can become an important source of employment, income, and foreign exchange that would represent a diversification of existing agriculture. In view of its richness in protein; low carbohydrate; and also because it is extremely good for patients with diabetes, hypertension, and cardiovascular diseases, mushroom production is required on a large scale. Furthermore, there is a great demand for mushrooms in Pakistan, and this is expected to increase rapidly in the future as it has in other countries.

There is a need to establish a mushroom research laboratory and a training centre for mushroom cultivation, and for dissemination of technology to develop technical know-how among women. This would also involve further studies on the improvement of mushroom varieties and cultivation practices for higher yields. Women and men from small landholding and landless families can easily grow this unconventional crop to add to their income and to supplement diets for improved general health.

Kitchen gardening and floriculture

Small kitchen gardening clubs can be established in mountain areas for growing and selling seasonal and off-season vegetable crops. There is a need to involve more women in small-scale vegetable production, preservation, preparation of jam, jellies, pickles, and other vegetables, and fruit products. Similarly, floriculture is another promising technology that can yield a high income.

Water conservation devices

Women spend much time and labour in fetching water and other such activities. It is necessary that appropriate time and labour saving technologies, especially relating to energy and water, be introduced to reduce the excessive burden on women. In Australia, water tanks with an average capacity of three thousand gallons [13,600 l, ed.] are used to store rainwater coming down through small pipes along the edges of the roofs. Sometimes underground water tanks are used.

Information technology training

Information technology can be another discipline for women, especially those restrained by physical disability and not able to participate in other activities. They can work out useful information on a particular variety, yield, quality, and marketing prospects of various agricultural produce of the mountains.

Conclusions

The execution of a multi-disciplinary project based on integrated agricultural technologies for commodity farming system would provide nutritional, economic, and ecological security to mountain communities and the national economy. There is a great scope and potential for increasing income both from on-farm and off-farm activities by encouraging small enterprises. Skill development and training efforts have to be made to develop the capacity of women to undertake small businesses and enterprises, and adopt an integrated approach for the productivity of their farms. The environmentally sound technologies can also help stop ecological degradation and contribute to the natural balance of our mountain forests.

Bibliography

UN (2000) *United Nations Statement on Food Security in Pakistan*. FAO Thematic Group on Rural Development and Food Security. The United Nations System in Pakistan. Publication No.UN-PAK/FAO/2000/1

Ahmad, R.; Muzaffar, N. (1993) *Silkworm Rearing* (in Urdu). Islamabad: Pakistan Agricultural Research Council

Muzaffar, N. (2000) *Status of beekeeping in Pakistan. Annual Report of the Honeybee Research Institute.* Pakistan: Pakistan Agricultural Research Council

Rab, A.: Afzal, M. (1986) 'Fish Cage Culture.' In *Progressive Farming*, 6 (5): 26-30

Gender Roles in the Production and Marketing of Allo (*Girardinia diversifolia*): an Income Generating Activity of the Kulung Rai Community, Makalu-Barun National Park Area, Sankhuwasabha District, Nepal

K. Gurung
The Mountain Institute, Kathmandu, Nepal

Introduction

The nettle, *Girardinia diversifolia*, locally known as 'allo' in eastern and 'puwa' in western Nepal, is an indigenous plant valued for fibre. It is a stinging nettle species that grows naturally at altitudes of 1200-3000m in areas not suitable for agricultural crops.

The women of the Kulung Rai community play an important role in producing a variety of allo products. The Rai people, known as Kiranti in ancient times, live around the Arun River. At present, allo has become an important source of income in the district. Harvesting allo is an ancient craft, and the plant is still used for certain religious ceremonies, especially funerals. Over the past 13 years, the high demand for allo clothing has increased the price and made it difficult for local villagers to buy and use it for their ceremonies.

This paper is based on a study of mountain areas close to Makalu-Barun National Park in the Sankhuwasabha district of eastern Nepal. The main objectives were to examine the present gender roles in allo production and marketing; to review the marketing activities for allo products; and to assess the present constraints and opportunities for production and marketing of allo products.

Methodology

Data were compiled by interviewing the local people in villages such as Lakuwa, Chinkha, Sikidim, Dhankhila (Tamku VDC), Tenchong, Hoyangla (Sisuwatar VDC), and Benchong (Mangtewa VDC). Informal discussions were also held with different groups of women in different villages involved in allo production.

Allo Production Activities

Cultivation

The allo plant is found as an undergrowth in forests. A number of shoots come out of rootstocks, which are not up-rooted in harvesting. As many as 22 stems can sprout from a single rootstock. Regeneration from seed in the forest is very low. Allo plants re-generate after harvest. Local people grow allo along forest edges and on community lands or community forest lands. As the cultivated plants take longer to grow, as much as three years to reach the harvesting stage, local people prefer those that are naturally grown.

Harvesting and Processing

Allo is harvested from September to December. The best quality fibre comes from the harvests around early December before the seeds ripen. Most of the villages still practice traditional harvesting methods that involve cutting the plants approximately 15 cm above the ground. When allo-growing areas are several days walk from a village, the villagers harvest collectively in groups.

Following the harvest, the bark is stripped out; soaked in water for one or two days; boiled in wood ash water for three to four hours; and washed 2 to 3 times in running water accompanied by frequent beating. The fibres so extracted are mixed with clay and dried in the sun to make them softer and easier to spin. Again they are dried and soaked in clay, which is later removed.

Allo threads come in a variety of natural shades ranging from bronze to reddish brown. They can be bleached to a light natural shade. In some places, threads are dyed rusty red, steel blue, cerulean green, or black. The thread is then knitted into cloth, shawls, and other products, or is woven (either pure or mixed with yarn) into place mats or cloth for coats or export. There are a number of different patterns of cloth, but all range in width from 68 - 72 cm.

Allo Products and Product Development

Allo provides a very strong fibre that is used for different purposes such as ropes, trousers, and so on. Such products are mainly for local use. Allo cloth is also used to make various designer clothes such as jackets, pants, and coats. Tender young leaves are sometimes eaten as vegetables or fed to livestock like pigs. Allo is also a source of medicine. Allo seeds can contain 10-12% oil, which can be used for making soap and other oil-based products. Allo products are some of the unique handicrafts of Nepal.

Sex Roles in Allo Production and Marketing

Table 1 shows the division of labour by sex. Three activities (seasoning/cooking, fibre making, and product design) are only performed by women. As they have few other opportunities to make cash income, women devote their time to allo production. Men do participate in other activities, which are noted as joint responsibilities. Men are involved in harvesting allo plants and in transporting the harvest. They also support women in establishing the equipment necessary for production, like looms, spinning wheels, weaving materials, and so on. But women do all the other activities, and play the main role in designing allo products.

Table 1: Gender division of labour and decision-making in allo production and marketing

Activity	Male	Female	Joint	Remarks
Harvesting & Transporting			✓	Men are more active
Seasoning & Cooking		✓		Sometimes men are also involved
Fibre making		✓		
Credit and investment			✓	
Design of allo products		✓		
Marketing of allo products			✓	
Access to and control of income from sales of allo products			✓	

Markets and Marketing Activities

The major markets for allo products are in North America (USA), Europe, and Japan. These are niche markets with small quantities serving a special class of consumers abroad. Kathmandu is also a key market because of tourists from western countries and Japan.

To promote marketing of allo products, the Koshi Hills Area Development Program (KHARDEP) assisted the local people in establishing the Allo Cloth Production Club (ACPC) in Sisuwatar in 1997. The main activity of this club is to link local producers with traders or shopkeepers in Kathmandu to sell allo products. The villagers bring their products to ACPC, and the club sends the products to Kathmandu, where it maintains market links.

Constraints to allo production and marketing

The present major constraint is the limited quantity of allo production, which is also decreasing due to the lack of appropriate management practices. Another problem is that producers are not getting good returns. The markets are unreliable, and the producers have to depend on middlemen traders. Other major constraints are the traditional practices and styles made, insufficient technology used in production, and high selling prices.

Allo production is declining at present. The local people, believe the reasons for this include

- no time for seed dispersal due to harvest of immature plants that have the best quality of fibre that comes at the flowering times or early harvests;
- deforestation has reduced the shady areas where allo grows best;
- lack of moist, humus-rich soil and heavy fertiliser (limited open grazing land or restrictions imposed by communities on open grazing); and
- lack of a sustainable management programme.

Conclusions and Recommendations

Allo can be a great source for improving the livelihoods of poor people in mountain areas. With appropriate harvesting practices, allo is a renewable source of plant materials, and production can be sustained or improved. The issue at present is how local people can increase their share of the ultimate selling price. In order to increase the production of allo, local people need to cultivate it on wastelands. Local people, mainly women, need exposure to major markets and to establish marketing linkages.

The local people have provided some valuable suggestions that could benefit them if implemented. These include the need for training on appropriate technologies to improve allo production on a sustainable basis; the need to cultivate allo on lands that are unsuitable for agricultural crops; the need for direct links to reliable markets; and the need for training in product design and diversification to add value to production.

Gender Relationships and Agrobiodiversity Management Practices among the Lepchas of Sikkim: Relationship and Effects

C. Gurung
Kathmandu, Nepal

Introduction

Agrobiodiversity occurs at three levels: the agroecosystem level, the species level, and the genetic level. The patterns of gender relationships in a community are reflected at all these levels in the classification of agroecosystems and crop species, in the division of roles and knowledge, as well as in the value and importance ascribed to all these. Therefore, the sex roles and patterns of gender relationships will affect agrobiodiversity management practices.

This paper shows how gender relationships are reflected in the agriculture and agrobiodiversity management practices of Lepcha communities of Sikkim, a state of India. The Lepchas are the indigenous people of this area, and now form a minority group of 7-10%[1] of the total population (Government of Sikkim 1994).

Historical Background

Traditionally, gender relationships among the Lepchas were based on their cultural beliefs and origin myths[2] that men were the active providers and women the caretakers and nurturers. The division of labour during this period conformed to this belief: women were completely in charge of agriculture, a crude type of slash and burn cultivation that raised dry rice, millet, and maize[3], while men were in charge of hunting. Men had only a minor role in agriculture, focused on physically heavy tasks such as felling trees and big branches (Gorer 1938). Thus each sex had complete control over its own sphere. The Lepchas practiced a mixed form of patriarchal and matriarchal patterns in which the mothers' family name and property descended to the daughters and the fathers' to the sons (Fonning 1987).

The Tibetans, who ruled Sikkim for approximately 300 years, came in the 17th century, and later the Nepalis arrived in the 19th. The introduction of new value systems, beliefs, and practices influenced the Lepchas. To this was added the influence of Christian missionaries and later 'modernisation'. The Lepcha lifestyle accordingly transformed in religious, social, cultural, economic, and political spheres, and gender relationships transformed as well. Gender relationsips came to be based completely on a patriarchal system, and men came to be regarded as more powerful providers.

Gender Relationships and Agrobiodiversity

Today, agriculture is the main livelihood practice of the Lepchas; hunting was abandoned years ago. The Lepchas practice two forms of agriculture - settled and 'swidden' (slash

[1] Nepalis form about 70%, the Bhotias about 15%, and the remainder are plains people
[2] For origin myths of the Lepchas see Fonning (1987)
[3] The Lepchas believe that the gods gave these three crops to them

and burn). The transformed gender relationships are based on the belief that men are more powerful. Consequently, agriculture is now under men's control and women are considered only as helpers without any control over it, although they still perform the major share of agricultural work.

Agricultural activities and knowledge have been classified into separate men's and women's spheres, and the value assigned to different knowledge and activities is based on this division.

Agroecosystem level

The Lepchas classify cultivation areas into four major agroecosystems. 'Punzok' are cultivated areas in the forests or where agroforestry is practiced; cardamom, the major cash crop, is cultivated here. 'Sadlium' refers to the areas where swidden (slash and burn) is practised; crops cultivated here are dry rice, maize, millet, and buckwheat. 'Leeden shing', the cultivated land near the homestead, is planted with vegetables, tubers, and other minor crops. Finally, 'ari' or 'yong' are terraced fields located at lower elevations where wet rice is cultivated.

These various agroecosystems are divided between male and female domains based on gender relationships and the different crops cultivated.

Punzok is considered a male domain. Traditionally, when the men were in charge of hunting, this area (i.e., the forests) was their domain, so present thinking is a natural extension of this traditional domain. Second, and probably more important, the crop cultivated is cardamom, a major cash crop, which is associated with men. Men do all the work here - planting, weeding, harvesting, curing, and marketing; women only help when required.

Sadlium areas were once completely under the control of women, but now are considered as a 'joint domain' of both men and women. Work in these areas is considered 'outside' work, which would be within the men's sphere, but the crops cultivated here are minor and traditional crops, which are associated with women. Thus, this agroecosystem is regarded as a joint domain. Due to transformed gender relationships, women have lost their control over this sphere of agriculture.

Leeden shing areas are considered women's domain, as they are usually small and the crops cultivated are minor subsistence crops. Women do all the work here, with men helping very rarely. A diversity of crop species and varieties is maintained in these areas, because women as the caretakers and nurturers are responsible for feeding the family. The emphasis in these areas is on cultivating subsistence crops for family consumption.

Ari or yong areas are considered men's sphere despite the fact that women do more work in them. The main reason for this classification is that wet rice, a major crop, is cultivated here.

Species level

Crop species are 'gendered' among the Lepchas. As mentioned above, traditionally women were completely in control of agriculture, and all crops cultivated were therefore associated with them. However, once gender relationships transformed into ones based on patriarchal patterns, the crops too became associated with men or women on the basis of their importance and commercial and status value. Crops like wet rice, wheat, and cardamom[1], which were all introduced relatively late by the Nepalis (Gorer 1938; Siiger 1967), came not only to be regarded as major crops, but also to be associated with men. Traditional crops began to lose their value, and consequently the varieties of those crops too began to decline as people stopped cultivating them. Previously 27 varieties of dry rice were commonly cultivated, whereas now there are only two, and these are cultivated only in some very remote areas of swidden land (Gurung 1998). Similarly, the 12 varieties of millet that were cultivated (Siiger 1967) have been reduced to only four varieties (Gurung 2000). Among the traditional crops, only millet is considered a major crop because of the cultural and religious values attached to it. The other traditional crops are now considered minor crops and are associated with women. Vegetables are considered minor crops, as they are only subsistence crops.

Looking at this classification of crops, it is evident that the women's sphere includes a much larger diversity of crop species and varieties than the men's. Although women are the primary maintainers of agrobiodiversity in the true sense, the way gender relationships are constructed does not give value or recognition to this fact.

Genetic level

At the genetic level, the women, particularly the old, do the actual seed selection and storage for all crops, except for cardamom, the cash crop. This role of women is legitimised by the culture and gender relationships, as women are considered the symbols of fertility as well as nurturers and caretakers. Thus, women are the knowledge holders of genetic management, which is crucial not only for conserving agrobiodiversity but also for the people's very livelihoods. However, neither the men nor the women themselves recognise the importance and value of this knowledge. The reason is that this type of work is done while sitting around, and because such work does not require women to go out, it is considered 'inside' work.

However, when this role gets changed due to particular circumstances and a man takes it over, the value and importance immediately increase, and his status in society rises. In one case in which a man had taken up this work because he was physically too weak for heavy work, he came to be considered as the seed expert not only in his village but also in the neighbouring villages.

The dynamics and complexities of gender-segregated power relationships within households and communities, which in turn are influenced by the conditioning processes of cultural values, influence the systems and practices of agrobiodiversity management. This is reflected in the management practices of communities. Therefore, one cannot discuss management of agrobiodiversity or agriculture, or for that matter any other natural resource,

[1] There are two versions of the origin of cardamom - scholars like Gorer (1938) state that the Nepali introduced this crop when they migrated to Sikkim, whereas Sharma and Sundriyal (1998) state that this is a native crop of Sikkim.

without understanding and considering social relationships, of which gender relationships are some of the most important.

References

Fonning, A. R. (1987) *Lepchas - My Vanishing Tribe*. New Delhi: Sterling Publishers Private Limited

Gorer, G. (1938) *The Lepchas of Sikkim*. Delhi: Gian Publishing House

Government of Sikkim (1994) *Sikkim: A Statistical Profile, 1979-80 to 1991-92*. Gangtok: Department of Planning, Bureau of Economics and Statistics

Gurung, C. (1998) *Indigenous Knowledge and Sustainable Livelihood Practices Among the Lepchas of Sikkim*. A research project study report submitted to the UNESCO Team Leader for the UNESCO-ICIMOD Project, Kathmandu

Gurung, C. (2000) *Gender, Ethnicity and Agrobiodiversity Among the Lepchas of Sikkim*. A research project study report submitted to the Coordinator, IDRC Project, Kathmandu

Sharma, E.; Sundriyal, R.C. (1998) 'The Successful Development of a Cash Crop from Local Biodiversity by Farmers in Sikkim, India'. In Pratap, T; Sthapit, B. *(eds) Managing Agrobiodiversity*. Kathmandu: ICIMOD

Siiger, H. (1967) *The Lepchas - Culture and Religion of a Himalayan People, Part I*. Copenhagen: The National Museum of Denmark

Managing Marginalisation in Shifting Cultivation Areas of North-east India : Community Innovations and Initiatives

D. Choudhury, D. Ingty, and S. Jamir
North Eastern Region Community Resource Management Project for Upland Areas, Meghalaya, India

Introduction

For the majority of the upland communities of north-east India, shifting cultivation (popularly known as 'jhum') is the primary – and often, the only – agricultural practice and means of livelihood. Until a few decades ago, 'jhumming' afforded food security for upland farmers without raising serious concerns about the associated environmental damage. Today, this is more the exception than the norm.

Although reducing shifting cultivation has been central to development planning for north-east India for over two decades, numerous programmes under successive five-year plans have not been able to eradicate this practice in spite of their best efforts and the infusion of substantial funds. In most areas, with no assured and satisfactory returns from settled agricultural activities, the jhumiyas became more vulnerable over time, and their socioeconomic conditions worsened, forcing them to revert to shifting cultivation. Shifting cultivation still exists as a primary agricultural practice in the uplands of the region, with no viable alternative that is acceptable to the jhumiyas.

Examples of community initiatives and innovations to solve the problems of progressive marginalisation and increased vulnerability have started to emerge all over the region. This paper highlights two examples from the uplands of the region – one from the Mokokchung district of the state of Nagaland, and the second from the Garo Hills district of Meghalaya.

Methodology

Field observations and surveys; interactions with community elders, government officials, and individual jhumiyas; and assessment of agricultural statistical data at the district and block levels formed the basis of the study at Khar village, Nagaland. In the Garo Hills study, statistical information was gathered from the district and block level offices, and joined with personal observations made in the study area over a period of approximately a decade.

Results

Increasing cycle lengths: innovations within the traditional land practices

Khar village, Mokokchung (Nagaland)

Khar is an Ao village of approximately 400 households in the Mokokchung district of Nagaland. For these villages, declining productivity from the jhum systems and the lack of avenues for income generation had became a growing cause for concern by the early 1990s. With jhum cycle lengths declining to nine years (from 15) and reduction in productivity, the villagers were compelled to address the situation. The villagers recognised that to ensure food security, the cycle lengths in the jhum had to be increased and non-perishables with high returns had to be cultivated. They also realised that the answers to their plight could not be found in exogenous systems; solutions to the twin issues of food security and cash flow had to be sought within the traditional system.

Jhum lands are a common property resource, owned and managed by the community through the traditional institution of the village council. Each year, the village selects a patch for jhumming, termed 'bokh'. Within each bokh, clan patches, or 'kitong bokhs', are selected by the clans, the choice of patch being governed by the status of the clan in the village hierarchy.

After selecting the kitong bokhs, the clan distributes individual plots to each of its members. The distribution of individual plots, known as 'among', again follows a set custom. The choice of the best plot within the kitong bokh goes to the eldest member of the clan followed by others in hierarchy of age. 'Among' size is determined not by family size, but by the number of family members residing in the village. Families that do not have an 'among' in a bokh are accommodated and allowed access to plots which otherwise would be uncultivated by their tenants due to temporary migration, or are given access to plots which arise due to reductions in plot size. This flexibility is possible only because of community ownership and is not possible where land ownership is individual or private.

Increasing, rural-urban migration has reduced the labour force per family. A related consequence was the reduction in the number and size of 'amongs'. Khar villagers saw an opportunity in this situation and decided to consolidate 'among' sizes and numbers. By consolidating the surplus 'amongs' from several bokhs and realigning the bokh sizes, Khar villagers generated new bokhs or jhum patches that permitted an increase in their jhum cycles from 9 to 12 years – a step towards improved productivity and food security.

Through plot consolidation, surplus land was generated and then merged with 'amongs' that were unused because their tenants resided outside the village. The resultant plot has been put under forestry with high-value timber species. This strategy ensured tree farming and an avenue for income generation on maturity. The innovation in Khar lies in the fact that the villagers used their traditional land use practices to find innovations that would ensure food and economic security without depending on external sources.

Ensuring food and economic security under intense land pressure

West Garo Hills, Meghalaya

In the Rongram Block of West Garo Hills, shifting cultivation was the primary agricultural practice until the late 1980s. Efforts by different central and state government departments (e.g., Agriculture, Horticulture, Soil Conservation and Forest) to replace jhum practices were initiated in the 1980s to promote and expand permanent plantations of horticultural and cash crops. These efforts met with limited success primarily because of the failure of the agencies to ensure storage, processing, and effective market linkages.

While villagers accepted the initiatives in the early phase, the poor returns brought disillusionment, and plantations were rapidly abandoned. This is clearly reflected in the land use figures for the district for the periods 1981-82 and 1986-87. While nearly 10% of the area was under permanent plantations by 1981-82 (mainly under coffee, cashew nut, rubber, areca nut, and orange), by 1986-87 only 3% of the district remained under such plantations.

The area under forests increased by approximately 8% in 1987-88 with the establishment of Nokrek Biosphere Reserve, and the Balphakram and Siju Sanctuaries. The result was that jhum cycles reduced drastically, with corresponding declines in productivity. For the jhumiyas, this meant marginalisation and increased vulnerability. The villagers responded by taking initiatives to improve their conditions in the face of intensifying land pressure and declining productivity from jhum fields. Their first response was to ensure food security; this they did by shifting their staple production from jhum fields to terraces.

In its initiative to replace jhum, the Soil Conservation Department had tried to convert suitable land to terraces in the late 1980s. The villagers accepted this alternative as productivity declined in the jhum, and by the mid-1990s the increase in terraces started showing in the uplands; by the end of the 1990s, 290 hectares of wet terraces had been established in the uplands (Table 1). The values in Table 1 suggest a reduction in area under jhum paddy, but not the total area under jhum, as terraces met the requirement for growing paddy. The area vacated by paddy in the jhum fields has been replaced by commodity or high value cash crops. This is clearly evident on a temporal comparison of crops grown in jhum fields in the 1970s and now (Table 2).

Table 1: Land use dynamics in the west Garo hills: increase in terraced land

Rice varieties	1989/90		1992/93		1995/96		1998/99	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Jhum paddy	3126	-	2905 (- 221)	(-) 7.07	2880 (- 246)	(-) 7.9	2871 (- 255)	(-) 8.2
Early (aus)	149	18.2	152	18.3	291	29.8	290	28.9
Late (sali)	681	83.1	678	81.7	687	70.3	715	71.1
Total	830		830 (+ 10)	1.2	978 (+ 158)	19.3	1005 (+ 185)	22.6

aus – terraces in the uplands; sali – wet rice in low lying areas; figures in brackets show the changes in area for the period compared to 1989-90; percentage figures for wet rice correspond to the total area under wet rice.
Source: District Agriculture Office, West Garo Hills, Tura

Table 2 also depicts the changing patterns of the crops grown in response to changing conditions. Earlier, staples such as cereals constituted the principal crops. Today, cereals have been relegated to intermediate crop status. Overall, while 10 of 21 crops were (staple) food crops in earlier jhum systems, at present out of 19 crops grown, only two are (staple) food crops the remainder are cash (commodity) crops.

Besides commodification of jhum systems, Garo Hills villagers have also taken advantage of opportunities to promote plantation crops such as areca nut and cash crops like tea as

Table 2: Changing ratio of food crops and commodity crops in jhum fields		
	CROPS GROWN IN JHUM FIELDS	
Relative area occupied	1970s	1998/99
Principal crops, 70%	Cereals: Paddy, Maize*, Millet Tubers: Tapioca*, Yam* Vegetables: Pumpkin*, Cucurbits*, Sorrel leaves	Cereals: Maize* Tubers: Ginger* Veg.: Pumpkin* Spices: Chillies*
	(3:5)	(0:4)
Intermediate crops, 20%	Spices: Chillies Tubers: Ginger, Turmeric Veg.: Brinjal, Tomato Other: Cotton*, Jute*, Mesta*	Cereals: Paddy, Millet Tubers: Tapioca*, Yam* Veg.: Cucurbits*, Beans*, Spring Onions* Other: Tobacco*, Cannabis*
	(5:3)	(2:7)
(Minor crops, 5%	Oil seeds: Sesame Other: Tobacco*, Cannabis* Vegetables: Beans, Spring Onions*	Oil seeds: Sesame* Vegetables: Hill Tomatoes*, Beans* Other: Cotton*, Mesta*, Jute*
	(2:3)	(0:6)
Total	(10:11)	(2:17)

Source: Field study
*commodity crops; figures in brackets depict ratio of food to commodity/cash crops

a means of increasing their income and ensuring economic security. Transformation in this sector has been gradual, but in the last decade (1989-1999), there has been a significant increase in the area under such plantations – from 1673 hectares in 1989-90 to 2778 hectares in 1998-99, an increase of 66% (Table 3).

Table 3 also reveals the community's choices in spreading risk. The areas under perishable crops such as orange, pineapple, and banana show few significant changes. The area under orange showed increases up to 1995-96, reflecting promotional efforts by different departments rather than villagers' choice. Similarly, cashew nut was promoted by government agencies, but in the absence of processing and market linkages, cashew plantations declined and eventually were confined to pockets with relatively better access to markets. The villagers chose instead to expand areca nut plantations due to the non-perishable nature of the crop and good market linkages. Areca nut plantations constitute the largest proportion consistently in all periods from 1989-90 to 1998-99.

Table 3: **Changes in the area under orchard/permanent crops in the 1990s**

Crops	1989-90		1992-93		1995-96		1998-99	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Papaya	7	0.4	41	2.1	65	2.5	74	2.7
Pear/Peach	9	0.5	10	0.5	14	0.5	18	0.7
Orange	228	13.6	355	18.3	617	23.6	465	16.7
Pineapple	380	22.7	386	19.9	390	14.9	507	18.3
Banana	145	8.7	168	8.7	166	6.3	178	6.4
Cashew	391	23.4	220	11.4	375	14.3	387	13.9
Areca nut	490	28.7	670	34.6	887	33.9	892	32.1
Tea	23	1.4	89	4.6	106	4.1	257	9.3
TOTAL	1673		1939		2620		2778	
Increase			266	15.9	947	56.6	1105	66.1

Source: District Agriculture Office, West Garo Hills, Tura
Figures depicting increases refer to 1989-90 as base year; percentages are in relation to total area for the period under consideration

In addition, a new transformation witnessed in these areas is the growth of tea plantations. Tea was introduced by the Agriculture Department and later promoted by the Forest Department under its ecodevelopment scheme. Tea has become an acceptable option only because of the availability of processing and an assured market. Currently, with returns from tea assured, more villagers are choosing this option.

Conclusions and Future Implications

These case studies highlight a simple lesson: faced with the challenge of adversity and progressive vulnerability, communities seek their own viable solutions. These answers could be sought through introspection of their empirical experiences and collective traditional wisdom, as in the case of Khar village, or could be adaptations, modifications, and replications of options observed in their surroundings, as in the case of Garo Hills.

A viable option for agricultural development in the uplands of northeast India has yet to emerge. The answer has to be sought within the traditional framework of customary practices (Palni and Choudhury 2000; Ramakrishnan et al. 1994). The two case studies reported here provide examples of possible strategies that could be developed under different sets of stress conditions. These also suggest that solutions can be found that are flexible enough to allow a synthesis of traditional practices and scientific approaches.

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References

Palni, L.M.S. and Choudhury, D. (2000) *Agricultural Self-Reliance in Northeast India: The Potential of Indigenous Technical Knowledge and Traditional Practices,* Proceedings of the National Seminar on Resource Management for Self-Reliant Agricultural Economy of NE Region. Tezpur: NERIWALM

Ramakrishnan, P.S.; Purohit, A.N.; Saxena, K.G.; and Rao, K.S. (1994) *Himalayan Environment and Sustainable Development,* INSA Diamond Jubilee Publication. New Delhi: INSA

Sustainable Management of Beekeeping in Jumla District of Nepal: The Role of Farmer-led Institutions

M.B. Gurung, S.R. Joshi, and F. Ahmad
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

Past development efforts have often ignored the vital elements of sustainable development: involvement of the beneficiaries and strengthening their institutions. It is now realised that sustainable management of any development activity is possible only if the people in need are involved in all the phases of development from planning, through implementation, and monitoring to benefit sharing. This paper highlights the role of farmer-led institutions in ICIMOD's bee-keeping project which is being implemented using a community-based approach in Jumla district of Nepal.

Beekeeping in Jumla

The rich tradition of beekeeping in Jumla is associated with the genetic diversity of Jumla *Apis cerana*, the availability of bee forage plants, and a wealth of indigenous knowledge on beekeeping. Nowadays only the poorest of the poor in remote villages keep native *Apis cerana* bees. At present, there are around 5000 log hives with bee colonies in Jumla district. The Jumla strain of *Apis cerana* is a good genetic race in the sense that it is larger, and produces more honey, and has a lower level of absconding, than other strains like *Apis cerana himalaya* and *Apis cerana indica*.

Why beekeeping in Jumla?

In Jumla, most of the farmers living in remote villages above 2600m keep bees primarily for selling honey and other value-added products. Most beekeepers do not have 'khet' (irrigated land) for rice growing and a system of bartering honey for rice from lower altitude areas has existed for many years. Beekeeping is one of the major sources of income for beekeepers, as there are limited options for cash income. Sustainable beekeeping management is, therefore, crucial for poor farmers to generate cash income. This enterprise provides benefits to individual beekeepers at a local level (food, nutrition, better crop yield through pollination, cash income, medicine, and so on) as well as to society, at national, regional, and global levels (biodiversity, clean air, water, and so on).

Project Initiatives

The Austrian government funded a project entitled 'Promotion and Development of Beekeeping Through Preservation of Indigenous Honeybees, *Apis cerana*', from July 1993 to December 1998. This project focused on research and development, particularly in Nepal. During the phase, the project carried out research on the genetic diversity of *Apis cerana*, crop pollination, honey plant resources, and comparison of straw and wooden hives. From 1995 to 1998, the focus of the project shifted to training and extension, particularly in Jumla. The training and extension activities initiated in Jumla communities became the basis for further beekeeping development in the region. Some of the activities undertaken in Jumla to make the project's initiatives more effective and sustainable included: (a) farmer-trainers training, (b) village-based training and workshops, (c) farmer field trips, (d) distribution of written materials, (e) exhibitions, (f) participatory planning and extension, (g) group formation and mobilisation, and (h) marketing activities.

Project Accomplishments

Awareness about the conservation of indigenous honeybees

Through applied research, training, and extension activities, the project raised awareness among beekeepers, honey hunters, local farmer-led organisations, government, and non-government organisations about the importance of conserving *Apis cerana* and other wild bees (*Apis laboriosa* and *Apis dorsata*).

Building farmer organisations

The establishment of farmers' groups and networks facilitated a wide exchange of experiences and resources. The development of farmer-trainers within the communities further facilitated the process of linking farmers' groups to district-based government and non-government organisations. The strengthening of some farmer-led organisations and community-based farmers' groups for the development of farmer-to-farmer extension and marketing services for bee-based products and other local products has led to sustainable beekeeping management in Jumla.

Establishment of a beeswax collection and processing centre

A beeswax collection and processing centre was established in Jumla bazar. A farmer-led organisation was made responsible for beeswax processing and marketing of honey. With the help of the ICIMOD beekeeping project and the farmer-led local organisation, the farmers have been able to make candles and herbal creams for their own use and for marketing to generate income.

Women farmers' participation in beekeeping enterprises

The project initiated the formation of women's groups and trained women who later worked together with other groups. Participatory approaches such as PRA tools and techniques were used to analyse gender roles and examine ways to make project activities relevant to women farmers. Previously, women farmers were being excluded from participating in community development activities. With the advent of the project, quite a few women farmers have been trained in both technical and organisational aspects of beekeeping.

Human resource development in beekeeping

Various types of training were imparted to both men and women beekeepers. The farmer-led organisations also trained their staff in various aspects of beekeeping management and enterprise development. The farmer-trainers form a valuable resource for the community as they are the source of information regarding beekeeping management. A total of 143 beekeepers have been trained as local farmer-trainers on such aspects as beekeeping management, hive making, queen rearing, and honeybee diseases. The staff of the farmer-led organisation has also been supporting other government and non-government organisations in organising training events on beekeeping management in general and candle and cream making in particular.

Improvement of Appropriate Technologies for Beekeeping

The project facilitated improvement of traditional beekeeping through the use of appropriate technologies. The Jumla top bar hive proved to be the most appropriate technology for the area. A number of farmers constructed these hives with their own investment. The farmer-led organisation in Jumla is promoting the hive by collaborating with other organisations. Out of 24 VDCs where ICIMOD implemented its beekeeping programme, 19 VDCs adopted Jumla top bar hives; the remaining five have not yet adopted this hive due to a lack of farmer-trainers and wood for making the hives.

Factors Contributing to the Development of Farmer-led Institutions

Several factors contributed to the development of farmer-led institutions. They included: (a) strong beekeeping traditions and indigenous knowledge, (b) abundant natural wildflowers and plants available in forests and on uncultivated lands, (c) participation of both men and women beekeepers in the process of beekeeping development, (d) facilitation by the project team for mutual learning through sharing ideas and experiences, and (e) supporting of local partner institutions and farmers' groups to build institutional and human resource capacity through training and experience sharing.

Future Implications

Strengthening farmer-led organisations for the development of farmer-to-farmer training and extension is imperative for sustainable beekeeping management. Equally important is farmer's participatory research on *Apis cerana* for a new professionalism with new concepts, values, and behaviour.

Beekeeping should be taken as an integrated approach to development, rather than a sectoral approach. A beekeeping project focusing on poverty alleviation and biodiversity conservation cannot work in isolation. Therefore, partnership with local communities is crucial to integrate other forms of income generation programmes such as vegetable seed production, apple farming, promotion of local products like blankets, herbal tea, bamboo, and woollen products.

Participatory Action Research on *Apis Cerana* Selection for Improving Productivity and Conserving Biodiversity: A Case Study from Alital VDC of Dadeldhura District

S. R. Joshi, F. Ahmad, and M. B. Gurung
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

Apis cerana, the native hive bee of Asia, is the most valuable natural resource of beekeeping in the Hindu Kush-Himalayan (HKH) region and has been considered a vital component of the natural ecosystem. This species is equivalent to the European honeybee *Apis mellifera* in comb building, dancing, and nesting behaviours. Being native to the region, *Apis cerana* is better adapted to the local environment and to its co-evolved flowering plants, and can survive without supplementary feeding or medication. It is an excellent pollinator of early blooming mountain crops such as almond, apple, pear, plum, and different vegetable seed crops (Partap & Partap 1997; Verma & Partap 1993). However, it produces less honey and has some undesirable behavioural characteristics like frequent swarming, absconding, and robbing. For higher honey production, *Apis mellifera* has been imported in many parts of HKH countries and is becoming popular among commercial beekeepers. Surveys conducted by ICIMOD during recent years showed that the population of *Apis cerana* in the HKH region is declining (Partap 1999; Verma 1992).

Bee researchers, development workers, and pollination scientists warn that the decline in *Apis cerana* population may result in a loss of plant biodiversity in an area and create socioeconomic problems. As *Apis mellifera* beekeeping requires more resources (time, treatment against epidemic diseases and predators) and needs a high level of inputs in terms of capital and management, it is unsuitable for subsistence rural farmers/ beekeepers (Pechhacker et al. 2001). Keeping this in mind, ICIMOD's beekeeping project has adopted a participatory approach to conduct action research on *Apis cerana* selection and multiplication in different areas of the HKH region to imporve the performance of the bee. Based on the richness of bee flora, prevalence of *Apis cerana*, and concentration of bee colonies, Alital VDC of Dadeldhura district in far western Nepal was selected as one of the potential sites, and 53 beekeepers were identified as action research partners.

The research seeks to improve the productivity and behavioural characteristics of *Apis cerana*. The participatory action approach calls for people's participation in every stage of the *Apis cerana* selection and multiplication process. This innovative programme is farmer managed, farmer supervised, and farmer operated.

The Action Research Programme

The approach used focuses on a group of people who participate in the action research process. Farmers are involved at every stage from data recording to colony management and data analysis. The project uses a dialogue-based participatory approach to enhance local people's awareness and confidence, and to empower their actions. Staff professionals from ICIMOD and NGOs have roles as convenors, catalysts, and facilitators. The approach involved five basic steps: formation of beekeepers' groups/associations, enhancement of skills and capability, capital formation, improvement of beekeeping management techniques, and improvement of the productivity and behavioural characteristics of *Apis cerana* through selection.

Formation of groups or associations

For the effective selection and propagation of better stock, beekeepers need to have larger apiaries from which to choose more productive colonies. But most *Apis cerana* beekeepers are subsistence farmers keeping one or a few colonies in traditional fixed comb hives. To generate data from a large number of colonies, it is essential to organise beekeepers. Hence the project facilitated a series of meetings with beekeepers/farmers to discuss the issue and build consensus about the approaches, methodologies, and activities to be implemented in Alital VDC. The project also sensitised the community members to the benefits of working collectively and encouraged them to form a community organisation. As a result there is now a very dynamic group known as Alital Mauripalan Sumuh (Alital Beekeeper's Association; ABA). This association has both men and women members.

Enhancement of skills and capability

To bridge the knowledge gap and improve existing skills and capability, the group of action research farmers/beekeepers was trained in different aspects of beekeeping including hive making, colony management, queen rearing, data collection, and group mobilisation. The main objective of training was to develop knowledge, skills, and confidence in strengthening beekeeping activities at a community level. A variety of participatory training methodologies were used to make training as effective as possible. Practical aspects of the training were emphasised in preference to a classroom orientation. Training sessions were conducted at an active beekeeping site where trainees had an opportunity to do hands-on work. The training encouraged participation of beekeepers who are keeping bees and need such support and help. Women beekeepers were especially encouraged to participate.

Capital formation

Capital is an essential input for any development work. Although currently many of the activities related to this programme are sponsored by ICIMOD's beekeeping project through the Rural Women's Development Unity Centre (RUWDUC, a local NGO), the intention is for ABA to develop over the coming years into a farmer-led self-financing organisation. With this intention, ICIMOD provided a revolving fund of NRs 30,000, which ABA has been using as seed money. Members of ABA also have a savings and credit scheme. They meet regularly and deposit NRs 15/month and mobilise capital among group members as loans for procuring beekeeping equipment. The project has also been facilitating them in mobilising local skills and resources. Farmers with training on hive carpentry were encouraged to construct hives and sell them in the local market. In the long term, we hope that the action research farmers and ABA will be able to run the *Apis cerana* selection programme on a sustainable basis.

Selection process

Fifty-three beekeepers with a total of 258 bee colonies were identified in three different villages of Alital VDC. Each hive was given a code number, and data are regularly generated. Beekeepers were provided with technical support for raising their bees in movable comb hives. The following criteria were adopted for selecting the best colonies of *Apis cerana*:

- honey yield;
- colony age;
- colony strength;
- brood and egg laying pattern;
- tendency of swarming and absconding; and
- resistance to diseases and parasites.

After selecting the colonies, queens are reared using artificial or semi-artificial methods of queen rearing that have already been tested and perfected on *Apis cerana*. The queens of weak, diseased, and less productive colonies will be replaced by newly reared, mated queens for better performance.

Preliminary Data on *Apis cerana* Selection

The farmers are participating regularly in generating selection data. Some preliminary data are presented below in Tables 1 and 2. However, as selection is a continuous process, the data have not yet been analysed statistically.

The preliminary data suggest that there are a few colonies that are exceptionally good (i.e., have a very low swarming tendency and good honey gathering qualities). There are a very few colonies that have not absconded or deserted their hives over an eight-year period (Table 1). Even with traditional beekeeping methods, some colonies of *Apis cerana* produce more than 5 kg of honey per harvest (Table 2). The results support the decision to start a selection and multiplication programme.

Rearing of queens from productive colonies that are well adapted to the local environment and have survived between five and eight years will surely improve the honey yield and absconding behaviour of *Apis cerana*. By choosing the best individuals and multiplying them, the gene-pool of a population grows more and more uniformly. The continuous and collective work of selection and multiplication will improve not only the yield of the colonies but also the behaviour of *Apis cerana* bees.

Honey production can be increased many times by adopting modern methods and selective breeding programmes. Wongsiri (1992) has reported that the number of colonies and

Table 1: **Colony Age**

Age	Percentage of colonies (n = 257)
< 1 year	67
2-4 years	27
5-7 years	5
> 8 years	1

Table 2: **Honey Production**

Honey harvested	Percentage of colonies (n = 198)	
	May/June	Nov/Dec
< 1 kg	8	9
1-2 kg	79	41
3-5 kg	11.5	44
> 5 kg	1.5	6

honey yield increased year by year following adoption of modern management methods and selective breeding programmes in Chonghua County, Guandong, China.

Integration of *Apis cerana* Selection and Biodiversity Conservation Programme

Plants and bees are interdependent and equally important for environmental conservation. Plants provide bees with their habitat and food requirements, and in return bees perform the critical activity of cross-pollination. It is evident that the return from honeybee pollination is several times more than the returns from honey and wax alone. Many cultivated crops or wild plants do not yield seed and fruits without pollination of their flowers. However, understanding of the importance of bee pollination is negligible in the HKH region. Therefore, by conducting training and producing awareness-raising materials, the project has been trying to change the mind set of people from beekeeping for honey production to beekeeping for increasing overall productivity and conserving biodiversity.

Conclusions

The area has a productive physical infrastructure and offers great potential for beekeeping development. Farmers are convinced of the value of the participatory action research programme on *Apis cerana* selection and are generating data regularly. However, they are still waiting for real outputs and want to have immediate benefits from the programme. Practically, it is not possible to show significant changes in colony productivity within one or two years, such changes may take five to ten years, so there is a need for long-term participation. The process of *Apis cerana* selection has just been established. Further strengthening of beekeepers' capability is essential for sustainability and continuity of the selection and multiplication programme. To promote beekeeping as a sustainable option for rural development, there is a need to link beekeeping with other development activities and biodiversity conservation programmes.

References

Partap, U. (1999) 'Conservation of Endangered Himalayan Honeybee, *Apis cerana* for Crop Pollination'. In *Asian Bee Journal* 1 (1): 44-49

Partap, U.; Partap, T (1997) *Managed Crop Pollination: The Missing Dimension of Mountain Agricultural Productivity,* Discussion Paper Series No. MFS 97/1. Kathmandu: ICIMOD

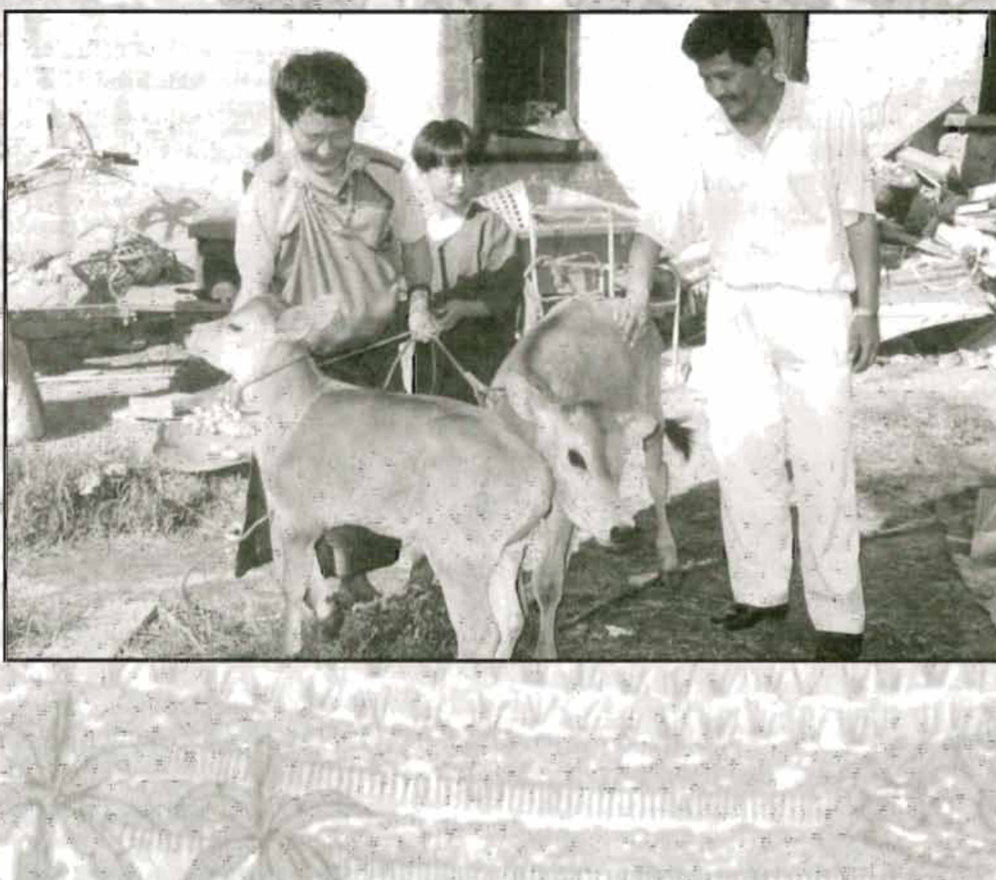
Pechhacker, H.; Joshi, S. R.; Chatt, A. (2001) 'Traditional Beekeeping in Rural Areas: a Comparison between *Apis cerana* Beekeeping in Nepal and *Apis mellifera* Beekeeping in Morocco.' *Bee World* 82 (2): 99-105

Verma, L. R. (1992) *Honeybees in Mountain Agriculture.* New Delhi: Oxford and IBH

Verma, L. R.; Partap, U. (1993) *The Asian Hive Bee, Apis cerana, as a Pollinator in Vegetable Seed Production.* Kathmandu: ICIMOD

Wongsiri, S. (1992) 'Beekeeping Problems in Developing Countries of South-East Asia'. In Verma, L. R. (ed) *Honeybees in Mountain Agriculture*, pp 239-248. New Delhi: Oxford & IBH

Institutional Strategies for Developing Mountain Farming



An Institutional Strategy for Improving Mountain Farming: A Study of Uttaranchal State in the Indian Himalayas

H. C. Pokhriyal
National Society for Promotion of Development Administration, LBS National Academy of Administration, Mussoorie, 248179, Uttaranchal, India

Introduction

The need for alternative policies to provide opportunities for improving the livelihoods of the people living in mountainous areas is now increasingly understood. Generally, a technological bias has been reflected in many of the policy documents aimed at improving mountain agriculture. However, recent understanding of farming experiences emphasises the institutional dimensions of mountain agricultural development. It also emphasises that sustainable results can only be achieved if the technological aspects are kept as complementary and supporting components to the institutional approach.

The institutional approach mainly focuses on the 'insiders' viewpoints and 'their own perception' about traditionally sustainable and sedentary mountain farming that have been collected from land settlement reports and land records. The institutional cutting edge issues mainly relate to ownership of land and water resources, attitudes and perceptions, land consolidation, and capacity building, along with proper sensitisation of the development functionaries including bureaucracy. In the institutional dynamics of marginality, gender participation and empowerment are an essential part of development strategies based on an institutional approach.

This paper analyses and demonstrates the benefits of an institutional strategy that could become an integral part of alternative policy advocacy for improvement in mountain marginal farming, specifically in the context of Uttaranchal development. It analyses the institutional dimensions of agricultural development by selecting a mountain region that is still practicing traditional sedentary mountain cultivation. Other secondary sources and databases related to land use information are also reviewed. A participatory rural appraisal (PRA) was also conducted to ascertain the community's perception of various issues related to mountain farming.

Present Status of Mountain Farming in Uttaranchal

Uttaranchal is a new Indian state that earlier had been an economic region comprising a few districts in Uttar Pradesh state. Uttaranchal has diverse agro-climatic features, including a somewhat flat area called 'Tarai', mid mountains, and high land nearing the snow line. These diverse agro-climatic regions have not been utilised to complement each other in terms of farm production or providing two-way linkages. Based on the latest population estimates from the 2001 census, 8.5 million people comprising 75% of the population live in 15,024 inhabited villages, and there are 84 urban centres spread over 53,483 sq.km. A relatively high literacy rate of around 72% can be taken as one of the better indicators of social development.

The production of the main crops reflects the diversity in the agro-climatic conditions and the relative importance given to agriculture in different districts. The average productivity for the high yielding varieties like wheat and paddy is 18.4 quintal[1]/ha for wheat and 19.8 quintal[1]/ha for paddy, whereas for traditional non-irrigated crops like 'mandua', 'jhangora', and maize the figures are 13.1, 10.7, and 11.1 quintal[1]/ha, respectively.

The land use data in Uttaranchal also show a steep rise in both the 'current fallow' and 'cultivable waste' areas, indicating a considerable decline in the net sown area. This peculiar aspect has been continuously reflected in the land use data (Pokhriyal and Bist 1988), and the process of abandoning cultivated land still continues. The net sown area was around 13% of the total geographic area in 1998, and the cultivable waste area and other fallow land were together around 7%. Similarly, water utilisation and irrigation proportion have also gone down in recent years. This has further increased the marginalisation of mountain farming communities, especially in areas of high migration. Although various government departments and other institutions support mountain farming and other related activities, attitudinal indifference, non-accountability on the part of development officials, and a non-participative approach mean that the marginal farmers, especially women, remained detached. The mountains are treated as a place for punishment posting of government officials, thus the extension officials cannot be expected to show any interest in innovation. There is a great need for attitudinal change among the government functionaries. Equally, the net potential and possible advantages from using both the net sown area and waste land for niche-based economic activities need comprehensive policy advocacy.

Learning from the Land Settlement Process

Recently, environmental sustainability, food security, and biodiversity related issues have become important in the context of mountain farming development. In the debate on the need for a better quality of life and on the relevance of bio-farming, mountain agriculture re-emerged as important. It is expected that in the future marginal mountain farming will get more attention than in the past, and that better market linkages will further improve the income opportunities for mountain farmers, especially women.

In Uttaranchal, some institutional efforts were carried out during the British rule from 1815 to 1910, but the period between 1910 and 1947 was a more inactive phase. The technological phase began in the post independence period starting from 1947. During the technology dominated phase, half-hearted efforts to improve hill farming were made. But, during this phase there was a considerable reduction in mountain farming. Intentional neglect of the potential of mountain farming was (and is) one of the major factors contributing to the sluggish growth of hill agriculture.

Much can be learnt from the various conscious efforts made in the different phases of the farming history on mountains of Uttaranchal. The last two hundred years can be divided into three broad phases On the basis of the land settlement records and the reports on land tenures, the 'khaikari/occupancy phase' before 1790, the 'hissadari/

[1] 1 quintal = 100 lbs or 100 kg, ed

right to transfer the cultivated land' phase (1815 to 1920), and the 'post-independence phase of indifferent attitude' (post 1947). In between these three phases two transitional intervals can be seen, one from 1790 to 1815 and the other from 1920 to 1947. During the first transitional interval, some conditions were created intentionally through government intervention, and in the later transitional phase circumstances pushed down mountain farming in Uttaranchal. A normative scale was prepared on the basis of the overall efforts made through public policy and programme intervention to improve mountain farming. The trends calculated using this scale are shown in Figure 1. The normative scale also considers the kind of enthusiasm that was found and the importance given to creating a sustainable resource base for the farmers in terms of expansion of the area under sedentary cultivation and better utilisation of water resources for irrigation. The settlement of new villages was also taken as an important determinant of the slope of the trend line. The slope of the trend line was taken as an indicator of the trend in mountain development.

There was an upward movement in mountain development in the middle phase between 1815 and 1900 which was mainly due to deliberate public policy initiatives and strong support on the part of implementing government agencies. Institutional initiatives and introducing the right to private property within cultivated land were the vital institutional instruments. This innovative concept originated from an industrialised country, England, and was transplanted by the British colonial authorities into the cultivable lands in the mountains. Gradually the mountain farmers realised the significance of the occupancy right and the right to transfer, with the result that every peasant family tried to make use of the extended opportunity to own the cultivated land legally. The awareness of private ownership over land resources, and the consistent effort on the part of the government, resulted in a major transformation in mountain farming during the nineteenth century.

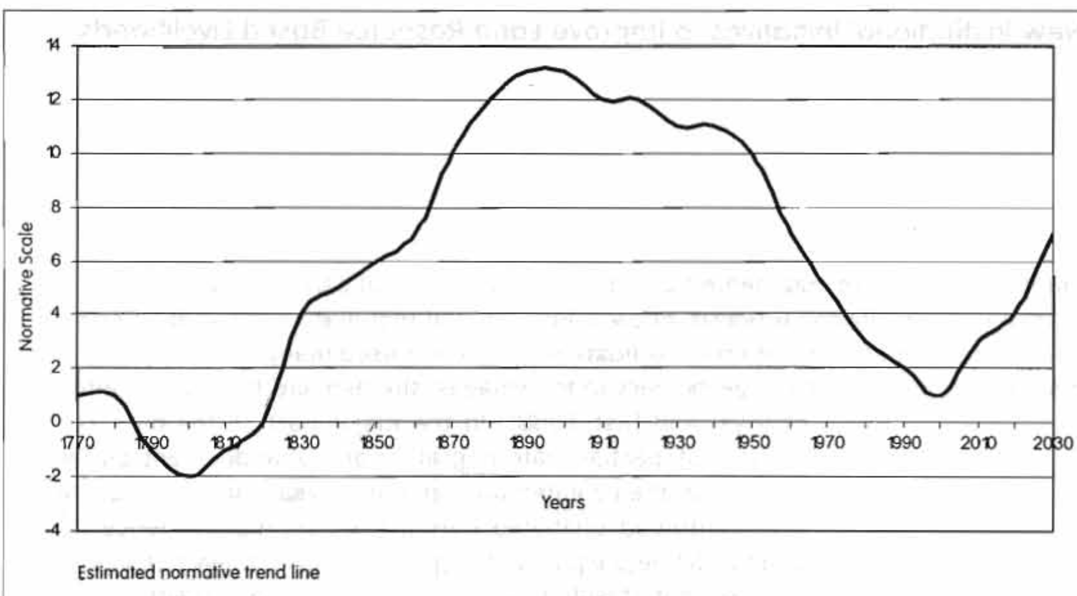


Figure1: **Ups and Downs in Mountain Farming in Uttaranchal**

A peculiar type of shifting cultivation known as 'katil' and 'ijran' was practised in the native phase before 1790. This was reduced considerably in the British period due to the institutional initiatives, and sedentary mountain cultivation became deeply institutionalised within the rural socioeconomic fabric of the mountain communities. These initiatives also resulted in empowerment of the people and environmental sustainability. Private property rights were limited to cultivable land, including the current cultivation and new land put under cultivation. The major portion of the common property resources, the forests, was kept out of the private property concept. This way, the nineteenth century could be seen as the golden era of mountain farming in Uttaranchal.

The twentieth century started with the independence movement against colonial rule in India. After the movement had begun but before independence was realised, the British stopped taking further initiatives to improve mountain farming. Ibotson (1931) did the last study of British land settlement in the mountains of Uttaranchal. The early twentieth century saw a degeneration of mountain farming, abandonment of cultivated fields, and reduced importance of mountain farming in mainstream mountain development. Other factors triggering deterioration in mountain farming have been identified as the opening of other economic sectors that provided employment opportunities to male migrants. Apart from military service, the service sector provided male migrants with employment opportunities in government departments in the plains.

Traditional farming is still practised in the larger mountain region of Uttaranchal, and there are many opportunities inherited within the traditional sector linked with biodiversity and the emerging demand for bio-farming based agricultural products. The future development policy of Uttaranchal needs to be seen in this perspective, and one of the inferences that can be drawn is related to the utilisation of the comparative advantages and the niches already available within the traditional farming sector.

New Institutional Initiatives to Improve Land Resource Based Livelihoods

One of the major aspects of the institutional approach is to put all the other interventions under the umbrella of institutional dynamics. Various initiatives related to ownership, land tenure consolidation, and appropriate technological interventions could be included under the institutional approach. It equally takes into consideration the demand-driven land reform process within the socio-political complexities and rural power structure.

The consolidation of fragmented and distantly located land parcels could be seen as the fundamental institutional reform needed for marginal mountain farming in Uttaranchal. The need to initiate 'mountain consolidation' has been raised many times; in focus group discussions with the real stakeholders in the villages, the demand for consolidation was raised as a priority (Pokhriyal and Bist 1988). In the major part of the mountains of Uttaranchal, the vicious cycle of partial male migration and abandonment of the net sown area, including reduction in the irrigated area and an increase in the proportion of cultivable waste area, has continued unabated during the post-independence period. Responsible factors include the deliberate policy of negligence and half-hearted programme interventions implemented without stakeholders' participation. The present scenario of mountain farming looks dismal; its inherent potential and comparative advantages cannot be harnessed.

The initiative for land consolidation was taken around 1975, and in the last 25 years almost all the land of villagers has been included in the consolidation frame. The result has been to reduce the average distance to the field and increase the size of individual holdings consolidated at three or four places (Society for Mass Communication 1999). The success was due to local leaders who constantly motivated the people, and the demonstrated at effect of the economic viability of a ploughing unit. This provided incentives to utilise the comparative advantages of mountain farming in the most sustainable manner. Women gained the most from these efforts, as they could save their hard-pressed time and devote the saved time to household activities and caring for their children. Apart from saving time, this whole process has provided a firm base for empowerment to the hill women.

Another important aspect of this institutional dimension is linked with the new legal initiatives taken through the 73rd and 74th constitutional amendments in India. In these amendments, the local governments, known as the 'panchayati raj' institutions, working at the district level and below, have been empowered to plan for village development. Major areas related to agriculture and other primary sector activities have been legally assigned to the local governments. Under the new situation, these provisions are needed to harness the inherent niches available in the mountains of Uttaranchal state.
In quantitative terms, the expansion of cultivated area within the 'revenue land' and relationship with common property resources like forests can also be associated with the consolidation process. The consolidation also maximises possibilities for making use of the vertical space available to the farmers. In such a situation, the requirement is to analyse 'their perception' of 'their problems' and 'their options' on sustainable development of mountain sedentary farming comprising tiny landholdings. In addition to qualitative issues like producing high demand traditional varieties and 'bio-food', other possibilities will open after the consolidation is complete.

Conclusion

The important inference to be drawn is the dire need for a new land settlement oriented towards the consolidation of land and recording the private rights in the consolidation process. The only post-independence land consolidation in Uttaranchal was completed during 1962 to 1967, and it was proposed that a new settlement would be carried out only 40 years after the earlier one. Such a time frame would be good in the context of plains areas. But keeping in view the need of the mountain communities for environmental sustainability, there is a dire necessity to conduct a new land settlement in the mountains.

References

Census of India 2001 (2001) *Provisional Population Totals - Uttaranchal.* Luknow: Directorate of Census Operation

Ibotson, A. W. (1931) *Revenue Rate and Assessment Report of Pargana Garhwal District.* Allahabad: Government Printing Press

Pokhriyal, H. C. (1994) *Human Environment and Socioeconomic Development in the Himalayas.* New Delhi: D. K. Publishers and Distributors (P)

Pokhriyal, H. C. (1999) *Rich Land and Poor Peasants: the Institutional Analysis of Marginal Farming in the Uttarakhand Himalaya.* Paper presented at the International Workshop on Issues and Options for Improving the Livelihoods of Marginal Mountain Farmers, ICIMOD, 11 –14 October 1999, Kathmandu, Nepal

Pokhriyal, H. C. (1999) 'Uttarakhand Development: Whose Priority'. In *ICIMOD Newsletter*, Spring 1999. Kathmandu: ICIMOD

Pokhriyal, H. C.; Bist, N. S. (1988) 'Planning for Agricultural Development in the Himalayan Region: An Environmental Approach.' *The Environmentalist* 8 (1), 47-56

Society for Mass Communication (1999) *Role of Land Consolidation in the Development of Uttarakhand.* Srinagar: Society for Mass Communication

Research and Development Strategies for Horticultural Sustainability in Himachal Pradesh: Existing Status, Challenges, and Future Prospects

R.P. Awasthi and K.K. Raina
Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (HP) India

Introduction

Among the hill regions of India, Himachal Pradesh is often cited as a model of economic growth through horticultural development. However, in contrast to production, the R&D support for marketing and utilisation of horticultural crops has not been sufficient. A sustainable horticultural model for Himachal Pradesh should support fruit crop diversification through designing location-specific and needs-based models for each group of farmers, village, or niche as the case may be. It therefore requires strategic planning to see if the growth of horticultural R&D in the state is sufficient for attaining sustainable production by meeting the specificities of mountains. Besides the technological problems increasingly faced by state horticulture, other challenges in the form of R&D funding, manpower generation, collaborative research programmes, and lopsided regional development need to be examined if sustainable horticulture is to be developed in the state.

Horticultural Development in Himachal Pradesh

Existing status of R&D in horticulture

The growth and responsibilities of research organisations and development agencies in the hill region have been slightly different from those in the plains. Besides transferring technology, development departments also attend to the input supply through village-level functionaries, while research organisations are involved in technology generation. The most important responsibility of the universities is to create trained manpower for development departments. These research institutes are also responsible for the transfer of technology, but at the nucleus level through localised demonstrations and training. Non-government organisations (NGOs) have also emerged as a link between development departments and farmers for ensuring economic and ecological security through development of farming systems.

Development activities in Himachal Pradesh started in 1948, immediately after its creation from the former princely states. Originally, two separate departments of agriculture and forestry were established, but in 1950 they were merged into a single 'Forest Department' based on the plea that there was more area under forest than under agriculture. Two years later the agriculture department again attained independent status. In 1970, a separate 'Department of Horticulture' was carved out of the Agriculture Department with responsibility for developing ornamental and fruit crops. At present, the state's R&D in horticulture is supported through a well structured R&D network in Dr YS Parmar University of Horticulture & Forestry, with transfer of technology on horticulture as the prime responsibility of the State Development

Department of Horticulture. The Agricultural University at Palampur and the Department of Agriculture also contribute towards vegetables, flowers, and fruits through their limited mandates. The research input that was at one time embodied in the Department of Agriculture and other development departments has either been transferred to the agricultural universities or is the responsibility of the Indian Council of Agricultural Resources (ICAR) and Council of Scientific and Industrial Research (CSIR) laboratories. The primary duty of the developmental departments is to transfer the technology generated by the research institutes and universities at the grass roots level. These departments have to maintain close, effective, and continual linkages with the beneficiaries to obtain necessary feedback, and to establish linkages with research organisations for timely solution of problems posed by the farmers. The developmental departments are efficiently organised to meet the growing requirements of hill farmers, who have shifted from traditional subsistence farming to growing off-season vegetable crops and fruit farming. Over the years ICAR has initiated many projects on technology transfer, mainly through institutional-village linkage projects with the aim of transferring technology based on the participation of farmers, and the National Agriculture Technology Project (NATP) for strengthening of agricultural research, development, and extension. A number of farm science centres (krishi vigyan kendras or KVKs) have also been established to serve as district-level technology demonstration centres with adequate on-campus training facilities for the functionaries of the development departments, NGOs, and farmers. At present four KVKs are at Dr YS Parmar University of Horticulture & Forestry and another eight at Himachal Pradesh Agriculture University, Palampur.

Need for R&D Restructuring/Production Reorientation

Recently the existing R&D strategy module has stumbled due to the emerging challenges of increased interference by world trade and financial institutions, globalisation, financial constraints, market failures, and a variety of production problems. This scenario is putting enormous pressure on the sustainability of horticulture in the Himachal hills, requiring restructuring of production planning. The average productivity and quality of several horticultural crops remains far below the expected potential. Technical and production-based factors contributing to the problem include superior genetic material; senile orchards; inadequate adoption of advanced production technology and plant protection measures; non-availability of critical inputs like fertilisers, herbicides, pesticides, packing boxes, and raw material of the right quality for processing; inadequate post-harvest handling, credit support, marketing facilities, and extension support; and a weak database.

Existing R&D strategies must be modified in the light of new research and development priorities and modern technologies. The institutional set-up needs to be restructured with the advent of demand-driven extension modules, NGOs, and other grass roots institutions. Development of horticulture is also stressed in other regions of the Indian Himalayas. Future R&D strategies demand sectoral complimentarity through integration of indigenous knowledge, information technology, scientific back-up, gender equity, and farmers' decision-making, besides the protection of the interests of small and marginal farmers.

R&D Restructuring: Issues and Strategies

The sustainability of horticulture in Himachal Pradesh requires institutional strengthening and restructuring in the wake of increasing world trade competition, paucity of funds, emergence of new R&D sectors like NGOs and industries, and greater emphasis on demand-driven extension modules. The following issues and strategies can help in this effort.

Interactions among institutions

The present state of interactions among the research institutes and developmental departments is not very encouraging and seriously compromises efforts to achieve sustainability through effective dissemination of technologies generated by the research institutes. There are few linkages among the government institutes and the two farm universities working in research and extension. Farmers who follow mixed farming require advice on integrated development of their farming systems. It is obvious that unless there is an intimate cooperation, pooling of resources, joint planning, and execution of programmes, it will be difficult to meet the needs for technology generation and transfer, and to provide advisory services to the farming community and extension departments concerned with development activities. This collaboration should help to avoid unnecessary duplication of research efforts and enhance the pay-off from investment in research and extension. Consultation among these institutes to identify research priorities and strategies will be very useful. Proper linkages should be established among research institutes and universities by formulating joint research programmes wherever feasible.

R&D linkages with industry

There is a great scope for developing R&D linkages with industry because fruits and vegetables can be processed to add value and generate employment. Unfortunately, these linkages have not yet been developed; until now production has received most attention. Often remunerative prices for produce are not realised and farmers have to look to the sales agents of industrial houses for preservation and processing of fruits and vegetables. Therefore, it is of paramount importance to develop extension education strategies for the industrial clientele as well. Fortunately, some state processing institutes like HIMCU (Himachal Canning Unit), HPMC (Himachal Pradesh Horticultural Produce Marketing and Processing Corporation Ltd), and so on are coming up along with farmers cooperative agencies. These processing units need to be encouraged.

Linkages between R&D and NGOs

The new class of enthusiastic social workers should be encouraged by the research organisations as a link between farmers and the development departments. On the one hand, NGOs understand the inherent weakness of the implementation mechanisms of government agencies, and on the other hand they know the pulse and aspirations of the people. Government departments should utilise this vocal and aggressive sector to facilitate technology transfer. The linkages with women farmers can be strengthened through female NGO workers.

Restructuring transfer of technology module

The mechanism of transfer of technology (ToT) is important for disseminating the technology from research institutes to the beneficiaries. Development departments are responsible for the supply of inputs, dissemination of emerging technologies, and providing on-the-spot advice to farmers. Through an organised training and extension system, a two-way chain is formed linking the farmer to the contact farmer to the VLWs (Village Level Workers) to the ADOs (Agriculture Development Officers) to the SMSs (Subject Matter Specialists) and finally to the university research scientists. It seems to be an ideal mechanism, but due to the peculiar specificities of mountains the results have not been encouraging. The planning yardsticks applicable to the plains cannot be applied to the hills owing to the handicaps of difficult terrain, varying topography, diversified niches, and special localised needs. Therefore, the existing transfer of technology module must be restructured if it is to contribute to the sustainability of horticulture in the state. Future extension strategies will have to be based on demand-driven criteria and should be geared towards the transfer of location-specific technology. The needs of the farmers should be considered in a holistic manner. The transfer of technology through 'radio schools' should be made a regular feature due to restricted mobility of hill farmers. The feedback on farmers' problems and their solutions should be better coordinated for broadcast through the AIR (All Indian Radio). Telecast facilities can also serve this purpose. It is very important to include women because they are bound to play an important role in hill farming, and the education extension programmes must be responsive to their needs. Women extension education specialists should therefore be employed to promote direct ToT to women rather than to men, to avoid the dilution of technology when communicated indirectly. Further, the farmers need constant advice on the more remunerative patterns of farming and other newly emerging trends best suited to their requirements and agro-climatic situations. They need strong research and farm advisory support to achieve success.

Conclusions

The sustainability of horticulture in Himachal Pradesh requires that a variety of fruits with domestic marketing and export potential be cultivated in diverse and rich agroecological farming situations of the state. Structural changes in horticultural production systems through diversification, value-addition, harmonious integration of modern and indigenous know-how, organised marketing strategies, and infrastructure development are needed to ensure sustainability. Besides many technological problems increasingly faced by the state's horticulture, many other challenges in the form of R&D funding, manpower generation, collaborative research programmes, and balanced regional development need to be properly examined.

The existing R&D strategies need to be modified in the light of new research and development priorities and modern technologies. The institutional set-up needs to be restructured with the advent of demand-driven extension modules, NGOs, and other grass roots institutions. Future R&D strategies further demand sectoral complimentarity through integration of indigenous knowledge, information technology, scientific back-up, gender equity, and farmers' decision-making in addition to the protection of the interests of small and marginal farmers.

Agricultural Development in the Arid Mountains of Pakistan: the NADRI Approach

A.W. Jasra and S.A. Khan
National Aridland Development and Research Institute (NADRI), Ministry of Food, Agriculture and Livestock, Islamabad, Pakistan

Introduction

Mountain areas constitute 60 to 65 per cent of Pakistan's total area. These mountainous zones may be divided into two categories, arid mountains and wet mountains. The arid mountains can be further classified into two geographical sub-divisions: northern dry mountains and western dry mountains.

In the northern dry mountains, the topography is dominated by mountains (34%) and rangeland (52%), with a small area of natural forest (4%). Less than 1% of the land is cultivated (Archer 1992). In the western dry mountains, of which Balochistan is the best example, rangeland accounts for 93% of the total area. Vegetation is divided between shrublands in the south and grasslands in the north.

The National Aridland Development and Research Institute (NADRI) is pursuing two separate integrated models for agricultural development and social uplift of marginalised communities in the arid mountains of Pakistan. They are (a) the NADRI model and (b) the seabuckthorn model. This paper explains the various activities of both models.

National Aridland Development and Research Institute (NADRI) Model

In Balochistan, field operations were undertaken in six highland districts including Quetta, Pishin, Mastung, Kalat, Ziarat, and Sibi in collaboration with various institutions. In the Northern Areas, field activities were targeted around Gilgit and Skardu in collaboration with the Aga Khan Rural Support Programme (AKRSP).

Vermiculture and compost fertiliser

A programme of compost fertiliser and vermiculture was implemented in six rural highland districts in Balochistan in collaboration with Khush-Hali Associates (KHA) and the Department of Agriculture, Quetta. A total of 710 compost pits were established on farmers' fields. Farmers were trained in making well-rotted compost for orchard plants. Compost pits measuring approximately 3m x 2m x 1.3m (9' x 6' x 4') were established free of cost on each farm; these produced sufficient compost for 100 apple trees after eight weeks. Thirteen earthworm hatcheries were established in collaboration with the Integrated Pest Management Institute (IPMI), the National Agricultural Research Council (NARC), and the Department of Agriculture Extension, Government of Balochistan, under the sponsorship of NADRI. Four earthworm hatcheries were also established in the Northern Areas in collaboration with AKRSP. These hatcheries are producing foundation stock, which is being introduced in the apple orchards.

Enhancing the Productivity of Orchards

The current yields of apple orchards in Balochistan are quite low compared to other apple producing countries. We anticipated that the productivity of these orchards could potentially be enhanced by up to 30% by improving soil fertility levels, proper pollination management, and pruning of apple trees.

Under NADRI's sponsorship, KHA, Quetta, implemented a programme to introduce modern orchard pruning and honeybee rearing to the rural population in six highland districts of Balochistan as a means of achieving better apple pollination. Awareness among local farmers was created and technology was transferred to them regarding orchard pruning techniques by short-term training of local growers. A survey of the area identified the major constraints and problems regarding apple pollination. Sixty honeybee colonies were provided to orchard producers on an experimental basis. The programme may be expanded in the light of farmers' success in handling and managing these colonies.

Range Livestock Production

Three approaches were chosen to improve animal productivity in the aridlands: nutritional balance through unconventional feed resources, genetic improvement through crossbreeding, and mobile veterinary camps.

Nutritional balance

More than 4000 urea molasses blocks (UMBs) were supplied to the Department of Agriculture, Balochistan and sold at cost to livestock producers in remote areas of the Chagai-Kharan district. The success of UMBs among local farmers has been very encouraging. Arrangements are underway to install one small feed mill at Gilgit and another at Dera Ismail Khan for ruminants in the Northern Areas and Rod-Kohi.

Genetic improvement

NADRI has introduced Angora goats in cold dry temperate regions of Pakistan. Forty male and ten female Angora goats were procured from the Livestock Experiment Station, Rakh Khairewala, and the Government of Punjab. These animals were supplied to the Livestock and Dairy Development Department (LDDD), Government of Balochistan, which has been keeping them for pure Angora breeding in Balochistan.

NADRI procured 60 more Angora bucks and supplied 30 to KHA, Quetta, and 30 to AKRSP, Gilgit. These bucks have been deployed for natural crossbreeding with local goats in mountainous regions of Balochistan and the Northern Areas. Another batch of 50 bucks is being supplied to KHA and LDDD Quetta for Balochistan. Similarly, 10 Friesian bulls were procured by NADRI from LDDD and deployed in various districts of Balochistan for natural crossbreeding through KHA. Another batch of 27 breeding bulls has been purchased for the Northern Areas to be deployed by the Agriculture Department, Gilgit.

Veterinary camps

Three mobile veterinary camel camps were organised by NADRI in Balochistan. Medicines, wheat straw, and UMBs were supplied to farmers in collaboration with the Arid Zone Research Centre (AZRC), Quetta, and LDDD, Balochistan.

Plant Nurseries

NADRI nurseries are a main source of seedlings and saplings, and produce specific plants for specific zones. A four-wing saltbush (*Atriplex canescens*) nursery has been established at Loralai (Balochistan) in collaboration with the Soil Conservation Wing, Forest Department (FD), Balochistan. More than 0.5 million plants are growing and are being planted in different areas of Balochistan. Arrangements have been finalised for raising another 2 million fourwing saltbush plants. A chilghoza pine (*Pinus gerardiana*) nursery has been established at Zhob to encourage large-scale plantation in the Rod-Kohi Sulaiman Mountains.

Dryland Farming

NADRI replicated its successful mechanism for quality seed production in mountain communities of Balochistan and the Northern Areas. More than 100 bags of improved wheat (Chakwal-86 and Sulaiman-96) were distributed among farmers in Balochistan through KHA. Similarly, 150 bags of Chakwal-86 wheat seed were distributed, with payment, among local farmers in Skardu, Northern Areas, by the NADRI field camp at Skardu. Successful wheat seed sowing was carried out by local farming communities in the Chagai-Kharan areas of Balochistan. A fine-row camel drill has also been manufactured by NADRI and is undergoing field trials.

Soil and Water Conservation, Propagation of Medicinal Plants

In collaboration with the Karakoram Agricultural Research Institute for Northern Areas (KARINA), Juglott, NADRI developed cultivation techniques for black zera (cumin) for Northern Areas farmers. About 750 bulbs of black cumin (kala zera) collected in September 1999 were planted in Astore. More than 300 bulbs were planted at KARINA, Juglot in February 2000. Out of 300, 150 plants emerged. At the time of this report, 91 plants have survived and are flourishing.

One thousand plants of pistachio and 1000 plants of three improved varieties of grape were supplied by the Department of Agriculture, Balochistan (Mastung), and KARINA planted 500 of each. Another 100 of each species were planted at Juglot, Astore, Chilas, and Skardu in the Northern Areas; 300 of each were planted by the NWFP Forest Department (Abbottabad); and 100 of each by the KATO Women Centre, which works for community development under the Japan Embassy in Haripur district. The main objective of these plantations is to evaluate the viability of pistachio and grapes in different agroecological regions including the Northern Areas, Kaghan-Naran valleys, and Kohistan district of NWFP.

Farmers' Training

A one-day introductory training programme on raising earthworms and their use in agriculture was held at two locations in Quetta and Mastung during May 1999. KHA, Quetta, in collaboration with the Honeybee Research Institute, NARC, organised a three-day training course on behalf of NADRI in Quetta during June 1999 on the management and production of honeybee colonies and their use by women for apple pollination. During this course, women were trained as master trainers for the management and production of honeybee colonies in Balochistan.

Training on modern pruning of orchards, particularly apple trees, was given to 120 orchardists in six highland districts of Balochistan by KHA under NADRI sponsorship.

Seabuckthorn Model

The seabuckthorn development activities in Pakistan are following a multi-dimensional model for the country as a whole, as described below.

Establishment of seabuckthorn nurseries

Three seabuckthorn nurseries have been established in Balochistan province, which is severely threatened by the hazards of soil erosion and high run-off due to very low vegetal cover. In view of the fragility of the ecosystem in Balochistan, NADRI decided to launch a large seabuckthorn development programme in this province. A close collaboration was established with the provincial Forest Department (i.e., Directorate of Soil Conservation), Department of Agriculture, AZRC (PARC), and KHA, Quetta.

A small seabuckthorn germplasm evaluation nursery has been established at Patriata near Murree in Punjab province. This site is mainly being used to propagate a Chinese improved variety of seabuckthorn (*Hippophae rhamnoides* sub-sp. *sinensis*). At this location, an arboretum of this Chinese subspecies has been established on more than 4 ha, where about 5000 plants are growing.

Field plantations

Roughly 250,000 seabuckthorn plants were planted all over Balochistan by the Forest Department, the Department of Agriculture, and KHA during March and April 1999. Since it was our first experience in carrying out large-scale plantations, not all collaborators were well prepared, and it took us an unusually long time (15 to 25 days) to plant. Consequently, the plants experienced a great deal of stress, leading to survival rates of 10% and 90%. The success rate was higher at sites where planting was completed earlier and where the plants received irrigation. We were encouraged by the survival results, particularly of seabuckthorn plants at the agricultural farm at Mastung and at a private farmer's land in district Loralai. Unfortunately, severe drought conditions for two consecutive years in Balochistan proved largely fatal to the seabuckthorn plantations.

During February 2000, 185,000 seabuckthorn plants from the Northern Areas were supplied for planting in different areas of Balochistan, North-West Frontier Province (NWFP), Punjab, and Azad Jammu and Kashmir (AJK) in collaboration with AKRSP. The results of field plantation have been very encouraging in northern Balochistan, with 30% to 40% success rates, despite a second successive year of severe drought.

Seed collection and aerial seeding

NADRI and the seabuckthorn development cell, Balochistan, planned for aerial seeding of seabuckthorn in northern Balochistan. AKRSP collected six tonnes of seabuckthorn seed from the Northern Areas. NADRI paid US$ 2.0 per kg to local farmers and collected 10 tonnes of seeds. AKRSP created awareness among farmers of the high value of seabuckthorn.

Aerial seeding of about 1.5 tonnes seabuckthorn seed was undertaken by NADRI in collaboration with the Soil Conservation Wing (SCW), FD Balochistan, and the Plant Protection Department (PPD), Karachi, along the Alambar Stream and the surrounding areas of Loralai during March 2000. PPD aircraft were used for the aerial seeding operation. More than 4.5 tonnes of seed were manually spread along the Spera Ragha and Surghund areas of Balochistan. The main objective is to achieve conservation of juniper forest during the next decade by providing an alternate fuel and grazing resource within juniper habitat and to improve micro-climatic conditions for young juniper seedlings.

Fruit processing and oil extraction

The Pakistan Council of Scientific and Industrial Research (PCSIR) and NADRI agreed to extract oil from five tonnes of seabuckthorn seed, and to establish a solvent extraction unit of 50 kg/day oil extraction capacity at Skardu. This would initiate oil extraction from seabuckthorn seed and pulp in the Northern Areas for the socioeconomic development of resource-poor mountain communities. NADRI is also working on preparation of a manual and a mechanised seabuckthorn berry harvester.

Five hundred bottles of seabuckthorn carbonated water and samples of 29 other seabuckthorn products have been prepared on an experimental basis by PCSIR and the National Council for Tibb (NCT) in collaboration with NADRI. Table 1 shows details of seabuckthorn products developed on experimental basis.

Research on the medicinal value of seabuckthorn

NADRI plans to create a national database on treatments of various diseases through seabuckthorn oil in acupuncture, unani tibb (indigenous medicine), and allopathy. A

Table 1: Seabuckthorn products

Food Products	Seabuckthorn toffee (seabuckthorn + apricot)
Seabuckthorn drink	Biscuits (sweet)
Carbonated beverage	Biscuits (salty)
Jam (apricot and seabuckthorn)	Seabuckthorn oil
Breakfast cereals (noodles with 5% pulp)	
Breakfast cereals (noodles with 10% pulp)	**Cosmetic Products**
Seabuckthorn granules	Seabuckthorn cream (vanishing)
Seabuckthorn powder (drink)	Seabuckthorn cream (cold)
Seabuckthorn powder (pulp + chocolate) drink	Seabuckthorn shampoo
Rice pops (with seabuckthorn powder)	
Rice pops (with 50% seabuckthorn oil)	**Medicines**
Rice pops (with 100% seabuckthorn oil)	Cancer unani medicine
Juice powder (chocolate) drink	Upton skin treatment
Juice powder (normal acidic) drink	Pain relieving capsules
Juice powder (moderate acidic)	Unani cough syrup
Fibrex mix (slightly acidic)	Sharbat seabuckthorn
Fibrex mix (moderate acidic)	

contract has been signed with the Pakistan Institute of Acupuncture and Medical Sciences (PIAMS), Zainab Memorial Hospital, Lahore, for research on seabuckthorn oil and other products as supportive medicine. Preliminary results show that seabuckthorn products may successfully be used as supportive medicines for curing various diseases. Similarly, an agreement has been signed with the National Council for Tibb (NCT), Islamabad, regarding research on the medicinal value of seabuckthorn products in unani tibb. NCT would work to promote seabuckthorn products as supportive medicines in traditional systems. NADRI is supplying seabuckthorn oil free of cost to PIAMS and NCT. NADRI has also arranged with the National Institute of Health (NIH), Islamabad, to initiate research on seabuckthorn's medicinal value in allopathy on the same lines as with PIAMS, Lahore, and NCT, Islamabad.

References

Archer, A.C. (1992) *End of Tour Report, Second Tenure, ARP-II, Federal.* Islamabad: PARC, HTS

New Approaches for Reducing Poverty among Farming Communities in Balochistan, Pakistan

Z.A. Khan
Agriculture Balochistan, Khush-hali Associates, Quetta

Introduction

Balochistan is the largest province of Pakistan, covering 43% of the country. Balochistan has a variety of ecological zones comprising temperate, sub-temperate, subtropical, Mediterranean arid plains, and a coastal belt. The coastal belt is dry and desert. Winter is often mild and summers hot, with temperatures ranging from 40 to 50°C in June. Rainfall in the coastal belt is less than 80 mm per annum. Snow falls in the north and north-eastern districts.

Due to the diverse climate, a wide range of crops is grown in one part or another of the province. Both irrigated and dry farming are practised. Water is the most limiting factor. Crops are grown by direct precipitation, by harnessing and exploiting floodwaters, and by using underground and surface water. Growing crops on unirrigated lands depends on rain and snowfall. The actual cropped area is reduced by the limited supplies of water for irrigation.

Strategies for Improving Livelihoods

To improve the livelihoods of people in mountainous areas in particular and Balochistan in general, a multi-pronged approach is required. The approaches are described as follows.

Community organisation

Community organisation needs to be stepped up on a massive scale. It will serve as a foundation for future sustainable activities to improve the socioeconomic activity of the area. The present scale of activities in this area is rather small. Through community organisations, further steps like creation of awareness, capacity building by providing credit facilities, introduction of technology, and arranging training, can be carried out.

Awareness creation

Creating awareness is the first tool towards bringing about change. Awareness of phyto-sanitary issues, health hazards, low output, poor quality and quantity of production, poor management of resources, illiteracy, and so on are to be taken into consideration on a priority basis. Once a community becomes aware of the difficulties it faces and reacts to them, change comes easily.

Capacity building

Capacity building is a prerequisite for initiating any development or improvement activity in any society. Capacities of the communities may be built through training and extending credit. Both short- and long-term credits for viable small-scale industries, education, and health care are needed. For efficient use of credit, technical backstopping is essential.

Human resource development

Developing human resources is another prerequisite for bringing change to a developing society. Untrained people will not be able to understand, grasp, or appreciate technology. Therefore, a human resource development programme has to be launched to develop skilled professionals and experts in various trades.

Introduction of new technologies

Introducing new technologies brings a real and visible change in society, and greater emphasis has to be laid on this area. Use of micro-irrigation systems, solar and wind energy, application of isomers for longer retention of water in the root zone, and use of gypsum to cure alkaline soils are some examples. Similarly, planting dwarf rootstocks, practicing integrated pest management programmes, using biological methods for controlling insect pests and diseases, and growing chemical-free vegetables and fruits are other examples of potentially useful technologies.

Cloud seeding

Cloud seeding can be highly beneficial in arid areas. But this activity must be implemented either by the central government or a large organisation. Successful use of the technology depends on accuracy and perfection and it is beyond the reach of poor communities.

New Approaches

Apart from the conventional and traditional methods currently in vogue, new creative approaches should be considered. The following new approaches have been suggested as useful for reducing poverty among farming communities.

Initiation of 'second agriculture'

Second agriculture refers to growing crops and trees with several objectives in mind. These can include environmental improvement, rehabilitation of ecosystems, soil conservation, increasing soil fertility, encouraging biodiversity, developing by-products for human and livestock use. A classic example is the seabuckthorn plant, which has all the above uses although nothing from the plant is directly edible. Seabuckthorn resists high temperatures up to 50 °C and low temperatures down to -40 °C, tolerates drought, binds soil due to its vigorous root system, protects against erosion, adds to soil fertility and increases its water holding capacity, encourages soil cover and secondary vegetation on the soil. It forms a good canopy, wood is available for fuel, and sheep, goat, and cattle eat its leaves and tender shoots. It attracts wildlife, encourages birds to nest, improves the environment, and increases precipitation. Its fruit and seeds are used for making oils, cosmetics, confectioneries, food products, medicines, alcohol, jams, syrups, and candies. In China more than 200 seabuckthorn by-products are made and sold on a commercial scale.

Use of appropriate technology

Use of cheap power from wind and solar energy for domestic and commercial use can revolutionise the economy of inhabitants of this region, as could the use of cheap material as fuel (e.g., coal dust can replace fuelwood and kerosene in villages). Biogas is yet another cheap source of fuel for lighting and cooking.

Food processing, making wool and cotton products, tanning hides and skins, wood working, pottery making, mat and rope making, agricultural tools, embroidery, and so on are some of the cottage industries that may improve household incomes. Small scale financing, skill development, and marketing regulation are required. Poultry farming, quail farming, fish farming, kitchen gardening, apiculture, and sericulture are yet other avenues that can revolutionise the economy of the rural poor.

Many appropriate technologies prevalent in the province can be improved, developed, industrialised, and popularised to promote farm and household incomes. The list includes water management, floodwater harvesting, floodwater silt collection, protection of spurs to prevent erosion, use of medicinal plants and herbs, plant products, animal products like landi, khurud and butter, dry fruit processing, orchard management, cottage products, nursery raising, and planting four winged salt-bush for fodder for small ruminants. Cottage industries like carpet weaving and palm leaf products, mushroom culture, and so on can be promoted. All these technologies need streamlining, development on improved lines, and conversion into regular cottage industries.

Another important practice is using saline water, particularly sea-water, for growing salicornia, an edible oil crop that can be grown on water having 55,000 ppm of salt. Oil is extracted from its seed. Its fresh plant tips can be eaten as salad, and its by-products can support many industries. These can also be grown on kallar soils and on brackish water.

Managing Coastal Regions and Deserts

Coastal regions can be managed by planting salicornia, seabuckthorn, mesquite (*Prosopis juliflora*), coconuts, and oil palms. A mass scale plantation programme will be needed. These crops have been successfully grown on coastal lands on a trial basis. Similarly, in deserts mesquite, jujuba (*Simmondsia chinensics*), timarex (*Tamarix Aphylla*), broom (*Leptadinia para-technica*), and other plantations will stabilise sand dunes, and provide opportunities to local people to develop industries such as making wettles, berries for fine oil production, forage for animals, and so on. They are also environmentally friendly plants, helpful in stabilising sand dunes, improving soils, and promoting wildlife.

The biggest threat to biodiversity comes from cutting down forests, particularly those of juniper, chilghoza (pine seed), and shina (*Pistachio khinjak*), and bushes and shrubs for fuel purposes. The situation is aggravated during periods of drought, when animals even eat unpalatable grasses and bushes. Therefore, there is a dire need to protect this flora by providing alternate fuel sources that are cheap and easily available. Programmes should be developed to (a) develop pastures and ranges, (b) provide alternate feed such as molasses blocks, and (c) limit animal numbers to the grazing capacity of the resources and exercise controlled grazing and stall feeding. A strong reforestation programme should also be launched as an ongoing practice.

Sustainable Commercial Use of Herbs and Plants

A number of herbs and plants have enormous medicinal or industrial value; these include ephedra, hermal, paneer (*Withnania Coagulaus*), thyme, caravy, neem, true barberry (*Barburis vulgaris*), maurai (*Zizyphora climopodiodes*), and dwarf palm (*Nanuorphos ritebieana*). Ephedra was once widely used but has been replaced by synthetics. However, its use can be revived with the better technical inputs now at hand. Similarly, juniper berries can be used for oil and scent. Use of hermal is so far limited to smoking, but it can be a good source of other by-products like edible oil, as it contains a fairly good oil percentage in its seed.

Conclusion

Having glanced through the avenues and potentials available in the Hindu Kush-Himalayan Region, it is believed that the plight of this region can be turned into a most prosperous zone by using the resources properly in the light of new advancements in technology and by adopting new approaches.

Development and Transfer of Agricultural Technologies for Sustainable Mountain Development: the Approach in China

Chen Guangwei
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

The twenty-first century is a century of knowledge and information. Technology plays an important role as many nations try to promote knowledge-based economies. Incentive mechanisms could be set up to encourage technicians to go to villages to serve farmers who need technology at a grassroots level. Development of training materials, development of institutions, and planning of action are also important for disseminating technology .

This paper presents the importance and general methods of knowledge and technology input for integrated rural development, with a set of examples of ways to select suitable technologies, technology transfers, and guidelines.

Importance of Knowledge and Technological Input

Technological input is a low-cost but highly efficient way to help achieve sustainable development (SD). Key issues for technology development and transfer for SD include selecting suitable technology; organising teams of trainers and resource persons; preparing training materials; establishing pilot demonstration sites or flagging households for seeding activity; using public media (TV, radio, telephone hot-lines, posters, technology fairs, the Internet, and others) for spreading technology and information; organising training and extension activities; establishing a technological extension network; and utilising the resources of universities and research institutes.

China's Agenda 21 and poverty reduction

China's Agenda 21 programme provides an example of poverty alleviation through technology transfer. Agenda 21 initiated a programme to collect suitable advanced technology for SD of mid-sized cities and townships (Gan and Wang 1996). Under this programme, professional staff from agricultural universities and research institutions attend science and technology fairs for rural people, providing technical consultation, new seeds, and market information to farmers. The technologies considered suitable for sustainable develop of townships and villages are listed below.

<u>Sustainable development of agricultural resources and technology</u>

- Technology of biomass utilisation
- Integrated technology of biogas
- Technology for agricultural water resources
- Technology for agricultural land environment
- Green food production
- Integrated utilisation of light and thermal resources
- Technology for agricultural product storage and preservation

Integrated utilisation of industrial resources and clean production

- Improvement of paper making technology, waste water treatment, and use of waste materials
- Technology for three-waste treatment of chemical fertiliser plants
- Technology for waste water treatment of organic phosphorous pesticides
- Technology for integrated treatment of waste water from the textile industry
- Technology for integrated treatment and recycling of waste water from the leather industry
- Technology of solid waste treatment and uses for recycled waste

Exploitation and utilisation of clean energy

- Clean energy technology of shaped coal
- Liquidising and gasifying technology of coal
- Water and coal mixed-burning technology
- Solar energy technology
- Wind energy technology
- Small-scale hydropower technology
- Biomass energy technology
- Applied technology of geothermal energy

Technology of building sustainable housing and its management

- Energy saving technology
- Clean water and water saving technology
- Gardening and farming technology
- Technology to control indoor environments
- Technology of residential environmental management and waste recycling use

Technology for crop growing

A book entitled 'Applied Technology 300 for High Efficiency of Agriculture' was prepared by more than 400 scientists and technicians who have practical experience introducing high-yield methods of growing rice, wheat, maize, cotton, rapeseed, potato, sweet potato, vegetable, herbal medicinal plants, fruits, flowers, edible mushroom, and so on. In it, rotations, inter-cropping, mixed farming, and others are described for various farming systems (Guo 1993).

In 'Village Prosperity by Means of Science and Technology', Li (1988) discusses many technologies applicable to activities like agricultural product processing, forestry and fruit trees, crop farming, animal husbandry, and aquatic farming, as well as business management, decision-making, and accounting.

Examples of technology use for sustainable development

Watershed Rehabilitation Project (WRP)

There are many examples of technology use at project level in the 181 page of the 'Technical Rules' or the Y2.2 billion[1] World Bank Loan for China's Loess Plateau Watershed Rehabilitation Project covering five provinces in the middle reaches of the Yellow River (WBP 1995). The table of contents is as follows.

1. General principles
2. Comprehensive planning and management of small watersheds
3. Terracing
4. Sediment control dams
5. Irrigated land, land formation from river bed reclamation and warping land
6. Other soil conservation works
7. Afforestation
8. Orchards
9. Nursery
10. Forage grass
    Annex 1: Tillage practices of soil and water conservation
    Annex 2: Provisional technical specifications of sediment control dams of soil and water conservation (SD175-86)

Integrated Rural Development in Ansai County

Ansai County has a population of 130,000 and an area of 3,000 sq.km, and is situated in a loess plateau in China, a mountainous area of the watershed rehabilitation project (WRP). The area has suffered from severe soil erosion averaging 5,000 t per sq. km per year. It is officially designated as a poverty county. The following experiences have influenced regional development.

- The oil industry of Ansai is one of the driving forces of its economy. But as oil is a non-renewable resource, the government has started to promote agriculture as a 'green industry'.
- Water and soil conservation projects have been carried out one after another to grow trees and grasses, to build terraced farm land on the hill slopes, and to build dams to catch silt (to improve the ecological environment, which is considered accumulation of 'natural capital').
- Four service companies have been established: a sheep-stock service company, an apple service company, an apricot nut service company, and a potato service company. The objectives are to create a sheep production base, a potato production base, an apple production base, and an apricot production base. Organising production on a suitable scale to allow entry into the market is considered 'social capital development'.
- Policy reform, household contracts for small watershed management, demonstration of technology transfer, and others are also social capital development. As a mechanism to achieve this, technicians have to earn a portion of their salary through technological service. Farmers are the fundamental users of their knowledge/technology. Technicians must provide technical service focused on the grass roots level according to the requests of households. For example, the villagers of Chafang jointly hired a technician from the apple service company and paid him Y2,000 for his services to ensure a good apple harvest .
- Benefit sharing is an equal opportunity base. For example, the improved farm land built through water and soil conservation projects was reallocated according to household input (social capital development).

[1] In 1995, Yuan 8.3 = US$ 1 approx.

The economy and social development have been improved and poverty eradication goals have been met. It is important to link soil conservation projects with poverty reduction and economic development.

Other applications

There are other technologies readily available on CD-ROM or the Internet, including pictures, figures, maps, and technical details, as well as market information. Specialised technologies exist in small watershed management; gardening and farming of high quality fruits, mulberry, bamboo, medicinal plants, flowers, and mushroom; plastic greenhouses; and raising high-value wildlife (the foxes, turtles, snakes). Appropriate technology can also help establish a production base for special native products on a certain commercial scale (such as chestnut, Chinese date, jingo, walnut, apple, peach, grape, and melon).

Conclusions

The most important aspect of technology transfer is to provide technology to the groups that need it, and therefore to pay great attention to the grass roots level. Incentive mechanisms must encourage technicians to serve farmers. Technological input has great potential to aid rural development. Integrated rural development is a major necessity to be pursued by all the means available. More attention should be paid to promoting the economies of mountainous areas by means of knowledge and technical input.

References

Gan, S.; Wang, R. (1996) *Guide Book of Suitable Advanced Technology for SD of Medium Cities and Townships. A Technology Volume.* Beijing: China Science and Technology Press

Guo S. (ed) (1993) *Applied Technology 300 for High Efficiency of Agriculture.* Beijing: Beijing Science and Technology Press

Li Zhimin (1988) *Village Prosperity by Means of Science and Technology.* Beijing: China Economic Press

WBP (1995) *Technical Rules of World Bank Loan for China Loess Plateau Watershed Rehabilitation Project (WBP).* Washington DC: WBP, Central Project Management Office

Smallholder Dairy Farming in the Mountains: Potential for Operation Flood in Uttaranchal, India

V. Singh[1], *P. M. Tulachan*[2], *and T. Partap*[3]
[1]*Department of Animal Science, College of Agriculture, GB Pant University of Agriculture & Technology, Pantnagar (Uttaranchal) India*
[2]*International Centre for Integrated Mountain Development, Kathmandu, Nepal*
[3]*CSK Agriculture University, Palampur (HP) India*

Introduction

In the hills and mountains of Uttaranchal State, smallholder dairy farming is one of the most important activities in the mixed crop-livestock farming systems. Livestock are the best means of converting local vegetative biomass into useful products and work, and of diversification into products of higher economic value, such as dairy products. Production from smallholder dairies is making an increasing contribution to the economy of rural mountain areas. Over the years, this has been the driving force behind the transformation of the rural hill economy, as reflected in the strengthening of milk marketing, dairy cooperatives, the increasing number of milk collection centres and chilling centres, an impressive increase in milk production, and city milk sales (Tulachan and Neupane 1999; Singh 2002).

Given the specific geographical, socioeconomic, and environmental circumstances of the region, large dairy units are generally inappropriate and hill farmers have seldom opted for them. Smallholders' small dairy farms, on the other hand, are appropriate, manageable, and can conform to mountains' specificities. Smallholder dairy production is therefore a potential area for development intervention in the region. This paper attempts to characterise smallholder dairy production systems and explore the potential opportunities to improve mountain livelihoods. The evidence presented is based on secondary data and rapid appraisal of two milk-shed areas of Nainital and Almora districts of the state.

Smallholder Dairy Farms vs Large Dairy Farms

The conventional technical approach to dairy development relies on three components: crossbreeding of indigenous cows with specialised exotic dairy cattle, mainly the Jersey breed and artificial insemination; cultivation of fodder crops, especially legumes, and high use of concentrates; and health coverage involving modern veterinary medicine. This approach, however, depends heavily on investment and capital and only farmers who are already better off can afford it. This approach supports large, intensive dairy farms.

The indiscriminate application of the conventional technical approach in Indian Himalayan regions such as Uttaranchal would impose a higher dependency on imported inputs at farm, local, and national levels (dairy genetic stock – semen as well as live animals – depends entirely on imports). Smallholders cannot afford to spare any piece of their land to cultivate leguminous fodder, and instead must nurture their dairy animals on limited, fragmented, and scattered land. Some basic features of the two types of dairy farms are shown in Table 1.

Table 1: General features of smallholder dairy and large/ intensive dairy farms		
	Smallholder Dairy	Large/ Intensive Dairy
Breed	Local/crossbred	Crossbred
Mating	Local bull, mostly while grazing	Artificial insemination, or exotic bull
Feed/feeding	Non-farm (CPR) fodder, crop residues, food waste, grazing, and stall-feeding	Cultivated fodder, concentrate (foodgrains and cakes), mineral mixture etc.; stall-feeding
Milking	Female family members	Paid skilled labour or mechanical
Daily care	Women and children	Paid labour at a dairy farm
Use of milk	Domestic consumption, sale of surplus milk	Sale in the market
Use of male calves	Ploughing and other agricultural work	No use
Linkages with farming system	Strong linkages; waste is used as soil nutrient	No linkage; wastes cause pollution
Treatment of sick animals	Family care and herbal medicines	Vet care and modern drugs

Trends in Milk Production

With a gradual emphasis on the dairy sector, milk production in the Uttaranchal hills has increased from 419,000 tonnes in 1979-80 to 715,000 tonnes in 1999-2000, a rise of 71%. Although milk production from cows increased only 19%, buffalo milk production increased by 111%. Buffaloes contribute more than 60% of the total milk production. However, the milk-yield increase per cow (73%) has been far higher than that per buffalo (45%). This is attributable to institutional policies focusing on cows rather than buffaloes.

Urban Consumption Pattern of Dairy Products

Consumption of milk per capita per day increases as the income of a family increases. The average per capita per day consumption in the urban areas was 321 ml. This figure was higher for Nainital (342 ml) than for Almora (300 ml) (Table 2).

Table 2: Per capita daily milk consumption (ml) in two urban centres			
Family Category	Almora	Nainital	Average
Low-income	150	125	138
Mid-income	350	400	375
High-income	400	500	450
Average	**300**	**342**	**321**

Undoubtedly, liquid milk is the most wanted dairy product, comprising about 90% (by weight) of all dairy products. The least preferred dairy item in the region is cheese, which is seldom consumed by low- and mid-income families. The consumption level of all dairy items was directly proportional to income level. On average, all urban households spent a little over 8% of their total monthly income on dairy products. The low-income families spent a larger share of their income on dairy products.

Rural Consumption Pattern of Dairy Products

About 32% of the total milk consumed per month was consumed directly by family members. Most milk (about 45%) was consumed in tea. The remaining 24% was consumed after conversion into other dairy products. Average figures showing consumption patterns for milk were quite uniform between the two areas, but the average consumption of milk

Table 3: Milk consumption in rural hill areas							
Villages in the milk shed	Family size (no.*)	Milk retained at home (l/month)	Per capita daily consumption (ml)	Different uses of milk (litres/month)			
				Directly consumed by		Used in tea	Used as other dairy products
				Adults	Children		
Almora	3.83	39.15	336	3.26	9.79	15.91	10.19
Nainital	3.40	35.03	339	2.66	7.96	17.52	6.90
Average	**3.62**	**37.09**	**337**	**2.95**	**8.88**	**16.72**	**8.55**

* Only those living in the family permanently and regular consumers of the milk produced at a farm were considered in calculating family size. Persons living and working away from their families, who make up a sizeable proportion of the rural population, were not counted in analysing the milk consumption in rural areas.

and other dairy products was significantly higher in the Almora villages than in the Nainital villages (Table 3).

Comparing urban and rural per capita milk consumption, the situation at milk producers' households, contrary to the popular belief, was no better than elsewhere. Although a dairy farm family took more milk than a low-income family in an urban area, its daily milk consumption status was poorer than the medium and high-income categories of the families in urban areas. Nevertheless, on average, it was on par with the milk consumption of an urban family.

Smallholder Dairy Development: A Perspective

Livestock and natural resource base: existing potential

The evidence suggests an increasing trend in milk production, marketing, and consumption rates. The natural resource base that includes vast areas under the common property resource (CPR) regime, the huge population of dairy animals and their unique and highly adapted breeds, and diverse animal production systems hold the key to dairy development in the region. Due to the valuable self-containment feature of the farming systems in the region, almost all inputs regarded as indispensable for dairy development processes grow within the system itself. Smallholder dairy farmers, especially owing to the natural resource base they have access to, have bright prospects for economic development.

The main problem the region's dairy sector faces is the low productivity of dairy herd and production systems. Both the large populations of dairy animals and the rich natural repositories of quality fodder remain under-exploited by the dairy sector. Institutional interventions should focus on three aspects of dairy production: crossbreeding, health care, and fodder production. Smallholders are not participating in the process, and therefore institutional strategies have had little impact on the transformation of dairy production systems. The only significant impact has been on the marketing sector.

Dairy development that focuses on the natural and livestock resource base will be the most appropriate strategy for the smallholder-based community of the region. Inadequate supply of feed to dairy animals is one of the major constraints to dairy production in the region. Milk yields of both cows and buffaloes could be increased by feeding them adequate amounts of green fodder obtainable from CPRs, especially the forests.

Livestock resource base

Cows and buffaloes are the only two recognised dairy species in Uttaranchal. However, smallholders and pastoralists in the high mountain areas own a large number of goats and sheep that are seldom used for dairy production. Some selective breeds of these that could be used primarily for dairy purposes need to be identified.

Unlike in some other Himalayan areas, yaks are not utilised in Uttaranchal. This multipurpose animal is highly suitable for high Himalayan areas. Moreover, yak is a regular breeder, may live up to 40 years, and may give birth to 20 or even more offspring (Negi 1990). Prospects for exploiting yak for dairy and other purposes in the high Himalayan areas of Uttaranchal need to be explored.

Natural resource management

The hills and mountains of Uttaranchal have large areas of under or uncultivated land covered with forests, grasslands, scrub (poor forest cover), and perpetual snows. A large area under forests and grasslands comprises CPRs. This natural resource base endowed with a diversity of fodder-yielding plants is the best bet for dairy development in the region. Natural resource management, in fact, is the most important issue relating to dairy development in Uttaranchal. An efficient natural resource management system could increase milk production an estimated two-and-a-half times.

Technological options

Maintaining diversified crop production with an emphasis on minor crops, cereal-leguminous mixed cropping, cultivation of forage crops, annual-perennial links, high grain vis-à-vis stalk crop cultivation, and variability in crop maturity (Jodha and Shrestha 1990) would be more promising for smallholder dairy production systems in the hills.

Agroforestry systems are not only environmentally friendly but also contribute to the fodder supplies necessary for sustained dairy production. Some more suitable indigenous trees and shrubs that yield fodder of high nutritive value and digestibility also need to be identified and incorporated into the agroforestry systems.

Seasonality of fodder supplies coupled with an acute shortage of fodder and low rates of concentrate feeding severely constrain smallholder dairy production systems. We must formulate balanced systems incorporating local feed resources and assess them on farm. Long-term testing of the impact and feasibility of these feed technologies on smallholders' farms is also necessary.

Applying breeding techniques aimed at reducing first-calving age, increasing lactation length and productivity, and decreasing the dry period (and taking advantage of modern veterinary advances to control prevalent problems like parasite infestation, infertility, etc.) are yet another relevant area for intervention.

Reviving and strengthening cost-effective and well-proven ethno-veterinary practices as part of animal health management will be a novel approach for an inaccessible and povertyridden region that is rich in indigenous knowledge like Uttaranchal. This exciting possibility should be researched in the context of modern medicine.

Institutional intervention

Present institutional policies and programmes are not aimed at conservation or management of natural indigenous livestock resource bases. Market-oriented production is necessary to ensure income opportunities for smallholder dairy farmers. However, any market-oriented dairy system should focus on conservation of the resource base for its sustainability. Protection of communities' ownership of CPRs and people's participation in the management (conservation and utilisation) are important factors influencing the sustainability of dairy production systems.

Dealing with specific local breeds, especially of cattle, might help in advocating an appropriate, participatory, and mountain-perspective-based breeding policy ensuring conservation of local breeds of unique and superb traits. Implementation of such a breeding policy could be instrumental in improving dairy systems in the region.

Integrated management of animal health involving both traditional and modern systems of treatment that provides adequate health coverage to all animals, addressing particularly the inherent problem of inaccessibility of mountain areas, would be a cost-effective and accessible system for smallholder dairy farmers.

The cooperative system of milk marketing based on the Anand Pattern is an appropriate one for market-oriented dairy farming in mountain areas. Efforts should be made to link even remote villages with the Milk Union.

Quality assurance of dairy products in the informal market and the rules and regulations to be imposed on milk suppliers are issues of great public interest. Continuous exposure of small dairy farmers to dairy-related education and training, provision of credit, a dynamic and efficient marketing system, remunerative prices for production, together with awareness about health and hygiene among consumers, can create a dairy revolution in the mountain region.

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References

Jodha, N.S.; Shrestha, S. (1990) *Some Conceptual Issues of Livestock Farming in the Mountains.* Mountain Farming Systems Discussion Paper No. 4. Kathmandu: ICIMOD

Negi, G.C. (1990) *Livestock Development in Himachal Pradesh: Retrospect and Prospect.* Mountain Farming Systems Discussion Paper No. 7. Kathmandu: ICIMOD

Singh, V. (2002) 'Smallholder Dairy Farming in Uttaranchal, India'. In Tulachan, P.M.; Saleem, M.A.H.; Neupane, A. (eds) *Smallholder Dairy in the Mixed Farming Systems of the HKH.* Kathmandu: ICIMOD

Tulachan, P.M.; Neupane, A. (1999) *Livestock in Mixed Farming Systems of the Hindu Kush-Himalayas: Trends and Sustainability*. Kathmandu: ICIMOD & FAO

Biological Diversity of Medicinal Plants and Cereals of North-eastern Mountainous Regions of Pakistan, and their Exploitation for Sustainable Development

S.D.A. Gardezi
University College of Agriculture, Rawalakot, A.K. Pakistan

Introduction

The north-eastern regions of Pakistan represent an important area of the Hindu Kush-Himalayan (HKH) region, with a rich diversity of natural biological resources including vegetation, insects, fungi, microbes, domesticated animals, and wildlife. Micro-niches comprise almost all climatic conditions from tropical to alpine zones. The diversity of higher plants, including cultivated crops and fruits, is known to some extent but the diversity of medicinal plants, animals, and microbes in many environments of the area remains unknown.

The under-development of the area has restricted its economic prosperity, but helped to conserve important biological species. Over the centuries, the continuous selection of cultivated crops has robbed these species of many valuable genes. Consequently, the commercial crop varieties have become input-intensive and are not economical for farmers with small landholdings (Gardezi 1993). However, the primitive ancestral genotypes of cultivated crops are still cultivated in restricted patches (Shah and Ahmad, in press), and the precious gene pool extinct elsewhere is still available in this region. The gene pool of unique characteristics may be of worldwide importance, and needs to be conserved in situ. Similarly, the area is abundant in diverse medicinal plants (Amin 1984). However, increasing the area under cultivation and clearing the rich forest land have threatened the diversity of plants.

The importance of preserving the biological diversity of cultivated and wild plant species has increased due to the advent of recombinant DNA technology. The technology has great potential to modify the characteristics of biological organisms like plants by transferring those characteristics from other organisms of any nature. The biological resources of the area need to be classified, characterised, preserved, and registered to ensure future potential economic benefits.

Agriculture in the area is conventional, and the trend is to grow only a few varieties of grains like maize and wheat, some vegetables, and to rear a few cattle and chickens. The livelihoods of farmers tend to be inadequate.

The diversification of agriculture to make it economic and sustainable has led to the introduction of high value cash crops on small land holdings. Precious crops like medicinal plants, flowers, and non-conventional crops may increase earnings and reduce the miseries of the local population. Traditional medicines of plant origin still contribute more than 50% of the total medicinal needs of the local population. The value of medicines of biological origin is increasing with the new environmental trends and awareness of the hazards of synthetic chemicals. Even today, the world's pharmaceutical industry earns more than US$100 billion every year from drugs derived from natural compounds of plant origin (Sittenfeld 1996). Locally available medicinal plants could fetch good prices in the market as raw material for pharmaceutical industries. Similarly the development and introduction of cold- and drought-tolerant varieties of forage grasses and legumes in natural pastures could increase production and the development of dairy and meat animals on a commercial scale. The area is also suitable for the commercial cultivation of flowers and spices. Locally available species of flowers and spices are abundant but have never been developed as marketable products. New job opportunities resulting from the above-mentioned activities could reduce urbanisation and help traditional societies and communities to survive.

For many years, the University College of Agriculture, Rawalakot has helped to introduce new farming technology and to conserve biological natural resources for commercial exploitation. Though the pace of progress is slow due to limited resources, the problems have been identified and the line of action set.

Progress to Date

The biological diversity of some cultivated crops including wheat, maize, potato, and tomato from the north-eastern regions of Pakistan has been investigated. Local land races, genotypes, and varieties were collected from various micro-climatic conditions, inventories were prepared, and molecular markers based on seed and plants at a particular stage of development were explored. The results indicated immense variability among the genotypes, land races, and local cultivars, which could be exploited in future breeding programmes. Similarly, local medicinal plants from various environmental conditions including *Ocimum sanctum*, *Racinus communis*, *Adhatoda vasica*, *Mentha*, and *Rumex* (Ahmad et al. in press), seabuckthorn, *Piganum*, *Pimpinella*, and others have been investigated. The investigation showed significant variability in their genetic make-up as observed by their phenotypic characters and molecular/biochemical constituents. Species of flowers and spices with good aesthetic and commercial value were also included and their biological diversity and potential for commercial production in the area investigated.

To develop and introduce drought- and cold-tolerant varieties of forage grasses and legumes, germplasm was collected from all over the world and evaluated under local conditions (Ahmad in press; Hammad and Ahmad 1996). Introduced species and varieties were hybridised and potential varieties for *Lolium parennea*, *Lolium multiflorum*, *Festuca*, *Lathyrus* (Khan et al. 2000), and white and red clovers (Iqbal and Ahmad 1996) were developed.

Natural forage grasses and legumes only provide green herbage during the monsoon season, but the newly developed varieties can produce green herbage from late March to November with maximum production from July to October (Ahmad and Chaudhry 1995). The nitrogen fixation potential and the biological diversity of *Rhizobium* from clovers of mountain origin were also investigated using molecular techniques (Ahmad and Hassan 1998).

Conclusions

The north-eastern mountainous regions of Pakistan are rich in biological natural resources, but their potential has not been properly realised. The local population cannot prosper on a sustainable basis unless and until these resources are exploited and utilised scientifically. The University College of Agriculture Rawalakot has initiated investigations for proper utilisation of the existing biological resources for the betterment of the local communities and the region at large.

References

Ahmad, S.D.; Shah, A.H.; Nadeem M. (in press) 'Characterisation and Conservation of *Mentha* and *Rumex* Biodiversity in Azad Kashmir, Using Molecular Techniques.' In *Pakistan Journal of Agricultural Resources*

Ahmad, S.D.; Hassan, L. (submitted) Biodiversity and Performance of Rhizobia in Relation to Plasmid Genes and their Transactional Products.

Ahmad, S.D. (in press) 'Cold Tolerant Potential of Introduced Varieties of *Lolium* and *Trifolium* under Rawalakot Conditions'. In *Pakistan Journal of Genetics*

Ahmad, S.D.; Chaudhry, M.B. (1995) 'Development of Grass-Legume Mixture, A Potential Source of Sustainable Development of Agriculture in Hilly Areas of Pakistan'. In *Sci. Tech. Dev.*, 14 (4): 15-22

Amin, A. (1984) 'An Assessment of the Productivity of Medicinal Plants in Leepa Valley (Jehlum Valley Forests Division) Azad Kashmir'. In *Pakistan Journal of Forestry*, 34 (4): 243-246

Gardezi, S.D.A. (1993) 'Diversification of Agriculture: A Prospect in Temperate Regions of Pakistan'. In *Proceedings of the 2nd All Pakistan Scientific Conference*, pp.136-138

Hammad, M.; Ahmad, S.D. (1996) *Evaluation of European and American Varieties of Lolium perennae under Rawalakot Conditions*. Lahore: Sci. Int.

Iqbal, M. A.; Ahmad, S.D. (1996) Evaluation of Introduced Varieties of Trifolium for their Forage and Soil Cover Potential under Rawalakot Conditions. Lahore: Sci. Int.

Khan, M.Q.; Gardezi, S.D.A; Narayan, R.K.J (2000) 'Study of Polygenetic Relationships between Different Species of Genus *Lathyrus* Using Rapid Markers'. In *Sarhad Journal of Agriculture*, 16(4):411-421

Shah, A.H.; Ahmad, S.D. (submitted) Biological Diversity in Local Races and Genotypes of Cultivated Wheat from Azad Jammu & Kashmir

Sittenfeld, A. (1996) 'Issues and Strategies for Bioprospecting'. In *Genetic Engineering Biotechnology*, 4:1-13

An Explorative Analysis of the Productivity of Croplands in Tibet Autonomous Region, P.R. China

N. Tashi
International Centre for Integrated Mountain Development, Kathmandu, Nepal

Introduction

The potential productivity of croplands can be defined as the maximum amount of food produced under ideal conditions in a particular eco-region or administrative region. Analysis of productivity has significance for planning to ensure food security. A number of studies of potential food production have been carried out in Tibet. Liu Yanghua (1991) studied the potential productivity of croplands in the middle reaches of the Yalongzangpo River (Brahmaputra River), where the majority of the Tibetan population is concentrated. He examined the maximum potential yield of crops such as barley and wheat; the potential productivity of cropland; the carrying capacity of rangeland; and the co-dependence of land resources, food production, and population. This research became the guideline for integrated development of agriculture in this region. Yang Gaihe (1995) focused on the potential productivity of cropland and rangeland, and the capacity for food production based on the existing cultivated land and pasture land. Other studies have focused on resource management and assessment of agricultural productivity, and potential productivity of technological innovation and dissemination (Nyima Tashi 1998).

In the study described here, an explorative analytical approach was used to distinguish the potential, attainable, and actual production of croplands in different agricultural systems for different crops in Tibet.

Potential Productivity of Cropland

The potential productivity of cropland has been estimated by a number of scientists using different methods (Dang Anrong 1997; Liu Yanghua 1992). The data were aggregated according to agricultural systems (Table1) and administrative prefectures (Table 2). The potential productivity of climate (light, temperature, and water) and potential productivity of cropland (light, temperature, water, and land) were calculated and compared to actual yields.

Table 1 indicates that the potential productivity of cropland varies greatly among agricultural systems. The crop-dominated system has the greatest potential productivity for both climate and cropland: 24.6 t ha^{-1} and 13.4 t ha^{-1}, respectively. These figures are 53% and 63% higher, respectively, than the average for Tibet, whereas pastoral system potentials are 56% and 78% lower, respectively, than the average for Tibet. Actual yields in the crop-dominated system (3.2 t ha^{-1}) were 56.7% higher than the Tibet average, whereas in pastoral systems where cropping is practised, the yield (0.75 t ha^{-1}) was 63.5% lower than the Tibet average.

Table 2 shows the great variation in potential productivity of both climate and cropland among the seven prefectures. The actual yield is affected by both the potential productivity

Table 1: Potential productivity (t ha^{-1}) of climate and cropland in agricultural systems

Yields	Crop-dominated system		Agro-pastoral system		Pastoral system		Agro-forest-livestock mixed farming system		Tibet average
	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}
Potential productivity of climate	24.63	53.2	12.59	-21.6	9.66	-56.5	15.79	-1.7	16.07
Potential productivity of cropland	13.35	62.6	5.56	-32.2	1.81	-77.9	9.50	15.7	8.21
Actual yield	3.23	56.7	1.91	-7.2	0.75	-63.5	2.36	14.5	2.06
Yield gap P1	11.28		7.03		7.85		6.29		7.86
Yield gap P2	10.12		3.65		1.06		7.14		6.15

Note: Yield gap P1 = difference between potential productivity of climate and potential productivity of cropland; yield gap P2 = difference between potential productivity of cropland and actual yield

Table 2: Potential productivity (t ha^{-1}) of climate and cropland in prefectures

Yields	Lhasa		Changdu		Shannan		Shigatse		Naqu		Ali		Linzhi		Tibet average (t ha^{-1})
	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	t ha^{-1}	% of Tibet average	
Potential productivity of climate	24.54	52.7	13.48	-16.1	18.24	13.5	19.01	18.2	5.92	-63.1	11.59	-27.8	18.35	14.1	16.07
Potential productivity of cropland	13.43	63.5	5.64	-31.3	10.35	26.0	9.62	17.1	2.19	-73.3	3.99	-51.4	12.06	46.8	8.21
Actual yield	2.59	27.5	1.53	-24.6	3.09	52.2	2.43	19.7	0.38	-81.2	0.93	-54.1	2.68	32.0	2.03
Yield gap P1	11.11		7.84		7.89		9.39		3.73		7.60		6.29		7.86
Yield gap P2	10.84		4.11		7.26		7.19		1.81		3.06		9.38		6.15

Note: Yield gap P1 = potential productivity of climate minus potential productivity of cropland; yield gap P2 = potential productivity of cropland minus actual yield.

of the cropland and the management of the farmland, including irrigation, inputs, and agronomic practices. It is clear that there is a need to improve the management level of farmland. If this is accomplished, self-sufficiency of cereals could be achieved.

There is a huge gap between potential productivity of climate and cropland, and between potential productivity of cropland and actual yield. Table 1 shows this in more detail. In the crop-dominated system, the yield gap P1 (gap between potential productivity of climate and cropland) and the yield gap P2 (gap between potential productivity of cropland and actual yield) are both high and quite close. This indicates that both land suitability and management constrain the production of cereals. On average, both yield gaps are considerable and indicate that improvement of land suitability, land fertility, and farming management are crucial for increasing production of cereals.

Yield gaps were also estimated for each prefecture (Table 2). The P2 yield gaps in Lhasa and Linzhi prefectures are high at 10.8 t ha^{-1} and 9.4 t ha^{-1}, respectively, with Naqu and Ali prefectures, at 1.8 t ha^{-1} and 3.1 t ha^{-1}, respectively, and medium in Shannan and Shigatse prefectures at about 7 t ha^{-1}.

Tibet possesses substantial potential production of both climate and cropland; on average, 16.1 t ha^{-1} and 8.2 t ha^{-1}, respectively. Extrapolating from the existing cultivated land, total production of cereals could reach 5.6 million t and 2.7 million t, respectively. Comparing the 1 million t of cereals produced in 2000 with the potential productivity of cropland, less than 40% has been utilised. There is a tremendous gap between the theoretical yield of cropland and what is actually produced.

Potentially Attainable Crop Yields

In most cropping areas, there is great potential productivity of land, and thus a possibility for increasing crop yield per unit area. Two factors have to be considered. One is biological productivity, which differs for different crops and varieties. The other is managerial: the economic and technological capability for crop farming, determined by farmers' knowledge, technological innovation, agricultural infrastructure, level of agricultural input, and related policies.

The potential production and yields achieved at different management levels in the different production systems are shown in Table 3. In the crop-dominated system 'grains' are spring and winter barley and wheat, in the agro-pastoral system they are mostly spring barley with some spring wheat, and in the mixed system spring and winter barley and wheat. Rice and maize are also grown in the mixed system areas.

In the crop-dominated system, the average historical record of highest yields for cereal crops and rapeseed are 12.0 t ha^{-1} and 6.6 t ha^{-1}, respectively. The highest yields in experimental plots for grain was 7.7 t ha^{-1} and for rapeseed 3.4 t ha^{-1}. Actual yields of cereal crops and rapeseed in 1997 were 3.3 t ha^{-1} and 1.4 t ha^{-1} (Table 3). This indicates a yield gap. Similar situations can also be seen in the agro-pastoral system and the agro-forest-livestock mixed farming system. In addition, there are also big differences between agricultural systems influenced by different management and biophysical conditions. All

Table 3: Yield changes at different management levels (potentially attainable yields) in four agricultural systems (t ha^{-1})

Productivity	Average grain yield				Average rapeseed yield			
	Crop-dominated	Agro-pastoral	Agro-forest - livestock mixed farming system	Tibet average	Crop-dominated	Agro-pastoral	Agro-forest-livestock mixed farming system	Tibet average
Potential productivity of cropland	14.1	5.9	8.6	9.5				
Historical record of highest yield	12	5.8	7.6	8.5	6.6	3.6	4.8	5.0
Highest yield in experimental plot	7.7	4.9	6.5	6.4	3.4	2.2	3.2	2.9
Highest yield in ideal farmland	6.2	4.7	6.2	5.7	2.4	1.9	2.1	2.1
Average yield in 1997	3.3	2.8	3.3	3.1	1.4	1.2	1.4	1.3
Average yield in recent five-year period	3.1	2.1	3.1	2.8	1.3	1.1	1.2	1.2

Note:

[1] Historical record of highest yield is the yield of a crop variety produced in one plot under best conditions and management in each zone. The minimum experimental area was 30 m^2.

[2] Highest yield in experimental plot was the average yield of a crop variety produced in a minimum of three plots under best conditions and management in each zone. Different crops were tested in each zone. Each crop was planted in a plot of 30 m^2 in replicates of three. All varieties used were newly released cultivars.

[3] Highest yield in ideal farmland is the yield of a crop variety produced under ideal farmland and management conditions in each zone. The result was obtained using the farmer's own management supervised by a scientist. The minimum area was over 667 m^2. The ideal farmland was located on a flat riverbank with fertile soil and access to irrigation.

[4] Actual yield was the yield of a crop in 1997 in each zone with farmer's normal level of management.

[5] Average yield in recent five-year period is the average crop yield in recent five-year period in each zone using farmer's management.

Table 4: Potential increases in yields of cereals and oilseed (t ha^{-1})

Yield gaps	Average cereal yield				Average oilseed yield			
	Crop-dominated system	Agro-pastoral system	Agro-forest-livestock mixed farming system	Tibet average	Crop-dominated system	Agro-pastoral system	Agro-forest-livestock mixed farming system	Tibet average
Yield gap 1	2.1	0.1	1	1				
Yield gap 2	4.3	0.9	1.1	2.1	3.2	1.4	1.6	2.1
Yield gap 3	1.5	0.2	0.3	0.7	1	0.3	1.1	0.8
Yield gap 4	2.9	1.9	2.9	2.6	1	0.7	0.7	0.8
Yield gap 5	0.2	0.7	0.2	0.3	0.1	0.1	0.2	0.1

yields in the crop-dominated system are much higher than the Tibet overall average, while the agro-pastoral system has much lower yields than the average.

Considering the actual crop yields, there is a great potential to attain much higher yields and to increase cereal crops and rapeseed production. To attain the potential maximum yield in practice, it is important to understand why there is a gap, what the constraints are, and how to close the gap.

Potential to Increase Crop Yields

Generally, there are three possibilities for increasing production. The first is to expand the sown area of crops; the second is to increase cropping intensity; the third is to increase per unit area crop yield. At present, there is little scope for expanding cropping land because of poor economic capability. Intensification of cropping is also not possible on a large scale at the moment owing to low temperatures, technological limitations, and financial incapability. This leaves increasing per unit area yield.

Yield gap 2 is the gap between potential productivity and the highest ever recorded yield. For both foodgrain and oilseed production, it is highest in the crop-dominated system: 4.3 t ha^{-1} and 3.2 t ha^{-1}, respectively (Table 4). This indicates that breeding of high-yielding varieties or using high-yielding varieties with best possible crop practices has a great potential to boost crop yields in this area. Yield gap 4 (the gap between the highest yield in ideal farmland and the actual yield in 1997) was high in all three food-production areas. This indicates that improvements in farm management and the quality of farmland are key for increasing per unit area yields of crops under all three systems. In Tibet, poor management and poor quality of cropland are the most crucial factors that constrain increases in food grain and oilseed production.

Conclusions and Implications

Increasing per unit area crop yields is a useful approach to increasing production of cereals and oilseed. Potentially attainable crop yields are promising, and there is considerable room to increase yields. Sloppy and poor topographic conditions constrain increases in yields, but it is not easy to change topographic conditions. Selection of farmland on flat areas and land levelling would help.

Breeding and selection can improve the productivity of crop varieties. Extension of new varieties or replacement of old varieties often needs improvements or changes in cultivation techniques. With improved cultivation techniques, the whole system is more productive. Extension of improved varieties and modification of cultivation techniques posesses great potential for increasing production and contributes to increasing production of cereals and oilseed substantially.

In most of the agro-pastoral and crop-dominated systems, improved varieties have not replaced local landraces, and changes in cultivation techniques have not taken place. Breeding for a new variety requires more than eight years. Breeding programmes for high-altitude and non-irrigated areas have not been undertaken. Production of cereals and oilseed will increase rapidly if improved varieties for these areas are developed.

References

Dang Anrong (1997) GIS Based Study on Foodgrain Production Potential and Spatial Variation in China, Ph.D. Thesis. Beijing: Chinese Academy of Sciences

Liu Yanghua (1992) *Land Production Potential: Assessment of Land Resources in the Tibetan Autonomous Region*. Beijing: Science Publication House

Tashi, N. (1998) 'Assessment of Natural Resources and its Perspectives in Food Production Systems.' In *Journal of Tibetan Agricultural Sciences and Technology*, 1

Yang Gaihe (1995) *Land Resource Productivity and its Carrying Capacity of Population in Tibet*. Beijing: People's Publishing House

Annexes

Annex 1: List of Participants[1]

BANGLADESH

Dr. N. A. Khan
Associate Professor
Department of Public Administration,
University of Chittagong, Chittagong 4331
Tel: +88 31 682768
Email: nakhan@spnetctg.com
skymart@abnetbd.com

Mr. S. K. Khisa
Project Manager
Chittagong Hill Tracts Development Board
Khagrachari, Bangladesh
Tel: +88 31 2296
Fax: +88 31 716056

BHUTAN

Dr. T. Samdup
Director
Department of Agriculture & Livestock
Support Services, Ministry of Agriculture
Thimphu
Fax: +975 2 322094

Dr. K. Tashi
Extension Program Officer
RNR-Research Centre
Khangma, Tashigang
Tel: +975 4 535122/535194
Fax: +975 4 535132
Email: KT234_in@yahoo.com

Dr. P. Tshering
Head, Epidemiology Unit
Royal Veterinary Epidemiology Centre
(RVEC), Department of Agri. & Livestock
Support Services
P.O. Box 155, Serbithang, Thimphu
Tel: +975 2 351083/351093,
Fax: +975 2 351095
Email: rvec@druknet.net.bt

CHINA

Dr. S. Hui, Associate Professor
Chengdu Institute of Biology
Chinese Academy of Sciences
P.O. Box 416 Chengdu, Sichuan 610041
Tel: +86 28 5229223
Fax: +86 28 5222753
Email: sunhui@mail.cib.ac.cn

Mr. T. Ken
Eastern Bee Research Institute of Yunnan
Agricultural University, Heilongtan, Kunming
Tel : +86 8715227717
Fax : +86 871522822303
Email: eastbee@public.km.yn.cn

Dr. B. Weikai
Associate Professor
Chengdu Institute of Biology, Chinese
Academy of Sciences
P.O. Box 416, Chengdu
Sichuan 610041
Tel: +86 28 5246842
Fax: +86 28 5222753
Email: baowk@cib.ac.cn

Prof. Z. Yao-sheng
Professor
Northwest Plateau Institute of Biology
Chinese Academy of Sciences
59 Xiguan Street, Xining, Qinghai
Tel: +86 971 6109359
Fax: +86 971 6136412
Email: yaoshz@sina.com

Prof. H. Yonghua
Associate Professor
Chengdu Institute of Biology
Chinese Academy of Sciences
P.O. Box 416, Chengdu, Sichuan 610041
Tel: +86 28 5242193(O)
Fax: +86 28 5222753
Email: heyonghua@mail.cib.ac.cn

INDIA

Mr. Z.M. Albert
Project Manager
NCHCRMS/IFAD Offices
Haflong -788815, Assam State
NE India
Tel: +91 3763 67591

Dr. R. P. Awasthi
Vice Chancellor
Dr. YS Parmar University of Horticulture &
Forestry
Nauni-173 230, Solan, HP
Tel: +91 1792 52363 (O), 52343 (R)
Fax: +91 1792 52242
E-Mail: vc@yspuhf.hp.nic.in

[1] Position and address in 2001

Dr. D. Choudhury
Chief Natural Resource Management Adviser
FAD-North Eastern Region Community
Resource Management Society
Sympli Building, Dhankheti, Shillong
793001, Meghalaya
Tel: +91 364 500 496/497 (O)
+91 364 521 064/230379 (R)
Fax: +91 364 500 027
Email: dhrup@netive.com
dhrupad@mail.com
ifadnei@dte.vsnl.net.in

Dr. S. K. Ghabru
Scientist Incharge
GIS & Remote Sensing Applications Centre
CSK Himachal Pradesh Agricultural
University, Palampur 176062, HP
Tel: +91 1894 30314 (O), 33255 (R)
Fax: +91 1894 30511, 30311
Email: ghabru@cskkv.hp.nic.in
ghabru@yahoo.com

Mr. D. Ingty
Project Manager
North Eastern Region Community Resource
Management Society
Shillong, New Tura, Meghalaya - 794101
Tel: +91 3651 42751 (O)
+91 3651 23317 (R)
Fax: +91 3651 42751

Dr. M. Mangal
Research Associate
Department of Biotechnology
Dr. Y. S. Parmar University of
Horticulture and Forestry
Nauni, Solan 173 230, HP
Tel: +91 1792 29239
Email: manisha mangal@usa.net

Ms. D. V. Massar
Project Manager
Khawkylla Community Resource
Management Society (KCRMS) Ladweitang,
Nongstoin, West Khasi Hills District
Meghalaya
Tel: +91 3654 22361/22359
Fax: +91 3654 22359

Dr. G. S. Mehta
Fellow
Giri Institute of Development Studies Sector
O, Ahjang, Lucknow - 226024
Tel: +91 522 32501/321860/334059
Fax: +91 522 373640
Email: gids@lwl.dot.net.in

Mr. S. Ningthoujam
Project Manager
Senapati District Community Resource
Society
SEDCORMS/Senapati District HQ. Manipur,
Hillbird Building 795
Tel: +91 385 229231/442468

Dr. T. Partap
Vice Chancellor
CSK Agriculture University
Palampur 176062, HP
Tel: +91 1894 30521(O)
Fax: +91 1894 30465/ 30511
Email: vc@hpkv.hp.nic.in

Mr. S. Phanbuh
Project Manger
KACRMS (IFAD), IFAD-NERCRMS
Hamren, Karbi Anglong, Assam
Tel: +91 3677/70123/70124 (O)
Fax: +91 3677 70123 (O)

Prof. H. C. Pokhriyal
Senior Fellow
National Society for Development
Administration, Research and Training
LBS National Academy of Administration,
Mussoorie, Uttaranchal
Tel: +91 135 630842 (O)
+91 135 650907 (R)
Fax: +91 135 632686/632350
Email: hcp@lbsnaa.ernet.in

Dr. S. Rafique
Coordinator-Monitoring, Agribusiness &
Extension, NERCRMP/IFAD
Sympli Building, Near Law College, Dhankuti,
Shillong - 793001
Tel: +91 364 500497/500494 (O)
+91 364 537291 (R)
Fax: +91 364-500027
Email: shaheelrafique@ yahoo.com

Dr. H. R. Sharma
Associate Professor
Deptt. of Agricultural Economics
CSK HP Agricultural University
Palampur - 176062, HP
Tel: +91 1894 30313 (O)
+91 1894 32861 (R)
Fax: +91 1894 30311
Email: sharmahr@cskv.hp.nic.in

Dr. V. Singh
Professor
Department of Animal Science
College of Agriculture, G.B. Pant University of Agriculture & Technology
Pantnagar 263145, Uttaranchal
Tel: +91 5944 33887
Fax: + 91 5944 33611/33473
Email: drvirsingh@rediffmail.com

Dr R. K. P. Singh
Scientist
Agricultural Engineering, Division of Agricultural Engineering, ICAR Complex for NEH Region, Barapani -793103 Meghalaya
Tel : +91 364 570276 (O)
+91 364 570434 (R)
Fax : +91 364 570213/570288
Email: rkp1969@rediffmail.com
rkp@icarneh.ren.nic.in
rkp.singh@lycos.com

Dr. R. Singh
Research Officer
Agro-economic Research Centre
Himachal Pradesh University
Shimla 171005, HP
Tel: +91 177 230269 (O)
+91 177 230182 (R)
Email: ranveersi@yahoo.com

Dr. R.C. Sundriyal
Scientist Incharge
G.B. Pant Institute of Himalayan Environment and Development
North East Unit , Vivek Vihar
Itanagar 791 113
Tel: +91 360 211773 (O)
+91 360 213177 (R)
Fax: +91 360 211773
Email: rcsundriyal@yahoo.com

Dr. C. S. Vaidya
Research Officer
Agro-economic Research Centre
Himachal Pradesh University
Shimla - 171005, HP
Tel: +91 177 230269 (O)
Email: csvaidya@satyam.net.in

Mr. T. Vashum
Project Manager
NERCRMP, Ukhrul District Community Resource Management Society
Ukhrul Manipur
Tel: +91 385 311404

Myanmar

Mrs. N. N. Ohn
Lecturer
Yezin Agricultural University
Pyinmana
Tel: +95 67 21098
Fax: +95 1 663984

Mr. M. Swe
Farm Manager
Myanmar Agriculture Service
Hilly Region Crop Research Farm,
Aunaban, Southern Shan State
Tel: +95 81 60159 (O)
Fax: +95 1 663984

Nepal

Mr. G. P. Acharya
Senior Scientist
Agriculture Research Station, ARS Lumle,
P.O. Box 1, Pokhara, Kaski
Tel : +977 61 429399

Mr. K. R. Gautam
Chief, Monitoring and Evaluation Section,
Department of Agriculture
Hariharbhawan, Lalitpur
Fax: +977 1 5524226 (O)
+977 1 4432967 (R)

Dr. H. Gurung
Chairman, Board of Directors
New Era, Panipokhari, Kathmandu
Tel: +977 1 4413603

Ms C. Gurung
Consultant
Ekanta Kuna, Jawalakhel, Kathmandu
Tel: +977 1 5538912/4416295
Email: chanda_gurung@yahoo.com

Ms. K. Gurung
Conservation Officer (NRM)
The Mountain Institute (TMI)
Kharbari, Sankhuwasava
Fax/phone: +977 29 60137
Email: tmi@cpp.wlink.com.np

Mr. N. Raj Khanal
Associate Professor
Central Department of Geography
Tribhuvan University, Kathmandu
Tel: +977 1 4274533 (R)
+977 1 4330320 (O)
Fax: +977 1 4331319
Email: nrkhanal@enet.com.np

Mr. R. B. Maskey
Senior Soil Scientist
Nepal Agricultural Research Council (NARC)
Soil Science Division, Khumaltar, Lalitpur
Tel: +977 1 5521149
Fax: +977 1 5521197
Email: dj@mos.com.np

Dr. R. P. Neupane
Adjunct Faculty
Asian Institute of Technology (AIT)
GPO Box 4
Khlong Luang, Pathumthani 12120
Tel: +66 2 5245618 (AIT)
+977 1 5528844 (R in KTM)
Fax: +66 2 5246431
Email: ramji@ait.ac.th
ramjineupane@hotmail.com

F.M.J. Ohler
Chief Technical Adviser
FAO-Technical Assistance to the Hills
c/o FAO P.O. Box 25 Kathmandu
Tel: +977 1 227632, 228377
Fax: +977 1 242640
Email: hlffdp@wlink.com.np
jritsohler@hotmail.com

B. H. Pandit
Executive Secretary
Nepal Agroforestry Foundation
P.O. Box 9594, Kathmandu
Tel: +977 1 4475043 (O)
+977 1 4276997 (R)
Email: naf@enet.com.np
bhpandit@ntc.net.np (R)

Dr. B. P. Tripathi
Senior Soil Scientist
Agriculture Research Station
Lumle, P.O. Box 1, Pokhara, Kaski
Tel: +977 61 29456/29399
Fax: +977 61 20653/24425
Email: dirlarc@mail.com.np

Dr. R. P. Sah
Station Chief
Agriculture Research Station, Lumle
P.O. Box 1, Pokhara, Kaski
Tel: +977 61 29399, 29456
Fax: +977 61 22653
Email: dirlarc@mail.com.np

Mr. B. K. Singh
Technology Development Offices
Department of Soil Water Conservation and Watershed Management/HMG-Nepal
Babar Mahal, Kathmandu
Tel: +977 1 4220828 (O)
+977 1 4241439 (R)
Email: bijendra25@hotmail.com

Mr. P. Shrestha
Programme Officer
Local Initiatives for Bio-diversity, Research and Development (LI-BIRD),
P.O. Box 324, Pokhara, Kaski
Tel: +977 61 26834 (O)
+977 61 26834
Email: pslibird@mos.com.np

PAKISTAN

Dr. M. B. Chaudhary
Dean/Principal
University College of Agriculture
Rawalkot AK
Tel: +92 58 710 42688
+92 58 710 43193
Fax: +92 58 710 42826
Email: bashir-bhr@yahoo.co.uk
Chaudhrydr@hotmail.com

Dr. D. A. Gardezi
Associate Professor/Head Plant Genetic Breeding
University College of Agriculture
Rawalkot Poonch AK
Tel: +92 58 710 42688
Fax: +92 58 710 42826
Email: dilnawazgerdezi@hotmail.com

Dr. A. W. Jasra
Director
National Aridland Development and Research Institute (NADRI)
RRI Building, NARC, Park Road
Islamabad
Tel: +92 51 9255068, 9255065
Fax: +92 51 9255068, 9255034
Email: cardn@isb.compol.com

Z. A. Khan
Managing Director
Khush-Hali Associate
House No. 4-36/5, Najam-ud-Din Road
Quetta
Tel: +92 81 831050, 831184
Fax: +92 81 831184, 443660 (R)
Email: zulfiqar@khushhali.qta.sdnpk.org

Dr. N. Muzaffar
Director
Honeybee Research Institute
National Agricultural Research Centre
Pakistan Agricultural Research Council Post Office NIH, NARC
Islamabad
Tel : +92 51 9255023 (O)
+92 51 5584840
Fax: +92 51 9255034/ 9202968,
Email: honeybee@hbri.isb.sdnpk.org

Dr. M. A. Rafi
Senior Scientific Officer
Integrated Pest Management Institute,
National Agricultural Research Centre
Park Road - Islamabad-45500
Tel: +92 519255219 (O)
+92 512254537(R)
Fax: +92 519255034
Email: marafi@isb.paknet.com.pk
arafi@usa.net

Others

Ms. L. Zhen
Rural and Regional Development Planning Program, School of Environment, Resources and Development
Asian Institute of Technology
Mail Box 351, P.O. Box 4, Klong Luang
Pathumthani 12120, Thailand
Tel: +66 2 524 6409 (O)
Email: rrdoo8486@ait.ac.th
zhenlinait@hotmail.com

International Organisations

Dr. D. Nangju
Vice President
World Association for Asia
World Association for Soil and Water Conservation
Tel: +6221/745-6852
Email: dimynangju@yahoo.com

Dr. A. R Y. Ebrahim
National Professional Officer
ICARDA, Mountain Terraces Project (II)
Dhamar, Yemen
Tel: +967 6 509413/501710
Fax: +967 6 509414

Dr. K. B. Saxena
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Patancheru, Andhra Pradesh - 502 324, India
Tel: 91 40 3296161
Fax: 91 40 241239

ICIMOD

G.P.O. Box 3226, Kathmandu, Nepal.
Tel: 977 1 5525313
Fax: 977 1 5524509

Dr. J. G. Campbell
Director General

Dr. B. Bhadra
Director of Programmes

Dr. Tang Ya
Agroforestry/Soil Conservation Specialist

Dr. T. S. Papola
Division Head, MEI

Dr. P. Tulachan
Farm Economist

Dr. N. S. Jodha
Policy Analyst

Mr. P. B. Shah
Country Coordinator, PARDYP

Mr. G. Nakarmi
Water Management Specialist

Dr. N.Tashi
Project Coordinator, ISNAR

Dr. K. Rijal
Renewable Energy Specialist

Dr. F. Ahmad
Project Coordinator, Beekeeping

Mr. R. White
Regional Coordinator, PARDYP

Prof. Chen Guangwei
Division Head, MNR

Ms. C. Richard
Rangeland Management Specialist

Ms. P. Tshering
Gender Specialist

Ms. A. Toda
Assistant Coordinator, IFAD Programme

Mr. M. B. Gurung
Institutional Development Officer

Dr. S. L. Joshi
Action Research Officer

Mr. S. B. Thapa
Manager/Horticulturist

Mr. A. Rotmans
Technical Coordinator, ISNAR Project

Ms. J. Gurung
Gender Specialist

Annex 2: Symposium Programme

DAY One - Monday May 21, 2001

Registration

Welcome Address
  Dr. J. Gabriel Campbell, Director General, ICIMOD
Keynote Speeches
  Dr. Harka Gurung
  Dr. Tej Partap
Address by the Chief Guest
  Minister of Agriculture and Foreign Affairs, HMGN

Address from Donor Representatives

Vote of Thanks

Technical Sessions

Session I ***Plenary Session***

Chairperson:	Dr. Harka Gurung
Rapporteur:	Ms. Atsuko Toda

Strategies for Agricultural Development in the HKH Region
  Dr. Binayak Bhadra
Poverty Reduction and Agriculture in Mountains: Some Emerging Issues
  Dr. Tang Ya
Livelihoods on Mountain Marginal Farms in the HKH Region
  Dr. Pradeep Tulachan

Session II ***Plenary Session (continued)***

Chairperson:	Dr. Binayak Bhadra
Rapporteur:	Ms Atsuko Toda

Indigenous Honeybees and their Role in Mountain Agriculture
  Dr. Farooq Ahmad
Land Use in the Middle Hills of the HKH - Examples from the five PARDYP watersheds.
  Mr. Roger White
Developing Sustainable Mountain Agriculture in the Hindu Kush-Himalayan Region
  Dr. D. Nangju
Assessing Mountain Farming Systems for Sustainable Agricultural Planning and Development
  Mr. Arjen Rotmans
Editorial Notes for Finalising Papers for Publication
  Dr. A. Beatrice Shrestha
Test and Demonstration of Farm Handbooks

PROGRAMME FOR GROUP ONE

Day Two - Tuesday 22 May, 2001

Session III ***Technologies for Improving the Productivity of Mountain Agriculture***

Chairperson : Dr. S. B. Saxena
Rapporteur: Dr. Farooq Ahmad

Assessment of Soil and Nutrient Losses from Bariland Terraces in the Western Hills of Nepal
Dr. B. P. Tripathi
Existing Soil Fertility Status, Loss and Its Improvement in the Bariland of Hills in West Nepal
Mr. G. P. Acharya
Development and Extension of Agricultural Technologies in the Mountains
Prof. Chen Guangwei
Application of a Knowledge Based Systems Approach in Participatory Technology Development: A Case of Developing Soil and Water Management Interventions for Reducing Nutrient Losses in the Middle Hills of Nepal
Mr. Pratap Shrestha
Farmers' Adoption of Improved Agricultural Technologies
Dr. Tang Ya
Options for Sustainable Land Management in the Mid-hills of Nepal
Mr. R. B. Maskey
Contour Hedgerow Farming in North East India – A Case Study
Dr. R. C. Sundriyal

Session IV

Chairperson: Dr. D. Nangju
Rapporteur: Dr. Tang Ya

Effect of Contour Hedgerows on Surface Flow and Soil Erosion Control in a Semi-Arid Valley of the Jinsha River
Prof. He Yonghua
Effect of Contour Hedgerows on Fertility Improvement of Sloping Croplands in a Dry Valley of the Jinsha River
Prof. Sun Hui
Impact of Contour Hedgerows on the Productivity of Sloping Land in the Chittagong Hill Tracts of Bangladesh
Mr. S. K. Khisa
Impact of Hedgerows on Soil Conservation of Terraced Land in the Middle Hills of Nepal
Mr. Bijendra Singh
Soil Fertility Management in Mountain Agricultural Land
Mr. P. B. Shah
Post-harvesting Handling of Horticultural Produce in the Hindu-Kush Himalayan Region
Dr. S. P. S. Guleria

Day Three - Wednesday May 23, 2001

Session V ***Opportunities/Options for Income Generation and Transitions in Mountain Agricultural Systems***

Chairperson: Dr. Tej Partap
Rapporteur Dr. Farooq Ahmad

Pigeonpea – A Potential Multipurpose Crop for the Mountains of Southern China
Dr. K. B. Saxena

Domesticated Non-timber Forest Products (NTFPs) as the Major Sources of Livelihood for Hill Tribes in Marginal Mountain Farms of Nepal
Mr. B. H. Pandit

Butterfly Farming: An Off-Farm Income of Mountain Farming Communities – Experiences from Pakistan
Dr. M. A. Rafi

Agroforestry Interventions for Improving Livelihoods of the Subsistence Farm Household in the Hills of Nepal
Dr. R. P. Neupane

Assessing Rural Community Livelihoods in the Mountain Terraces of Yemen.
Dr. Abdul Rashed Yaseen Ebrahim

Multi-strata Fruit Orchard: A Sustainable Model for Hill Slope Cultivation
Dr. M. S. Uddin

Alternative Irrigation Trial for Cash Crop Production : A Case Study from Jhikhu Khola Watershed, Nepal
Ms. Bandana P. Merz and Mr. Gopal Nakarmi

Session VI ***Opportunities/Options for Income Generation in Mountains (continued)***

Chairperson: Dr. Abdul Rashed Yaseen Ebrahim
Rapporteur: Dr. Farooq Ahmad

Apple Farming Productivity Concerns of Hindu Kush-Himalayan Farmers: Case Studies of Pollination Issues
Dr. Uma Partap

Honeybee Diversity and Its Value to Mountain Farming in Yunnan Province of China
Prof. Tan Ken

Sustainable Management of Beekeeping in Jumla District of Nepal: The Role of Farmer-led Institutions
Mr. Min B. Gurung

Role of Economic Trees in the Farm Economy – A Case Study of Apple Farming in Maoxian County, Sichuan Province, China
Prof. Bao Weikai

Carnation Latent Virus Elimination by Meristem TIP Culture, a Technology Demonstration
Dr. Manisha Mangal

Cash Crops and Sustainable Livelihoods: A Case Study of Potato Production in Sabu Village, Ladakh
Dr. D. McNab

PROGRAMME FOR GROUP TWO

Day Two - Tuesday 22 May, 2001

Session VII ***Issues of Marginal Farms/Farmers***

Chairperson: Dr. Harka Gurung
Rapporteur: Dr. Pradeep Tulachan

Issues and Options of Marginal Farms in Himachal Pradesh
Dr. C. S. Vaidya
Issues and Options of Marginal Farms in Nepal
Mr. Kamal Gautam
Socioeconomic Issues of Marginal Farms in Western Nepal
Dr. R. P. Sah
Productive Use of Marginal Farms: Experiences and Lessons of Himachal Pradesh
Dr. Hans Raj Sharma
Agricultural Development in Arid Mountains of Pakistan
Dr. A. W. Jasra
Impact of Leasehold Forestry on Marginal Farms of Nepal
Dr. F. M. J. Ohler
Role of Agricultural Mechanisation in Achieving Food and Nutritional Security and Employment Generation
Dr. R. K. P. Singh

Session VIII ***Issues of Marginal Farms (continued)***

Chairperson: Dr. F. M. J. Ohler
Rapporteur: Dr. Pradeep Tulachan

Research and Development Strategies for Horticultural Sustainability in Himachal Pradesh: Existing Status Challenges and Future Approaches
Dr. R. P. Awasthi
Managing Marginalisation in Shifting Cultivation Areas of North East India: Examples of Community Innovations and Initiatives
Dr. D. Choudhury
Socioeconomics of Marginal Farms in Bhutan
Dr. N. Tashi
Energy Issues in Mountain Agriculture
Dr. Kamal Rijal
Smallholder Dairy Farming in the Mountains: Potential for Operation Flood in the Uttaranchal Himalayas, India
Dr. Vir Singh

Day Three - Wednesday May 23, 2001

Session IX ***Gender/Empowerment/Local Participation***

Chairperson: Dr. T. S. Papola
Rapporteur: Ms Phuntshok C. Tshering

Rural Women of the HKH: The Prevalent, Yet Marginalised Farmers
Ms. Jeannette D. Gurung

Enhancing Employment Opportunities for Women through Diversification of Mountain Agriculture
Dr. Nasreen Muzaffar
Gender Role in Production and Marketing of Allo as an Income Generating Activity of the Kulung Rai Community in Sankhuwasava District, Nepal
Ms. Kamala Gurung
An Enthnographic Enquiry into the Adoption of Contour Hedgerow Intercropping Technology by the Ethnic Farmers of Chittagong Hill Tracts, Bangladesh: Problems and Prospects
Dr. N. A. Khan
Gender Relations and Agrobiodiversity Management Practices among Some Ethnic Communities of the Eastern Himalayas: Relationship and Effect
Dr. Chanda Gurung
Problems and Potentials of Crop Diversification for Marginal Farmholders in the Dry Mountains of Northwest China
Ms. Zhen Lin
Participatory Action Research on *Apis cerana* selection for Improving Productivity and Conserving Biodiversity: A Case Study from Alital VDC of Dadeldhura District
Dr. S. R. Joshi

Session X Land Use/Land Degradation/Transitions

Chairperson: Dr. R. P. Awasthi
Rapporteur: Ms Atsuka Toda

Institutional Strategy for Improving Mountain Farming – A Case Study of the Uttaranchal in the Indian Himalaya
Dr. H. C. Pokhriyal
Land Use and Land Degradation Issues in Western Nepal
Mr. N. Khanal
Farming Systems and Land Use in Uttaranchal, Central Indian Himalayas
Dr. G. S. Mehta
New Approaches for Reducing Poverty among Farming Communities of the Hindu Kush-Himalayan Region of Balochistan, Pakistan
Dr. Z. A. Khan
Biological Diversity of Medicinal Plants and Cereals of Northern Mountainous Regions of Pakistan and their Exploitation for Sustainable Development of the Area
Dr. Syed Dilnawaz Ahmad Gardezi
An Explorative Analysis of the Potential Productivity of Croplands in Tibet, China
Dr. N. Tashi

PROGRAMME FOR ALL PARTICIPANTS

Day Four - Thursday May 24, 2001

Group Discussion and Presentations

Participants will be divided into four groups. Each group will discuss one of the following thematic areas:

Repercussion of Globalization for Mountain Agriculture: Emerging Issues
Dr. N. S. Jodha
Group Discussion

Session VII *Group Presentations*

Chairperson: Dr. J. G. Campbell, Director General, ICIMOD
Rapporteur: Dr. Tang Ya

Group One
Group Two
Group Three
Group Four

Closing Session

Closing Remarks by Dr. J. G. Campbell

Afternoon Optional field visit to ICIMOD Godawari Test and Demonstration Site

about the authors

Tang Ya is currently Professor of Environmental Biology at the College of Environment, Sichuan University, China. He received his doctorate from the Kunming Institute of Botany, Chinese Academy of Sciences, in 1990 after which he joined the Chengdu Institute of Biology, Chinese Academy of Sciences, where he was promoted to research professor (the top professional position) within five years, becoming one of the youngest professors in China, and served as Deputy Head and Head of the Department of Botany and Ecology. He worked at ICIMOD from July 1995 to December 2001 as project coordinator, agroforestry/soil conservation specialist, Acting Head and then Head of the Mountain Farming Systems Division. Before joining Sichuan University in 2003, he worked as a professor and Chairman of the Academic Committee of Chengdu Institute of Biology. Dr Tang Ya has published widely, with around 100 papers and book chapters credited to his name, and during the course of his career has been elected to the boards of a number of science journals. His current research interests include sustainable mountain development, environmental biology, and biodiversity and environment studies.

Pradeep Man Tulachan has a B.Sc (Hons) in Agriculture from Haryana Agricultural University, Hissar, India, an M.Sc from the University of Illinois, USA, and a PhD in Agricultural Economics from Cornell University, USA. He began his career as a Lecturer at the Institute of Agriculture and Animal Science, Rampur, Nepal, worked in Papua New Guinea as a Senior Farming Systems Economist, and then for USAID as a Senior Project Manager and Agricultural Economist. He has been working as a farm economist at ICIMOD since 1996. At present he is the key professional working on various issues of livestock in mixed farming systems in high pressure mountain areas and is also involved in various research projects including research into the main issues and options for marginal farms in the HKH.




International Centre for Integrated Mountain Development
4/80 Jawalakhel, GPO Box 3226
Kathmandu, Nepal

Telephone: +977 1 5525313
Fax: +977 1 5524509/5536747
e-mail: distri@icimod.org.np
Web site: http://www.icimod.org
Cable: ICIMOD NEPAL

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