
From:

Sustainable Farming Systems in Upland Areas

©APO 2004, ISBN: 92-833-7031-7

**(STM 09-00) Report of the APO Study Meeting on
Sustainable Farming Systems in Upland Areas
held in New Delhi, India, 15–19 January 2001**

Edited by Dr. Tej Partap, Vice Chancellor,
CSK Himachal Pradesh Agriculture University,
Himachal Pradesh, India



Published by the Asian Productivity Organization

1-2-10 Hirakawacho, Chiyoda-ku, Tokyo 102-0093, Japan

Tel: (81-3) 5226 3920 • **Fax:** (81-3) 5226 3950

E-mail: apo@apo-tokyo.org • **URL:** www.apo-tokyo.org

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SUSTAINABLE FARMING SYSTEMS IN UPLAND AREAS

2004
Asian Productivity Organization
Tokyo

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This report was edited by Dr. Tej Partap, Vice Chancellor, CSK Himachal Pradesh Agriculture University, Himachal Pradesh, India.

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ISBN: 92-833-7031-7

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FOREWORD

Sustainable farming systems in upland areas are one of the greatest challenges facing Asian agriculture, since a balance is sought between economic development and environmental protection in those areas. Uplands are particularly sensitive to agricultural encroachments. Driven by growing food demand to feed increasing populations and low farm income in many Asian uplands, however, there is a tendency to use more productive, intensive farming methods in place of traditional subsistence farming characterized by poor crop yields and low farm productivity. Intensive farming methods suitable for lowlands can be disastrous when used on uplands without proven technologies and experience, promoting deforestation and soil erosion and reducing land productivity.

The problem of sustainable upland agriculture is not a technical one as such but it is more institutional, involving limited R&D investment in upland farming research, sociopolitical neglect of marginalized upland societies, low capacity of communities, and inappropriate development planning. In recent years, there have been some successful examples of sustainable upland farming which need to be shared among member countries.

The APO, cognizant of the importance of resource-based conservation in upland areas in the region, organized this meeting to review recent developments in upland farming in member countries, as well as to review the issues and constraints in promoting sustainable upland farming systems further. The study meeting was organized by the APO and hosted by India in January 2001. This volume contains the proceedings of the meeting. We hope that it will prove useful to all those interested in upland farming systems and sustainability relationships.

I wish to express my appreciation to the Government of the India for hosting the study meeting, and to the National Productivity Council and Ministry of Agriculture for implementing the program. Special thanks are due to the resource speakers for sharing their time and expertise with the participants and to Dr. Tej Partap for editing this publication.

TAKASHI TAJIMA
Secretary-General

Tokyo
July 2004

SUMMARY OF FINDINGS

INTRODUCTION

The Study Meeting on Sustainable Farming Systems in Upland Areas which was organized by the Asian Productivity Organization (APO) and hosted by the Government of India was held in New Delhi from 15 to 19 January 2001. The program was implemented by the National Productivity Council in cooperation with the Ministry of Agriculture. Fifteen participants from 11 member countries and four resource speakers participated in the study meeting.

The objectives of the study meeting were: 1) to review the issues and constraints affecting the performance of sustainable farming systems in upland areas in member countries; and 2) to suggest measures for improving the present situation.

The study meeting consisted of the presentation of resource papers by the selected experts, the presentation of country reports by the participants and the conduct of field studies. In the country reports the participants reviewed the present situation of sustainable farming systems in upland areas in their respective countries. The resource papers focused on the following specific topics: 1) People's Participation in Watershed Development: Experience of India; 2) Farming on Sloping Uplands of Asia: Sustainability Perspectives and Issues; 3) Technologies for Sustainable Management of Steep Lands in Asia: Harmonizing Economic and Ecological Sustainability; and 4) Agroforestry-based Land Management Systems in Indian Himalayas.

The highlights of the study meeting are presented as follows:

HIGHLIGHTS OF RESOURCE PAPERS

People Participation in Watershed Development: Experience of India

The paper introduces impacts of the Green Revolution on agriculture in India. The Green Revolution was largely confined to the irrigated areas, which account for about 37 percent of the total cultivated area of the country, the remaining 63 percent being rainfed. The rainfed agriculture depends on rainfall water and is characterized by low level of productivity, input use, wide variation and instability in crop yields. Thereafter, the paper highlights rainfed areas of India and points out high potential of these areas to contribute to poverty alleviation and national food security in future.

The Government of India accorded high priority to holistic and sustainable development of rainfed areas through integrated watershed management. The current strategy of various ongoing national, bilateral and foreign-aided projects for watershed development is based on promotion of diversified and integrated farming systems, management of common property resources, and augmenting family income and nutritional levels of participating watershed communities through alternate household production systems. Sustainable institutional arrangements at State, district, watershed and village level constitute an integral component of these projects for promoting people's participation and ensuring sustainability.

For development of rainfed, and ecologically fragile areas various projects are being implemented under the central and State sector programs. The Department of Agriculture and Cooperation implements several centrally-sponsored land-based conservation-cum-production schemes. These include National Watershed Development Project for Rainfed Areas (NWDPPRA), soil conservation in catchments of River Valley Projects (RVPs) and Flood Prone Projects (FPPs), Watershed Development Project in Shifting Cultivation Areas (WDPPCA), and foreign-aided projects on watershed development. The main principle of these projects is *in situ* moisture conservation to increase production and productivity of these areas on sustainable basis. Besides schemes on reclamation of salt-affected areas are also in operation. Till the end of VIII Plan, under central programs about 16.5 million ha of land have been developed. The paper also briefly reviews different projects for development of watershed areas and their targets under the 25-Year Perspective Plan and 9th Five-Year Plan.

Under the participatory approach, the watershed development project is to be implemented by the watershed community and funds for development activities are to be released directly to the community for execution of works. Similarly preparation of the watershed development plan and the annual action plan are to be undertaken with active participation of community members – individually or through different user groups. The following three organizations will be established/identified for implementation of the project, i.e., community-based organizations, project implementation agency for a cluster of 2-10 watersheds, and autonomous support organization on a pilot scale where there may be several NGO project implementing agencies.

The paper also discusses different committees, organizations, agencies, etc., envisaged under the participatory approach for watershed development project followed by a detailed discussion on capacity building and training of the watershed communities, trainers, administrators, managers, etc.

The watershed development in rainfed areas, in deed, must become a true people's movement for sustainable food production and livelihood support to rural communities.

Farming on Sloping Lands of Asia: Sustainability Perspectives and Issues

The issue of farming sloping lands in sustainable ways has taken the center stage today, for a balance is sought between economic development and environmental protection in the uplands of Asia. Uplands are particularly sensitive to agricultural encroachment and have suffered from erosion and degradation problems. In the past small upland farmers have used sloping uplands for subsistence farming but now the focus has shifted to improve productivity and sustainability of the sloping upland farming so as to meet enhanced needs of food security and livelihoods of an expanded upland population.

Sloping uplands are generally designated as marginal lands due to different combinations of constraints, which change according to the ways land is used. Hence marginality of sloping upland is a dynamic process rather than static. It can be managed in ways that support the process of marginal land upgradation. When sloping uplands are viewed from the economic perspective they are less favourable for agriculture. However, sloping land agriculture can have many values and potentials not available in the plain land agriculture and farmers can make use of these comparative advantages. Thus, even though opportunities exist to improve farming and livelihood on marginal lands but it has not happened so far in the Asian uplands. The problem is not of technology as such but it is more institutional, such as limited research and development (R&D) investment in upland farming research, socio political neglect of the marginalized upland societies, low capacity of communities, and inappropriate development planning.

The reports indicate that Asian uplands are passing through a dynamic stage of demographic scenario, whereby cropland scarcity and less job opportunities in the uplands have engineered out-migration from the uplands to growing economies in the urban plains offering better-off farm livelihood opportunities. Implications are both positive and negative. One may think of declining population pressure in the uplands as a positive outcome, but the abandonment of farmlands in Japan, Korea and even in Nepal gives warning signals about continued shrinking of upland agriculture. Many nations have realized that loss of upland farming resources is detrimental to national food security, evolving sustainable farming and even to local upland ecology.

Reversing the above trend is possible by developing sustainable production systems for sloping lands. It will require that new strategies follow certain guiding principles, which emphasize that “approaches to use sloping uplands will be sustainable if they are designed to mimic the control mechanisms that occur naturally in these ecosystems”.

Some success stories about sloping upland farming in Asia reveal that by taking advantage of specific niches, ecologically stable and economically productive production systems can be evolved. The three examples of success stories reflect a better understanding of the niche potentials of sloping marginal uplands and the opportunities for using them in sustainable ways. Fruit farming on sloping lands extends the availability of agricultural land resources. Cardamom farming demonstrates the use of local biodiversity as a good source of new crops for developing niche-based upland farming. Sea buckthorn example shows that soil and water conservation can be complementary to food security and poverty alleviation and that forests can also provide benefits of economically productive farming.

The issues of sustainable management of sloping upland farming systems are as diverse as the areas themselves. On top of all issues is the neglect of understanding to apply an upland perspective that is so

essential for formulating sloping land sensitive development strategies. It is also equally important to recognize that development issues in the sloping upland areas – such as sustainable agriculture, removing poverty, marginal environment, gender equity and inaccessibility are intertwined and call for an integrated approach. A range of issues emerge from the misconceptions, biases and neglect of sloping uplands farming.

Joint global efforts, joined by both poor and rich nations, are needed to address host of above issues. Today, the issues may be less of whether or not to use the sloping marginal uplands for farming, but of how to use these land resources in better and more sustainable ways to the advantage of both land and people.

Technologies for Sustainable Management of Steep Lands in Asia: Harmonizing Economic and Ecological Sustainability

Degradation of steep lands has become a worldwide concern about erosion, flooding, siltation of reservoirs and rivers, and disruption of coastal aquatic ecosystems. There are many densely populated steep land regions in Asian countries, where human and livestock populations have long exceeded the ecological carrying capacity of the land.

Technologies for increasing productivity of steep lands include biological and physical or mechanical measures. Widely promoted biological measures are forestry, agroforestry (e.g., alley farming), and contour grass strips (e.g., vetiver contour strips). Common physical measures include stone retention walls and various types of manually or mechanically constructed terraces. The choice of appropriate land modification technologies must be determined by soil and climate conditions and socioeconomic constraints of the site in question. At any rate, maintaining an effective surface cover (live or dead) during the onset of rainy season is of paramount importance for controlling runoff and erosion.

Historically, bench terraces, manually constructed over an extended period of time were common practices of converting steep land for agriculture. Modern approach to steep land use increasingly favors biological measures, such as alley cropping and contour grass strips. Notable international efforts of technology transfer are: (a) the Alley Farming Network of International Institute of Tropical Agriculture (IITA); (b) the Vetiver Grass Network of World Bank; (c) Asian Sloping Land Network coordinated by International Board for Soil Research and Management (IBSRAM); and (d) the Sloping Agricultural Land Technology (SALT) Initiative of International Center for Integrated Mountain Development (ICIMOD).

Sustainable management of steep lands for agricultural production cannot be achieved by onsite technological improvements alone. It must be supported by governmental and private institutions that are capable of implementing conservation policies, providing technical and financial assistance to steep land communities, and generating public awareness of the effects of upstream (onsite) land degradation (deforestation, soil erosion) on short-term economic benefits and long-term ecological and environmental consequences downstream (offsite).

The advancement in computing technologies enables both planners and practitioners using Geographical Information System (GIS) and remote sensing techniques to determine site-specific ecological and economic feasibilities for steep land use and conservation. Various watershed management models, land use policy guidelines, erosion prediction and decision support systems are being developed which integrate downstream agricultural and economic development with upstream land use, restoration and conservation. However, regional and worldwide applications of these models depend on continued efforts in building soil, climate and socioeconomic database.

The widening economic gaps between upstream and downstream communities in many densely populated regions could be socially and environmentally explosive. If the poor communities in the steep lands were left helpless, excessive deforestation and erosion in the hills would further undermine the economic welfare and environmental quality of the societies in the plains and valleys. Evidently, this is not merely a technological issue but a political one as well.

Agroforestry-based Land Management Systems of Indian Himalayas

The forest cover in India is a mere 19.27-percent of the total geographical area and is grossly inadequate to meet the nation's requirements for forest products, maintenance of ecological processes and environmental stability. Agroforestry, which is a combination of trees, agriculture and other land use technologies, has the potential for meeting the above requirements. The three basic types of agroforestry systems are agrisilvicultural, silvipastoral and agro-silvipastoral. One of the essential characteristics of

agroforestry system is its site-specificity. Five major agro-ecological zones for agroforestry have been identified in India. The paper describes the important agroforestry practices in the alluvial plains, the Shivaliks and the mid-western Himalayas.

In the mid-western Himalayas, of all the systems, the agro-horti-silvicultural system is highly diverse in vegetation composition and has the highest productivity of 25.8 mt/ha/year. In the Shivaliks, the well-known tree species are *Acacias*, *Leucacena leucocephala*, *Dalbergia sissoo*, *Melia azedarach*, *Eucalyptus hybrida* and *Emblica officinalis*. These trees are grown with local fodder grasses such as *Chrysopogon fulvus* and *Heteropogon contortus*. Bhabbar (*Eulaliopsis binata*), which is a commercial grass, used in the manufacture of paper, has also done very well in association with most of the above tree species. These two-layered agroforestry systems involving trees and grasses have demonstrated their superiority over traditional rainfed crops on poor quality soils. Moreover, on sloping non-arable lands in the Shivaliks, World Bank-assisted projects implemented from 1980 to 1999 with people's participation have helped in conserving natural resources and in substantially augmenting production and income from these agroforestry systems. In the alluvial plains of Punjab, Haryana and Uttar Pradesh poplar has done exceedingly well in association with a large number of annual crops particularly wheat, sugarcane and vegetables. In agroforestry system internal rates of return varied from 38 to 40.5 percent with wheat and fodder intercrops for first seven years in an eight-year rotation cycle. *Eucalyptus* is staging a come back in boundary plantations, windbreaks and shelterbelts where it has been found profitable after allowing for depression in crop yields.

Agroforestry interventions should examine the management in terms of farmer livelihood strategies rather than trying to merely increase supply of forest products. There is a need to improve market information and reduce market constraints to tree growing. Public investment is needed in research to improve the genetic quality of the planting material, and to refine existing agroforestry practices/models. Enhanced investment is required for improving extension services and develop mechanisms for transferring agroforestry technology from the research institutes to the farmers and other user agencies.

HIGHLIGHTS OF COUNTRY PAPERS

Republic of China

Taiwan is a mountainous island. Only one-fourth of the island is classified as a plain region, while the others are mountainous and hilly regions. After nearly one hundred years of continuous expansion of farming in the uplands and exploitation of land resources for other purposes, the area is witnessing several detrimental effects. The loss of habitats due to deforestation and farming on slope lands has resulted in decrease of biodiversity, serious soil erosion, sedimentation, landslide, debris flow, flood hazard and pollution of chemicals. The landscape has become monotonous and the ecosystem fragile. The sustainable farming on uplands is today a major challenge before the government and people of Taiwan.

Recognizing these challenges, the focus of R&D in upland agriculture in the Republic of China has shifted from purely economic contribution to one of food security and environmental conservation. With active research, education and extension, the Integrated Soil Conservation and Land Use Program was initiated to enhance the overall benefits of sustainable slope land farming. Programs of soil conservation, proper cropping pattern and management, adequate transportation, irrigation system, facilities for pest control, farm mechanization, and the introduction of a joint operation and management system were completed to improve land use and maximize production with reduced cost. Hillside ditches combined with cover crops have been extensively conducted on slope lands. Integrated fruit production practices have been implemented in slope land orchards of mango and citrus. The people of Taiwan recognize the fact that it has become necessary to readjust use and management of upland resources for the sake of sustainable development of Taiwan. The process is on to identify methods for adjusting the production-oriented farming systems to the ones that conform to principles of sustainable farming on uplands, such as integrated watershed management approaches and the use of bio-regionalism concept for upland resource management and development planning.

Fiji

With the increase in population and the move towards export-oriented cropping, marginal uplands of Fiji are under tremendous pressure from increasing intensive and extensive farming processes. Most of the

arable lands are now in use. Issues that confront efforts to develop sustainable farming in upland areas of Fiji include: land tenure, small land holdings, pressure on the production base, weak institutional infrastructure, declining soil fertility and erosion. Focus on upland farming systems research is evolving very slowly. The country also needs to enhance adequate financial support for developing and implementing appropriate policies and programs for bringing sustainability to upland farming.

Given the current socio-political environment in the country, the land ownership problems in uplands and inadequate institutional infrastructure, the country requires bold political initiatives.

India

Several provinces of Indian Himalayas and south India cover a large part of Indian upland. Here agricultural systems are further differentiated by agro-ecological zones and farming cultures. General concerns that confront Indian upland agriculture include: degradation of natural resources (soil, water, forests), change in climate, biophysical conditions, population and technology affecting the natural resources carrying capacity and social and economic development, land tenure, farmer's skills, marketing of agricultural products, gender issues, gaps in agricultural production processes, and marketing and industry in terms of regulations, technology, human resources and physical infrastructure.

For integrated development of uplands at present watershed approach based on the principle of people's participation is being adopted. Among the several integrated upland production systems, agroforestry has been recognized as sustainable farming system option for uplands. Three categories of agroforestry systems being promoted in India are; namely, basic need-based system, income generation-based system and environment-based system.

For implementation of the watershed development programs a common approach has been formulated to have uniformity in all the schemes. Detailed operational guidelines for individual schemes also have been developed for use by implementing agencies. Adequate policy measures have been formulated to follow watershed approach for better management of uplands.

Indonesia

Upland area in Indonesia constitutes 87 percent (around 50 million ha) of the total geographical area of the country. This area is mainly rainfed. Upland cropland, however, occupies 26 percent of total land area of the country, mainly in Sumatra, West Irian (Papua) and Kalimantan islands. At present, only 18 million ha of the uplands are being used, while more than 30 million ha are fallow or these are steep lands. The uplands are characterized by low fertility and diverse, potentially unstable, agricultural systems. In addition, uplands have poor infrastructure, limiting the farmers' access to agricultural supplies, services and information. Other constraints to sustainable farming in uplands of Indonesia include: deforestation, intensive cultivation leading to decline in soil fertility and increase in soil erosion/land degradation, scattered farming population, lack of site-specific technologies, lack of participation of stakeholders, and lack of knowledge/awareness about the sustainable agricultural development.

The country, however, recognizes that uplands hold great potential for expansion of farming and for enhancing national farm productivity. Many ways are being employed to develop and improve sustainable agricultural practices in the uplands. One such major effort was a joint project of Department of Agriculture and Federal Republic of Germany started in 1991 in the province of Kalimantan, named "Kalimantan Upland Farming Systems Development Project (KUF)". It aimed at improving *the performance of people in government and NGOs for improving upland farming systems*". This was expected to improve delivery of services to the target groups that, in turn, would help achieve the project goal. Four activities undertaken by the project included: improving annual and mid-term agricultural development planning; compiling and using technical information sets (*Kumpulan Informasi Teknis* or KITs); supporting agricultural extension; and empowering farmers' groups. The key output of the project was considered in generating critical level of human resources expertise that gained upland development experience. Further efforts in this direction continue so as to build manpower for effective delivery of services to promote sustainable upland farming.

Islamic Republic of Iran

In Iran mountains and upland area constitute almost half of the country's geographical area. Upland area is supporting about 90 million ha of rangeland and about 12 million ha of forests, and considerable area

of rainfed agriculture. In spite of socio economic, cultural and environmental importance, most upland areas have been neglected from the process of development. The natural resources of the upland area have been severely degraded. Factors such as vulnerability of the upland areas, shortage of arable lands, logging, deforestation, depletion of rangelands and lack of proper infrastructure and services have contributed to problems prevailing in upland areas. Both grazing and depletion of vegetative cover contribute greatly to erosion and loss of soil fertility.

In uplands of Iran cropping and livestock keeping are the main sources of livelihood. In the past few decades, overstocking and conversion of marginal lands to cropping have depleted vegetative cover, resulting in degradation of land resources. Sedimentation of dams and waterways in the downstream side and contamination of drinking water and salinization of irrigation water are adversely affecting people living in lowland areas. To combat such undesirable and deteriorative effects country recognizes the need for identifying and promoting alternative farming systems and practices with full participation of the stakeholders.

Republic of Korea

In the upland, the cultivation of food grains such as barley and wheat, beans, potato, and miscellaneous cereals has substantially shrunk. While area under cash crops, vegetables, and fruits has expanded remarkably.

The declining farming of food crops (cereals, legumes, and potatoes) and increase in vegetable farming has led to soil salinity, loss of nutrition, and crop diseases.

The excessive use of the chemicals for crop protection has led to large-scale contamination of food systems and environment. The farming has undergone complete change from food crop-oriented system (barley + beans, barley + sweet potatoes) to cash crop-oriented farming (tobacco + radish, strawberry + cucumber, red pepper + vegetables, etc.)

To counter upland farmers reluctance to grain crops farming due to low profitability, and to meet the national food security goals, various forms of incentives are being provided to encourage grain crops associated farming systems. The approach has also helped internalize the external economy of the winter crop rotation system, in order to introduce vegetable-grain crop rotation system.

Mongolia

Mongolia's total arable area occupies 1.2 million ha of land (about 1 percent of the total territory). About 75 percent of this area and 80-83 percent of harvest come from the central and northern uplands of the country. Over 90 percent of arable area is sown with wheat, and 1 percent with potatoes and vegetables. In the course of socioeconomic reforms, which started in Mongolia in the beginning of 1990s, farming is in deep crisis and crop production has dropped.

The national project for the development of farming was started in 1997. The project objective is to improve food security and increase family incomes to alleviate poverty. The focus is on promoting farming of potato, vegetables and fruits to meet the national shortages.

Even though around 20 thousand ha of cropland is irrigated in the central and northern regions of Mongolia but it requires large-scale repairs and technological upgradation. One of the key concerns is competition faced by local farmers from the cheap imports of potatoes, vegetables and fruits from China.

Tasks for improving farming in Mongolia are to improve food supply position, consumption patterns, provide improved varieties to farmers, develop irrigated and greenhouse farming, crop protection, land policies, improve postharvest facilities (storehouses and cellars) and marketing infrastructure.

Pakistan

The upland areas in Pakistan constitute 60-65 percent, with high uplands, 22-25 percent; and low uplands, 38-40 percent of total land area. They support about 10 percent of the national population of 140 million. The dry and arid regions vary in topography, vegetation, rainfall, farming systems and available water resources. There exists a great biotic physical, cultural and ethnic diversity in the uplands of Pakistan.

Fruit crops, like apples, peaches, pears, apricots, plums, cherries, walnuts, peanuts and almonds are cultivated in various degrees as cash crops under wide array of agro-ecological conditions of the uplands.

Besides fruits, a variety of temperate off-season vegetables are also planted for their high value farming potential.

Livestock is an important enterprise in the upland areas. Even though women are caretakers of livestock, crops, and forestland, and make crucial contributions to managing farmlands and livelihoods, there is continuing neglect of their important role in the upland agro-ecosystem. Like many other countries of the Hindu Kush Himalayan region, Pakistan is facing serious threat of environmental degradation, retrogression in biological diversity, depletion of forests, loss of soils, deterioration of rangelands and highly disturbed habitats for wildlife in the uplands.

The major concerns of upland farming are: free and overgrazing, small landholdings, shorter growing seasons, traditional cropping systems, poor quality of local livestock, shortage of trained fodder scientists and lack of improved fodder crops. etc.

For improving food and fodder security in the uplands country is looking forward to cooperation in introducing crops that are cold tolerant and are able to make good early growth. Fodder crops that are capable of regrowing after cutting, grazing or frost damage, crops that have early maturity, drought resistance/tolerance, high forage production, and high nutritive value. In exchange Pakistan will be willing to share knowledge, information and material about upland fruit crops and management of alpine pastures with other countries of Asia.

Philippines

Uplands constitute about 60 percent of the total land area of 30 million ha. Majority of the 75.3-million Filipinos, most of whom belong to the poor segments, live in the uplands. The uncontrolled migration to uplands has brought with it unabated forest denudation. About 52,681 ha of these lands were lost to *kaingin* in 1998 alone, even though several programs have been introduced to arrest the alarming rate of forest deforestation.

It is likewise quite alarming that uplands are also home to rebel groups. It has made upland people vulnerable to worsening insurgency situation. As is known, the basic cause of insurgency in the country is poverty, Philippines has a great challenge of alleviating poverty from the uplands.

Since 1970s various institutions are promoting a range of technological options for improving upland farming. The solution includes alternative agricultural systems to agroforestry schemes. Even if the success rate is high but several problems regarding appropriate technologies, *approaches* and *general constraints remain*. Infrastructure is indeed a good entry point for development as observed in farming systems development projects. Therefore, it has been integrated into the country's agriculture modernization plan since 1997. However, lack of political will and inadequate financial support to put this plan into action, are reasons why infrastructure development for upland development has not made any headway.

Sri Lanka

Sri Lanka has a population of 20 million people cultivating over 2.0 million ha of cropland, among which about 1.25 million ha are uplands. The uplands are undulating with sloping hilly landscapes and narrow valleys.

Tea, rubber and coconuts are the major plantation crops of uplands, largely cultivated by plantation companies as well as smallholders. The plantation systems were considered stable cropping systems until recent years. However, soil erosion and loss of valuable agricultural lands due to natural causes and non-agricultural pursuits are often evident in uplands.

There is a large number of such smallholdings which are cultivated by resource-poor upland farmers with unproductive crop species. Soil erosion, pollution and siltation of water bodies are reported in those areas. Excessive use of pesticides and overuse of fertilizers are reported in upland vegetable producing areas. Rising cost of labor and input further aggravate the sustainability of agriculture in uplands. Reduction of biodiversity, emergence of resistant pest species and new species of pests are reported recently. Low level of productivity has been compelling farmers to divert their land into non-agricultural pursuits. Low level of mechanization, large quantities of postharvest losses are also causes of the low profitability of upland farmers.

To meet the challenges faced by upland farmers, government investment policy is directed to increase productivity, to increase quality of agricultural produce and lower the cost of production through prudent use

of inputs. To achieve these goals country has focused its efforts for provision of research and extension facilities, infrastructure facilities, inputs, etc., and incentives for processing, postharvest handling and value addition for agricultural products.

A large number of government organizations and NGOs are involved in development of farming systems for uplands. Agricultural villages, agricultural productivity villages, sustainable farming villages and integrated farming systems are some of the government interventions aimed at sustainable upland farming.

Most success stories of sustainable upland agricultural systems based on low external input, organic farming and other conservation farming practices are however, yet to emerge in the country.

Thailand

In recent years, the upland areas of Northern Thailand have experienced resource degradation and social problems due to rising population pressure, declining productivity of farmlands and socioeconomic pressure both from within and outside the mountain regions. Issues affecting the performance of sustainable farming systems in upland areas include shifting cultivation, forest-tea (*miang*) system, lack of integrated farming system, lack of conservation farming and lack of alternative agriculture practices. Measures for sustainable farming in upland areas include: infrastructure development; appropriate policies for the upland areas; and measures for promoting integrated farming.

FIELD VISITS

The participants visited the following sites in and around Dehradun, the capital of the newly-formed State of Uttaranachal to observe and study on-site situation of upland areas in the host country.

- * Central Soil and Water Conservation Research and Training Institute, Dehradun (CSWCRTID)
- * Doon Valley Integrated Watershed Management Project – Aamwala Village, Case Study.

The Dehradun is situated at about 275 km in northwest of New Delhi.

Central Soil and Water Conservation Research And Training Institute, Dehradun

The participants were welcomed by a team of the scientists at the CSWCRTID. They visited the museum of the institute, which was a self-explanatory exhibition of the activities of the institute with the help of charts, models and pictures. The Institute was established more than 20 years ago. The mandate of the Institute includes protection of soil and water resources through undertaking the basic and applied research and imparting training on the subject. To achieve this objective the Institute has undertaken various research projects and has organized many training courses. It has adopted both the agronomic and engineering approaches to address issue of the soil and water degradation and to find appropriate technologies for their conservation. Among others, the Institute has developed various agronomic and engineering technologies: to control soil erosion and gully formation; to harvest water; and to recycle water. The Institute showed strong determination to cope with the challenges of soil and water conservation in the 21st century.

Doon Valley Integrated Watershed Management Project – Aamwala Village, Case Study

The participants were welcomed by Mr. K. L. Arya, Project Director, Doon Valley Integrated Watershed Management Project Division, Dehradun. The project team explained various aspects of the project. The project was implemented with the financial assistance of European Union (95 percent) and Government of Uttar Pradesh (GOUP) (5 percent) from 1993 to 2001. A total of 303 villages were selected for the project activities. The long-term objective among others was to arrest and as far as possible, reverse the ongoing degradation of the Doon valley ecosystem while short-term objectives, among others, included management of the natural resources in a sustainable manner through community participation and improvement of the socioeconomic conditions of disadvantaged groups particularly the women. The components of the project were: forestry, livestock, horticulture, minor irrigation, agriculture, soil conservation, energy conservation, and community participation.

The participants visited Aamwala village, a model village of the above project, situated in the Doon valley. The village is situated at an altitude of 900 m above the mean sea level with 104 households and 540

population. The participants observed the various project interventions such as small biogas plant, mushroom cultivation, plantation of shrubs and grasses along the gullies and slopes, etc. The participants also had a meeting with the members of the GAREMA (Gram Resource Management Association) and women's self-help group. The members expressed their full satisfaction on the project interventions. The project seemed to be sustainable since most of its activities were continued successfully by the village residents themselves after withdrawal of the project.

The participants also observed the situation of upland degradation while traveling through the Doon valley.

ISSUES AND RECOMMENDATIONS

In the plenary session, the participants identified the issues pertaining to sustainable farming systems in upland areas and suggested strategic actions to address such issues as follow:

- * Diversity of biophysical regimes, biodiversity and ethnic diversity in Asian uplands has been instrumental in evolving a range of upland farming systems. Their opportunities and constraints are so diverse that generalized common solutions applied to the upland farmers' livelihoods and their farming problems have been rarely successful. Thus efforts are needed to find site- and community-specific solutions to address problems of the upland farmers and farming.
- * Many member countries lack comprehensive database on promising indigenous and modern farm technologies, and crop and other resources for diverse agro-climatic conditions in the uplands. Thus a comprehensive database on upland technologies and resources need to be established.
- * Traditional farming is unable to meet the food and livelihood needs of the upland farming families. Therefore, there is need to look for alternative production systems leading to diversification. Thus appropriate need-based diverse upland farming systems should be developed.
- * It has been increasingly recognized that marginal lands will have to play an important role in ensuring the food and economic security of upland farmers in many APO member countries. However, R&D investment and initiatives for developing appropriate production systems on such marginal lands are still hopelessly inadequate. To develop appropriate sustainable farming systems for such marginal lands adequate R&D investment and initiatives would be inevitable. For this purpose appropriate policy support to promote R&D into marginal land niches-based farming systems, products, market opportunities and intellectual property rights to upland communities over their indigenous knowledge and plant material is needed.
- * Subsistence farming is diversifying to cash crops (fruits and vegetables) farming in most upland areas of the region. Landscapes are intensively farmed with cash crops, causing decline in soil fertility, increase in crop diseases, and overuse or misuse of chemical fertilizers and pesticides. Such situation is leading to escalation in environment degradation, increase in cost of cultivation and narrowing profit margins of small upland farmers. Expansion of farming in the uplands to sloping lands is further aggravating the situation. Besides developing appropriate farming systems, adequate extension services would be required to create awareness on the situation among all the stakeholders.
- * In many developing APO member countries, family food insecurity and poverty due to increasing non-viable farming in uplands are compelling migration of male folk in search of employment to urban areas. Thus uplands are experiencing increasing number of female-headed households and farm management. However, lack of gender-friendly farm technologies and extension systems add to poor adoption of new options for improving farming and continuation of subsistence farming in these areas. Besides development of gender-friendly farm technologies and extension systems, appropriate policies are needed to generate off-farm employment in the upland areas.
- * In developed APO member countries, large-scale migration of younger generation to urban areas, leaving farming in the hands of the aged family members has created serious problem of abandonment of farmlands and farming in the uplands that, in turn, could pose serious threat to the national food security. Provision of appropriate incentives would be inevitable to encourage the local youth to stay and work in the uplands.

- * Many nations in the region have poor investment in upland farm research as well as physical and institutional infrastructure, and lack properly trained scientific manpower for upland agriculture. Besides scattered farming population makes it difficult and expensive to deliver extension services. Adequate investment in agricultural research and extension, manpower training and development of proper infrastructure is needed.
- * Arable farming in marginal uplands and overstocking of livestock coupled with free grazing and overgrazing of support lands and rangelands are causing degradation of resources through increased soil erosion and endangered biodiversity in the uplands, and downstream sedimentation of water reservoirs/waterways. The latter is of increasing concern to lowland populations. Appropriate policies should be formulated and executed to grant clear land rights to upland farmers and ensure proper land use. A comprehensive policy of compensating upland communities for the ecological services they render to lowland communities also needs to be formulated and executed.
- * Besides measures would have to be adopted to minimize adverse impacts of arable farming, to ensure proper size of stocking livestock, and to avoid free grazing and overgrazing of uplands, particularly, of common property land resources. Thus adequate and proper subsidies should be provided to upland farmers not only for improving farming and productivity but also for adopting soil conservation practices and ensuring their economic viability.
- * Although commercialization of forest products can help upland communities achieve sustainable livelihoods but for maintaining sustainable use of these bio-resources, institutional steps are needed.
- * Due to the WTO initiatives for liberalization of trade and marketing the upland farmers are losing comparative advantage opportunities for fruit and vegetable production. This is because of the availability of cheaper imported products. This situation is endangering economic viability of small upland farmers. Appropriate policies would be inevitable to sustain economic viability of small upland farmers of the region under the WTO regime.
- * It is important to recognize that diverse issues in uplands such as sustainable livelihood, upland agriculture, poverty, marginal and fragile environments, poor infrastructure, gender and inaccessibility to market, etc. are intertwined and call for an integrated development approach for upland areas emphasizing active participation of all the stakeholders.
- * Little initiatives are seen for regular inter-country exchange of information and experience among the Asian nations, particularly with respect to sharing successful experiences of upland farming and natural resource management. This situation warrants establishment of strong networking among the Asian countries, especially those working for development of sustainable farming systems in upland areas.

CONCLUSIONS

The diverse gathering of participants, representing different countries and disciplines proved very useful in sharing a wide range of views on upland farming in Asia and its sustainability issues. Presentations and discussions held during the upland farming meeting generated lively debate about many new issues and perspectives; such as whether calling uplands as marginal lands is appropriate and whether it requires new balanced perspective thinking and mind-sets. There was agreement that probably a fresh thinking is required on marginality dimensions of upland and farming. Participants also recognized that the great potential niches of uplands have so far been less understood and remain unexplored. These niches offer tremendous scopes for evolving location-specific ecologically and economically sustainable upland farming systems. Niches also facilitate removal of marginality of upland farming systems in terms of productivity and stability. Similarly promoting people's participation and gender-balanced upland farming development approaches were believed to greatly help policymakers, planners, researchers and farming communities to revise their strategies for upland development in APO member countries.

Initiative taken by APO in providing a platform for discussion of emerging issues was fully utilized. The meeting offered an opportunity to identify a range of issues and options for international, national and local action. The outcomes of the meeting also set the stage for inter-country cooperation in sharing of experiences.

The objectives of the meeting were also achieved in terms of identifying technological and institutional constraints responsible for productivity and sustainability of upland farming. Focusing research on technological innovations for uplands was identified as one of the crucial factors for achieving the goal of building sustainable upland farming. However, delegates shared the common feeling that there has been an under-investment in technological research for sustainable farming in the uplands, as compared to plain land agriculture. They were convinced that a high uncaptured potential return to research on upland agriculture exists. It is hoped that information generated through this meeting on new perspectives, on emerging issues, and on possible potential scopes would immensely benefit both R&D professionals in their pursuit for evolving national and local strategies for improving upland farming in Asia.

1. PEOPLE'S PARTICIPATION IN WATERSHED DEVELOPMENT: EXPERIENCE OF INDIA

Dr. Rita Sharma
*Joint Secretary and
Land Resources Commissioner
Ministry of Agriculture
Government of India
New Delhi
India*

INTRODUCTION

The Green Revolution, initiated in the mid-1960s has been the cornerstone of India's agricultural growth and has been instrumental in taking the country from the state of food deficiency to one of self-sufficiency. From a production level of 51 million mt in 1950-51, food grain production has registered a record production of over 205 million mt in 1999-2000. While in the early years increase in production came from area expansion, for the past three decades the net cultivated area has remained almost constant and additional production has come about as a result of productivity increases. The latter has been the result of expansion of acreage under irrigation, wider use of high-yielding varieties, increased use of fertilizers and other modern inputs. It is essential that for obtaining better yields from modern inputs such as seed, fertilizers, insecticides, water, etc. adequate and responsive land conditions must be available.

It is important to recognize that the Green Revolution was largely confined to the irrigated areas, which account for about 37 percent of the total cultivated area. Rainfed area accounts for two-thirds of the total cultivated land of 142 million ha. In fact, the rainfed region of around 89 million ha is almost twice that of the irrigated tract. Yet, the irrigated area, about 53 million ha (37 percent) accounts for 55 percent of total food grain production whereas the rainfed region, nearly 90 million ha (63 percent) contribute only 45 percent.

Rainfed agriculture is characterized by low levels of productivity and low quantity use of inputs. Being dependent on rainfall, crop production is subjected to considerable instability from year to year. More than 200 million of the rural poor live in the rainfed regions. These risk-prone areas exhibit a wide variation and instability in yields. Gap between yield potential and actual yields are very high compared to the irrigated areas. The rainfed regions of eastern India have the potential to achieve higher yields. Indeed, with the development of infrastructure and improvement of access to inputs, agricultural growth in parts of the eastern region has exhibited a higher trend than in the traditional States of Punjab, Haryana, and western Uttar Pradesh. All areas where rainfed farming is predominant whether in the central plain, hill, semiarid or coastal lands, will need to contribute more to poverty alleviation and augment food security by producing marketable surpluses more reliably.

India's agriculture has now entered a post-Green Revolution stage of development that requires new strategies to enhance agricultural growth and reduce rural poverty. A move to an intensive diversified agriculture with strong forward and backward linkages is the next evolutionary step in the country's future agricultural development. Economic liberalization and adjustments to the market economy are placing new demands on the agriculture sector. Agricultural technologies, agro-management practices and public institutions will need to respond to emerging market demands and export opportunities together with redressal of poverty alleviation, nutritional security needs and environmental concerns. However, the speed and extent of such a change and its impact on rural development through multiplier effects would depend on the availability and adoption of improved technologies, restructuring of public institutions, supporting infrastructure, and developing an appropriate policy environment.

WATERSHED APPROACH TO RAINFED FARMING

The Government of India has accorded highest priority to the holistic and sustainable development of rainfed areas through using integrated watershed management approach. The current strategy of various ongoing national, bilateral and internationally-aided projects for development of watersheds is based on promotion of diversified and integrated farming systems approach, management of common property resources, and augmenting family income and nutritional levels of participating watershed communities through alternate household production systems. Suitable institutional arrangements at various levels (e.g., state, district, watershed, village) constitute an integral component of these projects for promoting people's participation and ensuring sustainability.

Resorting to the watershed approach is central to the development of rainfed areas, inclusive of various special problem areas, namely; saline and waterlogged lands, ravines, hill areas, coastal and desert ecosystems. A large number of national, bilateral and externally-funded projects are in operation. Some of the broad-based development objectives under these projects are:

- * attainment of targeted level of food grain production in a given time frame in a sustainable manner;
- * restoring ecological balance in the degraded and fragile rainfed eco-systems, by greening these areas through appropriate mix of trees, shrubs and grasses;
- * reducing regional disparity between irrigated and vast rainfed areas; and
- * creation of sustained employment opportunities for the rural poor.

AREA TREATED UNDER WATERSHED PROJECTS

For development of degraded areas various schemes are being implemented under Central and State sector programs. Under Central sector program various schemes are being implemented by different departments, namely; Department of Agriculture and Cooperation, Department of Wasteland under the Ministry of Rural Area and Employment, Ministry of Environment and Forests and Ministry of Water Resources. The working group on soil and water conservation, constituted by Planning Commission estimated that about 16 million ha have been treated by the end of the VIII Plan under various schemes being implemented by Central and State governments.

The Department of Agriculture and Cooperation, implements several centrally-sponsored land-based conservation-cum-production schemes. These include National Watershed Development Project in Rainfed Areas (NWDPR), soil conservation in the catchments of River Valley Projects (RVPs) and Flood Prone Rivers (FPRs), Watershed Development Project in Shifting Cultivation Areas (WDPSCA) and externally-aided projects on watershed development. The main principle in these schemes is *in situ* moisture conservation with the objective of increasing production and productivity of these areas on a sustainable basis. Besides, schemes on reclamation of salt-affected areas are also in operation. Till the end of VIII Plan, under central programs about 16.5 million ha have been developed.

In conformity with the common approach/principles for formulation of common guidelines, the NWDPR has been considerably restructured for its implementation during IX Five-Year Plan. The restructured NWDPR allows a much greater degree of flexibility in the choice of technology, decentralization in formulation and approval of model projects, greater thrust on research support, innovative activities, transfer of technologies, improved institutional arrangements for capacity building and community organization, better linkages with institutions including credit institutions, efficient management of common property resources with people's participation, etc. It is estimated that integrated watershed management approach with focus on farming systems development and diversification will go a long way in augmenting food production and productivity in 2.25 million ha rainfed areas under NWDPR during IX Plan.

The proposed coverage of rainfed areas to be treated under the three major centrally-sponsored projects/programs dealt by the Ministry of Agriculture during the IX Plan and the corresponding allocations approved by Expenditure Finance Committee (EFC) so far, may be indicated in Table 1.

Table 1. The Coverage under Various Internationally-aided Projects on Watershed Development

S.No.	Name of the Scheme	Physical Target (million ha)	Resource Allocation (US\$ million)
1.	NWDPRA	2.25	220
2.	RVP/FPR	0.87	130
3.	WDPSA	0.10	16
4.	Externally-aided projects	1.25	400
Total		4.47	766

PERSPECTIVE PLAN

Under the 25-Year Perspective Plan it has been projected that an estimated area of 63 million ha would be brought under various watershed development programs involving an overall investment of US\$16,344 million. These include the watershed development projects of the Central Ministries (Agriculture, Rural Development, and Environment and Forests). Out of this, an area of 10 million-ha will be covered during the IX Five-Year Plan. Similar initiatives are being undertaken to implement the RVP and FPR schemes.

To augment the budgetary resources, a watershed development fund with a corpus of US\$40 million has been established at National Bank for Agriculture and Rural Development (NABARD). This fund would be used to saturate 100 priority districts in 14 selected States. The States would obtain loan from NABARD to undertake watershed development in the selected districts after signing a Memorandum of Understanding (MOU).

INSTITUTIONAL ARRANGEMENT TO ENSURE PEOPLE'S PARTICIPATION

Under the participatory approach the watershed development project is to be implemented by the watershed community and funds for development activities are to be released directly to the community for execution of work plan. Similarly, preparation of the watershed plan and the annual action plans is to be undertaken with active participation of community members – individually or through different users groups. The following three organizations will be established/identified for the implementation of the project: (i) community-based organizations; (ii) project implementation agency (PIA) for a cluster of 2-10 watersheds; and (iii) autonomous support organization on a pilot scale in districts where there may be several NGO project implementing agencies.

Community-based Organizations

Community organizations at watershed level would consist of users groups (land- and water resource-based); self-help groups (SHGs) (consisting of women and landless families); watershed committee (consisting of representative members from users groups, SHG, *Panchayat*, etc.); watershed association (consisting of all members of the watershed). The watershed association shall be registered under the Societies Act whereas users groups and SHGs would remain as informal groups.

Project Implementation Agency

PIA shall be selected for each cluster of 2-10 watersheds. PIA shall hire a four-member Watershed Development Team (WDT) to work on full-time basis for the above watershed. The headquarters of the WDT members shall be kept at one of the watershed villages and they may be encouraged to stay in these villages in order to provide opportunities for working closely with the community.

Autonomous Support Organization

Support organization may be established/identified on a pilot basis where there are several NGO PIAs functional. These support organizations may be created in each district or for a cluster of districts or even at State level depending upon the number of PIAs. Each support organization would serve about 10 PIAs.

Management Committee

Under the project the following four types of management committees are envisaged to review and guide the program at different levels. These include National Watershed Committee, State Watershed Committee, District Watershed Committee, and Watershed Association.

National Watershed Committee

The Committee may be jointly chaired by the Secretary (Agriculture and C) and the Secretary (Rural Development) on rotation and have its members drawn from various organizations including Indian Council of Agricultural Research (ICAR), Departments of Animal Husbandry and Dairying, Planning Commission, Ministry of Environment and Forests, Ministry of Rural Areas and Employment and experts in the field. This Committee may meet once in a year for reviewing the progress and providing policy direction to the program.

State Watershed Committee

This Committee may be chaired by the Chief Secretary or the Agriculture Production Commissioner and the members of the Committee may be drawn from concerned line department of the State government including rural development and *Panchayat Raj* department; representative from State agricultural university (SAU)/ICAR institution in the State; representatives of selected autonomous support organizations; NGOs and Presidents of selected watershed associations. The above Committee may meet once in six months to issue policy directives, review progress and resolve management issues.

District Watershed Committee

This Committee may be chaired by the District Collector or the Chairman of District *Panchayat/Zila Parishad*. The Committee may meet frequently depending upon the need. Its members would be drawn from concerned district line departments, *Krishi Vigyan Kendra* ([KVK], farm science center), autonomous support organization in the district, selected PIAs from government organizations, NGOs and people's organizations, chairman of selected watershed associations, etc. The Committee would review the progress of the watershed project, assist in resolving management and administrative problems, guide in implementation, and identify policy issues, if any, for reference to State and national committees.

Watershed Association/Watershed Committee

The Watershed Association (registered under the Societies Act) will be the General Body comprising all members of the watershed community who agree to participate in the watershed development project. The Watershed Committee shall act as an executive body of the Watershed Association and carry out the activities of the watershed plan through paid employees. The Watershed Association will be the final decision-making body. The Watershed Association may meet in respective villages on monthly basis to plan and review the activities particularly during the implementation phase.

CAPACITY BUILDING AND TRAINING

According to an estimate about 4,000 macro-watersheds are likely to be covered for treatment under various ongoing centrally-sponsored schemes, namely; NWDPR, RVPs and FPRs, WDPSA, Alkali Reclamation Scheme, externally-aided projects and programs funded under Watershed Development Fund by NABARD. For implementation of program with a common approach spread over in the entire country, extensive training and capacity building of various stakeholders would be needed. These stakeholders will include government staff working at various levels for watershed programs, watershed committees and its members, village development committees, PIAs consisting of NGOs, KVKs, WDT, users groups, SHGs, *Panchayati Raj* institutions, etc. The orientation training and capacity building programs need to cover technical aspects of watershed management including production technologies, social aspects of watershed management, sustainability requirements, gender sensitization and modern information technologies, etc.

Main Issues

- * Identification of gaps in capacity building (resources and infrastructure – both public and private).
- * Mechanisms for networking and convergence within existing institutions.
- * Use of information technologies for networking.

- * Justification for a separate national institute for watershed management.
- * Role of bilateral agencies in capacity building.
- * Development of short- and long-term plan for capacity building.

Networking of Training Organizations for Capacity Building

In India, by and large, training organizations are able to conduct courses either on technological or on management aspects. It is rare to find an organization, which can effectively cover all aspects of either the technology or management component. A networking among training organizations with different strengths through exchange of resource persons, hosting a part of the courses in respective organizations, etc. will be useful. The State/district agencies may, however, select training institutions best suited to their needs.

Orientation and Capacity Building

To overcome the constraint of inadequate capacity particularly at PIA and watershed committee level a major orientation in the tools and techniques of participatory approaches and capacity program is a prerequisite to finalize the selection of PIA or watershed site. For this purpose the following specific steps are being proposed:

- * Orientation of members of various management committees and institution heads.
- * Training of State level trainers drawn from various organizations in the State.
- * Training of faculty members of autonomous support organizations at district level.
- * Training of PIA/WDT identified for each cluster of 2-10 watersheds.
- * Training of office bearers of watershed association, watershed committee, user groups, SHGs, etc.

Autonomous Support Organization at District Level

In districts where several NGO PIAs are likely to be involved with implementation of watershed development projects, the district nodal agency may identify an autonomous support organization at the district level to undertake responsibilities related to identification of appropriate NGO PIAs; building the capacity of the PIAs/WDTs; coordinating and supervising the progress of work of concerned PIAs; reviewing and evaluating performance; liaisoning between PIAs and district nodal agency. The support organization may hire a multidisciplinary team of four persons to provide the services. These support organizations may be started on a pilot basis in selected districts where there are likely to be a large number of NGOs.

Training of Personnel

Orientation/training of persons under serial 1 and 2 above may be undertaken by national institutions such as National Institute of Rural Development (NIRD), Central Arid Zone Research Institute (CAZRI), Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Central Research Institute for Dryland Agriculture (CRIDA), National Institute for Agricultural Extension Management (MANAGE), etc. Subsequently, State level trainers may build capacities of faculty members of autonomous support agencies wherever these may be established. These agencies in turn would train PIA/WDT. Responsibility for training office bearers of watershed committees, watershed associations, user groups, SHGs would rest with PIA/WDT. Autonomous support organizations at the district level can play a key role in building the capacity of PIAs. The funds for capacity building would be met out of the training budget of the project.

Orientation Course for Administrators and Managers

Administrators and managers may require only short duration orientation courses of 3-4 days. A tentative list of items/modules to be covered in these courses are indicated below:

- * Rationale behind watershed approach for sustainable development of rainfed agriculture
- * Rationale behind participatory approach under watershed program
- * Orientation about common guidelines of restructuring NWDPA
- * Focused exposure visit to successful watersheds
- * Sensitization about aspects related to equity for poor and empowerment of women
- * Attitudinal and behavioral aspects for facilitation of participatory approach

- * Operational aspects of new roles and responsibilities to be performed by administrators and project managers:
 - # Timely selection of PIAs and micro-watersheds in respective districts
 - # Preparation of detailed training plan for the State/district and its coordination and facilitation
 - # Facilitation of fund flow in time
 - # Monthly review and monitoring of physical progress with regard to organization of community, capacity building of different actors, preparation of action plan, progress of various works during the implementation phase, concurrent terminal evaluation of program, etc.
 - # Monthly review and monitoring of financial progress; timely release of funds to the PIA and community; maintenance of financial and physical records particularly at PIA and water association level including internal auditing of accounts on six-monthly basis and external auditing of accounts, on an annual basis; action taken on audit paras by the registered society; vigilance action on any misappropriation of funds at PIA/micro-watershed level.

Skill Enhancement Course for WDTs

Implementing agency may require a combination of short duration courses on the above items and long duration skill enhancement courses of about eight weeks duration. The content of the skill enhancement course may vary depending upon whether it is meant for WDT or watershed community as per details given below:

1. Watershed Development Team

- * Orientation of participants about items listed above
- * Focused exposure visit of participants to successful watersheds
- * Skill enhancement of above participants on the following aspects
 - # Organization of the community into a new institutional set-up at the village level which includes credit and thrift groups (SHG and users group); watershed association and watershed community, etc.
 - # Participatory Rural Appraisal (PRA) tools and techniques
 - # Team building, Association for Social Advancement (ASA), facilitation skills, group action, and conflict resolution
 - # Indigenous methods of mass communication for awareness building among community members
 - # Management information system and computer application
 - # Facilitation skills for organization of exposure visits to success stories
 - # Technological aspects regarding development of natural resources, production enhancement activities and livelihood support activities
 - # Participatory planning including preparation of design and estimates, supervision of quality of work
 - # Participatory implementation
 - # Participation monitoring and evaluation.

2. Watershed Community

- * Orientation of community about participatory approach as well as main feature of the operational guidelines (through indigenous methods of mass communication).
- * Motivation of office bearers and selected community members through focussed exposure visits to success stories.
- * Orientation of office bearers of the watershed community, watershed association, users group, SHG about their roles and responsibilities under the program.
- * Enhancement of skills of watershed secretaries, volunteers, community organizers about record-keeping and other job related management aspects.
- * Enhancement of knowledge and skills of indigenous paraprofessionals on technological aspects.

Skill Enhancement Course for Trainers

Trainers may require an additional longer duration course besides the orientation course and skill enhancement course on the items indicated above. The additional component would focus on trainer's skill

and facilitation skill to carry out their own training courses effectively. All the above components may require a total of about 12 weeks duration, which may include learning of required skill and also practicing them in at least three follow-up training courses under the supervision of master trainers.

The period for skill-oriented courses may be spread over 12-18 months in order to provide repeated contacts so that participants could simultaneously learn as well as practice the skills in a gradual manner.

Separation of Capacity Building Phase from the Main Implementation Phase

It is widely recognized that a few weeks of training input at the initial stages of the project is not adequate for building the capacity of the PIA and for preparing the community for participatory management of watershed program. Field experience has indicated that training input, particularly to WDT, watershed secretary, volunteers, community organizers, etc. should include not only learning of skills through structured courses but also a regular follow-up support for application of skills. This would require a longer period of association between the trainers and trainees. During this period physical and financial progress in the conventional sense is likely to be slow which may generate a negative pressure on the implementing agencies. It is, therefore, essential to separate out the capacity building phase from the main implementation phase so that their progress can be reviewed with phase-specific parameters.

During the capacity building phase which may be extended to about one year, the PIA/WDT should facilitate the following activities at the village level: orientation of watershed community about the proposed strategy and approach; skill enhancement of office bearers of the watershed committee and other concerned persons on organization of community into credit and thrift groups; use of PRA tools for preparation of action plan; record-keeping and supervision of quality of works during the implementation phase, etc. The WDT, office bearers and community organizers may use the above skills in such a way as to carry out organization of at least four SHG/user group; preparation of perspective plan of watershed for the project period; preparation of detailed action plan of a portion of watershed area to be implemented during the capacity building phase (which may include one representative drainage course; about 25-30 ha of private land associated with the above drainage course; 1-2 water harvesting structures; natural regeneration of vegetation through social fencing in one block of common land); implementation of above action plan; participatory evaluation of programs, etc.

The national level and location-specific training courses have helped in overall improvement of watershed management programs. The experiences have shown that as a result of human resource development through capacity building the professional competence of staff improved significantly for surveys, planning, estimation, selection of sites, implementation and post-care maintenance. In order to improve the perception of various stakeholders for watershed management programs, capacity building is an important tool. Various other aspects related to watershed management viz. social aspects, joint management of common properties, women empowerment, etc. are better taken care after the capacity building and human resource development.

CONCLUSION

The task of treating 63 million ha of rainfed areas in the next 25 years is indeed, a daunting one. It is not one, which can be accomplished by government and public functionaries alone. The entire community must be actively involved in developing rainfed areas through the watershed approach, only then will it be possible to ensure production of food surpluses from these areas which are so vital if food production is to exceed population growth. Capacity building of all actors in the drama must move simultaneously if the watershed development is to be effectively conducted. Indeed, watershed development in rainfed areas must become a true people's movement for sustainable food production and livelihood support to rural community.

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2. FARMING ON SLOPING UPLANDS OF ASIA: SUSTAINABILITY PERSPECTIVES AND ISSUES

Dr. Tej Partap

Head

Mountain Farming Systems Division

International Centre for

Integrated Mountain Development

(ICIMOD)

Kathmandu

Nepal

INTRODUCTION

The issue of sustainable farming on sloping uplands is becoming more pressing as a balance is sought between economic development and environmental protection. Sloping uplands comprising of hills, mountains and highland areas are sensitive to agricultural encroachment and suffer from widespread soil erosion and land degradation. Small and marginal farmers of Asian uplands have traditionally used sloping uplands for subsistence farming despite poor yields and low farm productivity. In order to improve the quality of livelihoods of farmers dependent on sloping farmlands, further efforts are needed to identify appropriate farming options that are environmentally stable and economically productive. However, it is not as easy as it appears, for there is a range of interlinked issues.

The focus of this paper is on highlighting issues concerning sustainability of agriculture on sloping uplands in Asia. The paper starts by defining sloping uplands as marginal lands and explains various dimensions of the new thinking and implications. In Asia, general feeling is that sloping lands support subsistence farming that has resulted in deterioration of the economy and environment. Various dimensions of this aspect are elaborated under the section on slopeland farming scenario in Asian uplands. A section on guidelines for sustainable use of marginal-sloping lands is added before illustrating examples of the emerging success stories of cash crops farming on sloping uplands which have provided hope of economic prosperity to upland inhabitants. Some of these examples from the Asian region demonstrate the sustainable use of sloping uplands for farming and the significant differences in improving the livelihoods of people. The paper finally sums up issues and recommendations for effective management of sloping uplands of Asia in particular and other uplands in general.

ARE SLOPING UPLANDS MARGINAL LANDS?

Using conventional thinking we assess land types according to its agricultural production capacity. Consequently, even though without definition, many names are used to designate sloping lands – marginal, low potential, resource-poor, fragile, vulnerable or degraded lands, but more widely used term is – marginal lands (Partap, 1998 and 1999; and Consultative Group on International Agricultural Research [CGIAR], 1999). The difficulty in formulating a clear definition for sloping lands can stem from the fact that productivity varies according to the type of land use. A tract of sloping land that is “marginal” for crop production may be well suited for grazing or fruit farming. Fragile sloping uplands may be sensitive to degradation under cultivation but may be sustainably used for forestry. Further, productivity is not only based in the biophysical characteristics of land, but also depends on the socioeconomic parameters of a specific environment. Technologies may be known but the necessary incentives, institutions, or inputs may be missing. The range of possible uses of sloping lands is so wide and socioeconomic conditions of upland farmers so diverse that no definition can encompass all relevant factors.

Marginality of sloping uplands can be the result of a range of combinations of constraints. For instance biophysically “good” land can be marginal on account of its isolation from markets, the availability of inputs, or the “small size of holdings”. The nature, composition and interaction of the factors, which determine marginality of sloping land, can differ widely. Accordingly, three broad land types can be identified:

- i. relatively favored sloping lands with high present agricultural use value
- ii. marginal lands with low present agricultural use value
- iii. lands at low or zero intensity of agricultural use.

Any number of factors may lead to shifts of sloping land from one category to another. These shifts may be upward, through applications of improved techniques, or downwards as a result of land degradation or inappropriate development of lands formerly at low use levels. Hence marginality of sloping lands cannot be a static concept, it is a dynamic process. Therefore, while dealing with natural resources management, marginality of sloping lands has to be assessed in terms of specific types of land use. Sloping land that is marginal for a crop requiring continuous irrigation and moisture for whole growing period (e.g., rice) could be highly productive for perennial crops that need less moisture and can even tolerate periods of drought in between rainfall periods. Also what is marginal land for cropping, because of terrain or short growing period such as highlands, may support a productive and sustainable livestock production system.

A key characteristic of marginal sloping land, as distinct from productive flatland, is the location specificity of terrain, climate, soils and socioeconomic conditions.

Using these criteria, sloping lands can be marginal depending on:

- * its use – for agriculture or for forestry
- * its natural biophysical characteristics – investments can alter
- * its location relative to infrastructure – road access to the area can completely alter the economic returns from the same land
- * the institutional and policy context – influence people’s access to land resources and opportunities
- * population pressure – size of landholdings (from nomads/herders viewpoint his/her large area of land is not marginal even though the biophysical yield is low; at the same time a farmer with less than one ha of favored agricultural land may feel that he or she is living on marginal land).
- * technology development – perennial drought resistant crops adapted to such lands
- * taking advantage of niche opportunities – high value crops/plantations.

A sloping land area of uplands (hills, mountains and highlands included) may move out of and into marginal status depending on which of the above dimensions are applied in the definition. Thus, it only makes sense to define sloping uplands – as marginal land, only in terms of a clearly defined specific situation. Further, even though technologies to remedy biophysical marginality are well known – the marked shifts in productive use of marginal lands results only with necessary incentives to apply results of technological research. These incentives include removal of range of policy and institutional constraints.

New Concerns and Shifting R&D Focus for Sloping Lands

Three common concerns have been identified by the current development processes that facilitate shift in research and development (R&D) focus towards marginal lands (CGIAR, 1998). These are:

- * *A concern for vulnerable and fragile lands* – because of the global dimension of the problems of degradation of sensitive natural areas – the deterioration of mountain environments, desertification and destruction of biodiversity (environmental lobby).
- * *A concern with poverty* – the thinking has gained ground that most of the poor live on marginal lands, specifically on the slopes of uplands of the developing world. Thus concern for marginal lands is a proxy for concern with poverty alleviation for those who inhabit these lands (development lobby).
- * *A concern for mountain agriculture* – where rainfed sloping farmlands are being marginalized/degraded through overuse or misuse. Therefore addressing the problem is necessary for sustainable use of these marginal lands (agricultural and environmental lobby).

Recently, in its efforts to reorient research priorities to give more attention to marginal lands CGIAR (1998) attempted to define marginal lands as marginal agricultural lands (MALs). According to this perspective MALs include all those marginal areas including sloping lands currently used for agriculture, grazing or agroforestry. They are characterized by poor soil fertility – nutrient deficiencies, acidity, salinity, poor moisture holding capacity, etc.; inaccessibility with all its social and economic implications; fragility; heterogeneity, i.e., physical and cultural diversity with inherent constraints and opportunities.

Although when sloping upland is viewed from the economic perspective it is less favorable for agriculture, yet sloping upland agriculture can have many values and potentials not available in flatland agriculture. By making use of intricate topography and rich biological resources, slopeland farmers can take advantage of these factors. While large-scale farming is difficult on sloping upland farms but unique small-scale farming niches with diverse products can be developed.

For further discussions and reference in this paper, a common word – “uplands” will be used to represent hills, mountains and high lands. Similarly sloping upland areas will be used interchangeably with marginal uplands and marginal upland farmlands.

WHAT LEADS TO UNSUSTAINABLE FARMING AND POVERTY ON SLOPING UPLANDS

As described above, sloping upland areas are one of the key categories of marginal areas. Because of the isolation, risky productive potential and the insignificant economic and associated political power of their inhabitants, marginal uplands have been neglected by most of the Asian nations. There is limited evidence of public investment in such areas and on societies inhabiting in terms of education, health, infrastructure, etc. There is little interest in determining the aspirations of marginal people or their knowledge of how to cope with harsh environments as a basis for focusing public action responsive to their capabilities and needs. Government agencies and policymakers hold the view that because of high costs of providing quality services to such areas, accelerated industrial and services development in non-marginal areas, i.e., plain land areas that are in or near the cities and towns with full access to markets – would be better alternative. General thinking supports the idea that such an approach will encourage migration from marginal areas at a scale that will reduce population pressure and increase the resource base (and income) per capita for the residual population. However, lessons can be learnt from the experiences of Japan and Korea, which will be described in later sections, which explain the backlash effects of this approach.

Thus, the poverty alleviation efforts in marginal areas in general and sloping land areas in particular have not worked well for several reasons. Without investment in the resource base of these people with expanding populations the expectations can only be progressive extension of poverty and degradation of the soils and forests on which they depend for a large part of their sustenance. In agriculture, inappropriate research has been blamed for not taking into account indigenous knowledge and the opportunities and constraints, which apply to the site-specific characteristics of upland marginal areas under diverse agro-ecological regimes. That may be the reason that few research results have led to widespread or significant improvement in the agricultural productivity and welfare of marginal people.

This applies to other crucial areas such as agricultural research, education, health or infrastructure development as well. None of these have been able to respond to complex diverse requirements for sustainable exploitation of sloping land opportunities deriving from natural resources and value-adding micro-enterprises. For those living on sloping uplands marginal areas the critical importance of income in poverty alleviation needs to dictate the research focus on: food and non-food products; opportunities and constraints to off-farm sources of earnings; and productivity from forest areas.

The problem may not be with technology as such. It is rather the institutional arrangements for farm research and support services; resource entitlements; the functioning of markets; and local capacity of communities to manage their own affairs. The concern is further compounded by the fact that long established common property systems face breakdown in areas where they played crucial role in risk sharing and survival strategies of the poor inhabiting the sloping marginal uplands (Jodha, 1995).

OVERVIEW OF SLOPING UPLAND FARMING CONCERNS IN ASIA

Initially, compelling conditions in the plains may have pushed people up onto the sloping uplands. In Southeast Asia, hill settlements started on volcanic fertile soils where farmers developed extensive terracing

systems. In other cases, unlimited land availability on some of the sloping upland terrains may have attracted people from crowded lowlands. There are watersheds in Asia, which practically offer open access resources situation because of lack of enforcement and property rights. Migration to sloping uplands with relatively less population density is also caused by the perception of better land opportunities.

In several Asian countries there is scarcity of cropland in the lowlands and therefore people have moved up to find alternative livelihoods. Indonesia is one good example of the process where urbanization has used up formerly productive cropland and forced farmers search for agricultural opportunities on sloping uplands. The emerging trends of market towns in the Hindu Kush-Himalayan (HKH) region countries, India, Nepal, Pakistan and China are in fact a reflection of the process of people moving up into the upland slopes (ICIMOD, 1986). In Bangladesh government felt that hills were less populated than plains so it arranged a regulated migration from the congested plains to Chittagong Hill Tracts (ICIMOD, 1995).

Further, Asia also is home to diversity of ethnic people. Most of these ethnic communities historically preferred inaccessible sloping upland terrains for settlements so as to avoid persecution and maintain autonomy. The ongoing insurgency and conflicts among government agencies and ethnic communities in several Asian countries cannot be ignored while talking about sustainable management of sloping uplands of Asia. Whether people lived on the sloping uplands for years or they have just moved in, the reality is that they will now continue to stay for political, social or economic reasons.

The following section makes an overview of issues concerning dependence of people on sloping uplands of Asia for agriculture and livelihoods.

State of Farming on Sloping Uplands of HKH Region

Livelihoods of the majority of the population in the uplands of HKH region countries (Nepal, Bangladesh, Bhutan, Pakistan, India, China, Myanmar, and Afghanistan) revolve around agriculture. Here land is the nucleus of all socioeconomic activities. For majority of the small and marginal farmers their wealth and poverty is associated with the ownership of the size of landholdings (Partap 1995; Banskota 1992; and Koirala and Thapa, 1997). For large number of small and marginal farmers of the HKH region, shrinking cropland holdings is a key concern for managing food and livelihoods (Banskota, 1998; Koirala and Thapa, 1997; and Pokhriyal and Bist, 1988). Rural development efforts across the HKH region face a serious challenge of finding a solution to this problem (Partap, 1998). However, calculating population density this way for the mountain areas is misleading. The actual picture of human pressure on sloping hills/mountains is revealed by the number of people depending on the available cropland. An overview of state of land resources in the HKH region, presented in Table 1, clearly indicates that much of the land resources of the HKH region are sloping and steep lands and only limited percentage is cropland. While calculating population pressure on total land area it is low to medium, data in Table 1 shows that per capita available cropland in almost all countries of the region is already too little to sustain livelihoods. The consequences of this situation to sustaining livelihoods and management of land resources may be serious.

The uplands of HKH region have limited cropland, i.e., 11 percent of total area (Partap, 1999) to support livelihoods of most rural households. This 11-percent cropland is further divided into a range of flat and sloping land types. Partap (1999) also reported that 37 percent of the cropland is sloping land of various degrees, and the Himalayan farmers are even cropping sloping lands beyond 25 and 30 degrees. But constrained by policies and mainstream perceptions, which emphasize promoting forestry on sloping lands, improving farming on sloping farmlands has never been included in the research agenda of most of the National Agricultural Research Systems (NARS). As a result there has been general lack of technological options for promoting sustainable and more productive farming on sloping lands. It is also partly for this reason that the mountain farmers share the blame for land degradation. The new human settlements, urbanization, industrialization and government infrastructure development activities, all are competing for converting the flat valley cropland into non-farm use.

In his landmark study about global cropland loss Gardner (1996) warned about the implications of global trends in cropland loss to food security and livelihoods of people. In his assessment, hills and mountains will be the worst sufferers of cropland loss. In almost all countries of South Asia, there are no laws which protect conversion of cropland for non-agricultural purpose. In the absence of laws favoring conservation of cropland, farmers find it hard to resist the lucrative land market for non-agricultural use.

Table 1. Sloping Lands and People in the HKH Region

Country	Mountain Area (km ²)	Sloping Land (8-30 percent) (percent)	Sloping Land (>30 percent) (percent)	Agricultural Land (percent)	Per Capita Agricultural Land (ha)	Population Inhabiting Marginal Areas (million)	Population Density (person/km ²)
Afghanistan	390,475	35.1	41.9	10.0	n.a.	13.8	35
Bangladesh	13,189	60.5	12.2	7.8	0.097	1.2	57
Bhutan	46,500	12.7	88.4	7.6	0.173	1.2	30
China	1,647,725	10.0	50.7	1.2	0.150	19.6	20
India	482,920	30.7	21.1	8.3	0.293	35.0	73
Myanmar	280,862	37.4	29.1	7.7	n.a.	5.8	21
Nepal	147,181	12.7	66.3	18.0	0.133	18.5	126
Pakistan	404,195	29.3	35.6	7.8	0.158	22.7	56

Source: Partap, 1998.

A study by Koirala and Thapa (1997) reported that for sufficient food a nuclear family in the hills needs 2.08 ha of rainfed cropland or 0.54 ha of fully irrigated productive cropland, provided it is put under intensive cash crops farming. By this estimate, farmers in the hill and mountain districts of Nepal are operating landholdings which are much below the critical size needed for sustenance at the present technological level available to them. It is partly because of small farmland size, that 16 mountain districts and 33 hill districts of Nepal are presently experiencing food deficits of varying degrees. In some mountain districts food grain production meets only 16 percent of the requirement.

Underutilized support land: Between the cropland and actual forests there is a sizable amount of land in most of the South Asian countries. It is known by various names, such as wasteland, grazing land, rangeland, shrub land and unclassified forests, etc. Much of this land provides crucial support to farming and livelihoods of hill/mountain farmers. In this paper it is termed as support land because it provides essential livelihood support to farming communities.

There is relative abundance of the sloping support land in the region (Partap, 1998a and b). Pokhriyal and Bist (1988) also indicated trends of increasing conversion of sloping cropland into non-crop support land in the Himalayan region. They reported that 14.5 percent of the sloping rainfed cropland was converted into non-crop support land in one and a half decade alone. The reasons may be many, including falling productivity of subsistence farming, migration of families in search of better livelihoods or absence of able-bodied family members in the households for better management of farmland. Above all it reflected the lack of technological options and institutional support to manage sloping farmlands productively for food security and poverty alleviation of the small farming households.

Implications of cropland scarcity in upland marginal areas are reported in the crisis area studies of ICIMOD (Jodha and Shrestha, 1994). These studies give documented evidence of unsustainability of upland agriculture in respect of land resources, production and livelihoods. The documented unsustainability indicators are in fact hidden responses of farmers to lack of access to cropland of adequate size and quality. Table 2 lists indicators of general trend of upland farming in HKH region. The key issues that emerge are shrinking size of landholdings, increase in erosion from sloping farmlands and decline in soil fertility and above all widening cycle of inadequate food production-food insecurity-poverty-resource degradation.

The state of croplands in the HKH region and its impacts on the food insecurity and continuing poverty paint a grim picture for sustainable upland agriculture. It highlights the fact that unless solution is found to cropland scarcity, agriculture as a source of sustenance for the small and marginal farmers may lose its significance. The hope lies in finding ways to use available marginal upland i.e. non-crop support land. To take steps in that direction will mean that mainstream society and institutions will have to get convinced of the necessity to make land use changes in respect of support land in the uplands.

Experiences of Upland Farming in Japan

Sloping lands in the hills and mountains account for 68 percent of total area of Japan. Country has over 30 percent cropland on slopelands. However, agriculture and people inhabiting the upland areas face uncertain future. Sloping land agriculture in hills and mountain areas of Japan is facing difficulties of social nature. Nakagawa (1998) and Sugaya (1998) report that an alarming rate of households is abandoning sloping farmland in the mountain areas. The abandoned farmland increased from 93,000 ha in 1985 to 162,000 ha in 1995. It was almost 3.8 percent of the nation's total farming area. Rate of abandoning sloping farmland has gone as high as 9.3 percent in some areas. As a result, upland farming communities of Japan face problem of extinction due to decrease in agriculture and forest areas, depopulation and aging of residents. As industrial growth offers ample job opportunities for younger generation of hill and mountain farmers in the urban areas, they are no longer interested to continue farming their family land. On the contrary, the farmland near the cities and in the plains of Japan has been already converted to non-farming use, e.g., industrial purpose. Agriculture in these areas has already become a marginal activity. Today Japan faces a paradoxical situation, where 91 percent of its agricultural land and 40 percent of fundamental agricultural resources actually exist in the uplands/mountains. It is these areas where the nation is witnessing an accelerated process of abandoning agriculture and farmland.

Table 2. Indicators of Unsustainable Upland Farming in HKH Region
(Time frame: 1954-91 = 37 years approximate)

Indicators Reflecting Problems relating to Resource Base/ Production Flow and Resource Management	Range of Changes (percent)
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	-20 to 55
5. Area of farmland per household	-30 to 10
6. 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 into dryland farming due to water scarcity	+7 to 15
16. Average crop yields on sloping lands:	
a. Maize and wheat	-9 to 15
b. 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. Labor demand for falling productivity	+35 to 40
21. Forestry farming linkages	Weak to weak
22. Food grain purchases from shops	+30 to 50
23. External inputs' needs for crop production	High to medium
24. Fuel wood fodder scarcity in terms of time spent in collection	+45 to 200
25. Fodder supply from:	
a. common land	-60 to 85
b. private land	+130 to 150
26. Emphasis on mono-cropping	High to high
27. Steep slope cultivation (above 30 percent)	+10 to 15
28. Weed and crop herbaceous products used as fuel wood	+200 to 230
29. Conversion of marginal land into cultivation	+15 to 40
30. Fallow periods	From 6 to 3 months

Source: Adopted from Partap, 1998.

Note: A positive sign (+) means increase and negative sign (-) means decline/decrease.

Sugaya (1998) listed following factors responsible for declining agriculture on sloping landscapes of Japan: decline in the number of farmers and their age; concerns over future prospects of liberalized agricultural trade; decline in job opportunities; delay in social capital infrastructure development; small land parcels making mechanization difficult; intricate topography and small size of landholdings; lack of adequate access roads limiting use of farm machines; and higher costs of land grading, irrigation, etc. Sugaya (1998) also reported range of implications of the rising rate of abandoned farming. These include increasing national food insecurity; loss of crop resources; and loss of indigenous knowledge of farming.

Japan considers declining mountain agriculture scenario on sloping lands as a national loss. Judging from the policy and investment initiatives one may say that nation is making serious efforts to reverse this trend. The Depopulated Areas Emergency Act and the Mountain Villages Development Act have been put

into effect for maintaining/conserving mountain agriculture on sloping lands. The policy aims to realize balanced development of industry through improving the environment, social welfare and traditional agriculture. To support niches based high-value farming and income-generating options for the mountain farming communities R&D support is focusing on: vegetable farming and floriculture with special highland products; animal husbandry on grasslands; labor-intensive organic farming; developing forestry; micro-enterprises development – food processing, etc.; adding value to the local farm produce; and changing tourism development approach to build stronger tourism-farming linkages “*farming for tourism*”. The Shikoku National Agricultural Research Station has been mandated to focus its research on “slopedland agriculture”. The thrust of current research has been focused on reversing the trend of declining mountain farming communities and conserving the agriculture on the sloping lands. This research station has already made substantial efforts in upland farm mechanization.

The factors and implications of farmland abandonment in Japan may have important lessons to other Asian nations, as many may face similar problems in not so distant future with the growth of national economies, advancement of urbanization and liberalization of agricultural trade. The adverse impacts of abandonment of farmland on the national food security scenario of Japan serves as warning to those who advocate migration from hills/mountains so as to conserve these areas for ecological interest only.

Experiences of Farming in the Uplands of Korea and Lessons

Korea has 66 percent mountain area and 33 percent of farmland of the nation consists of sloping lands. The 1994 Farmland Law identified 735,000 ha of good irrigated cropland (60 percent) and 193,000 ha of marginal sloping cropland (33 percent) and 99,000 ha of other land (Gim, 1998). In the last three decades, Korea has experienced rapid economic growth, which was accompanied with industrialization, urbanization, and migration to cities especially from uplands. The fall-out was that abandonment of farming in the uplands took serious proportions.

Additional reason was that Korea has been promoting the policy of “*Agricultural Promotion Area (APA)*”, which favored only plain areas for agricultural investment priority. For this reason the sloping land agriculture falling under “*Less Favored Area (LFA)*” was neglected for investment. As a result, Korean farmers living on sloping uplands find it harder to survive under poor production conditions. The quality of life in the uplands is certainly lower than in cities, encouraging younger generation of farming families to leave farming and farmland for jobs and better livelihoods in the cities. Gim (1998) believed that the tendency might even accelerate, if the current agricultural development policy continues to pursue APAs approach. The hardship of these farmers will be further compounded by the shortage of farm labor because of job-induced migration of young mountain folk to urban areas. It is a key factor that contributes to accelerated abandonment of agriculture and farmland in the Korean uplands. As an example, in 1993 alone over 66,500 ha of cropland was abandoned, which accounted for 3.2 percent of the cropland (Gim, 1998). By this rate nearly half a million ha of cropland in the uplands will have been abandoned by the year 2000.

The emerging thinking in Korea is that even though sloping lands in the uplands are less productive, continuing farming on these lands may yield higher positive externality to society than favorable production condition areas. Higher the positive externality of these marginal areas, higher is the price and percentage of “*Willingness To Pay (WTP)*” among the Korean society, so as to maintain farming on these marginal-sloping uplands (Gim, 1998). The trend has encouraged government to consider reshaping of the policy of agricultural promotion zone for investment and therefore includes sloping upland areas in it. Imposing tax on the city dwellers by the amount of WTP per capita and use this revenue for improving/maintaining farming in sloping uplands is among the measures being considered by the government.

Isolated Area Development Law (IADL) of 1988 was the first measure to pay attention to sloping upland farming. Under the policy less-developed and low income rural upland areas received special investment focus for integrated development (1990-99) to boost income and welfare of the inhabitants. Farmland Law of 1994 and Rural Improvement Law of 1994 were other steps taken by the government. One of the more relevant programs was “*the Marginal Land Improvement Program (MALIP)*” for hilly and mountain areas. It was two-dimensional. One, it was to improve the use of marginal upland as productive land; two, it was to promote use of marginal upland for other farm and non-farm purposes, such as rural resorts, livestock farming, fruit farming, and industrial development (Gim, 1998). Further, a scheme for compensating mountain farmers through direct cash payment to maintain farming on sloping uplands was

also introduced. It had two key objectives; increase food supply and preserve traditional farming areas on sloping landscapes.

The lessons of the Korean experience are summed up by Gim (1998) as follows: *“When the agricultural policies and measures consider only economic values, they are not sustainable and future generations may suffer access to resource base. Therefore, the current Korean policy favoring support for maintaining farming on sloping uplands is necessitated by both ecological and economic value considerations”*.

Farming on the Uplands of Taiwan and Lessons

Major part (73 percent) of Taiwan consists of hills and mountains. It is categorized as slopeland by Soil and Water Conservation Law. Farming on sloping uplands of Taiwan is largely focused on raising cash crops, such as betel nut, tea, mangoes, plums, Japanese apricots, apples, pears, citrus, peaches, cattle pastures, pineapples, persimmons, passion fruits, bamboo shoots, and highland vegetables (Chang, 1998). Heavy rainfall and typhoons make soil erosion from sloping farmlands a serious problem. There also is limited scale shifting cultivation on sloping lands that is associated with declining soil fertility. Government has launched a long-term development support under integrated soil conservation and land use program for sustainable farming on sloping uplands. The thrust areas of this development program include strengthening technology development for soil and water conservation, enforcing restrictions on construction on sloping uplands, emphasize on proper resource planning and conservation management, adopt integrated watershed management approaches, strengthening maintenance of developed slopelands, and support education and training of farmers for sustainable farming in sloping uplands.

The program has successfully completed construction of farm roads, irrigation and drainage facilities. In addition wider use of soil and water conservation practices by farmers on sloping farmlands has been promoted successfully. Successful efforts have been made to develop machines suitable for slopeland agriculture (Chang, 1998). There has also been frequent use of sloping uplands for other purposes, such as golf courses, mining and road development, which many consider harmful to the environment.

State of Farming in the Sloping Uplands of other Asian countries

In Fiji about 45 percent area is hilly and another 25 percent is excessively steep land ($>25^\circ$). Around 19 percent of farmlands are on sloping lands. Most land on islands is owned by foreigners but there is also large Fijian population on each one of these islands. Upland region above 600 m is excessively humid cloudy and not suitable for farming. Limited good agricultural land is being shifted to non-agricultural purposes, such as towns, housing, tourism, power and industries. Looking at these processes and the state of land availability Seru (1998) reported that all islands confront the awesome reality of limited cropland resources, as faced by farmers of the HKH region.

Because of wide spread cash crops farming in Fiji there is hardly any subsistence farming and hardly few real subsistence farmers exist in the country. The opportunities for cash crops farming are plenty. Crops, such as sugar, ginger and vegetables offer good market opportunities therefore intensive farming on sloping uplands is common (Seru, 1998). At present, most of the ginger farming is done on relatively steep sloping lands in heavy rainfall areas. It has created serious soil erosion and declining fertility problem. In addition, the farmers' practice of burning the crop residue to quicken harvests, further adds to scarcity of organic matter in the marginal sloping upland farmlands.

In Indonesia a large percentage of people live in the watershed areas because of easy availability of water and other natural resources. Population growth has made people move upwards onto the sloping uplands and farming on sloping uplands has increased substantially during the past few decades. Consequently, over 12.5 million ha of farmland has been identified as critical land, i.e., marginal sloping upland (Djadi, 1998). Sloping upland is both terraced-irrigated as well as rainfed on which crops like maize, peanuts, pulses, potatoes, cabbage and soybeans are grown. Farmers grow a combination of these annual crops with perennial tree crops such as coffee, cloves, vanilla, coconut, cocoa and several other tropical fruit trees. National land rehabilitation and soil conservation program has launched several projects promoting sustainable farming on the sloping uplands. Although little consideration has been given to people participation but few projects, i.e., natural silk farming and social forestry credit provision are inclined to encourage people participation for enterprise development.

In Iran the problems of sloping and marginal upland farming appear different. Over 52 percent of its total area of 165 million ha is mountainous and largely dry. There is very little rainfall and irrigation is necessary for farming. Thus, out of 17 million ha of cropland 50 percent is irrigated and rest is rainfed. If irrigation water was available there is potential to expand farming and agro-pastoral systems to additional 28.5 million ha of marginal land. Sloping upland in Iran is largely under fruit farming and water is harvested in several ways for irrigating the perennial plantations. Under agro-climatic conditions of Iran uplands attract attention of development planners for expanding farmland through developing irrigation facilities. The uplands are considered to hold great potentials for supporting farming and livestock production systems (Rouhani, 1998).

A PERSPECTIVE FOR SUSTAINABLE USE OF SLOPING UPLANDS

As revealed by the scenario of Asian countries, sloping lands need attention because the absolute number of people dependent in these areas for their livelihoods, is likely to increase and that high incidence of poverty in these areas requires focused attention. In the past, development planners may have underestimated the likelihood of population pressure that these areas will experience. Although many sloping uplands already support dense populations, others are going to be overcrowded in the near future. The strategy may therefore be designed to target both the needs of the people as well as the sustainable capacity of land.

Any action for sustainable use of sloping uplands needs to answer following two questions: is the sloping upland in question capable of supporting productive agricultural production systems?; and how much of a threat is the prevailing land use to the sustainable management of the sloping uplands and for securing sustainable livelihoods of people? Added to it is the question whether the sloping lands can support productive and sustainable upland use systems.

Because of the widely held view that cropping is unsustainable beyond 15 percent slope, agriculture R&D ignores focus on such areas. Sloping uplands in many cases have been managed by governments to protect watersheds, under regulations which set aside forests on lands with slopes on 18-30 percent or forbid annual cropping on these lands (Blaike, 1987). In the Philippines, e.g., government controls much of 55 percent of the upland area for maintaining forests because it has slope above 18 percent.

That means research will ignore finding solutions to farming in these areas despite the fact that people do cultivate these areas and need technological assistance the most. Partap (1998) highlighted the fact that large part of Himalayan uplands is under sloping lands with 8-30 percent, where most of the people live and they are mostly deprived of the necessary technological support to adopt sustainable farming practices.

One also finds that series of misconceptions have developed around forest role in sustainable management of sloping uplands. Although forests play important ecological role for maintaining the hydrology and soil movement from the sloping uplands, but they limit economic sustainability options. Unfortunately, the development planners and government bureaucracy has nurtured misconceptions about the role of forests to the extent that they block opportunities for adopting better sloping marginal land use alternatives. Implications could be far reaching for improving livelihoods of people and sustainable management of these lands.

GUIDING PRINCIPLES FOR SUSTAINABLE MANAGEMENT OF SLOPING LANDS

The development of sustainable production systems on the sloping uplands is possible. However, it will require that development planning processes for sloping uplands follow certain guiding principles, *“Approaches to use sloping upland will be sustainable if they are designed to mimic the control mechanisms that occur naturally in these ecosystems”*. The guiding principles for ecologically sound technical planning of sloping upland use are described by Partap (1998) in detail and these are summarized here for quick reference.

1. *Recognizing Diversity of Land Use Opportunities*

Structurally diverse land use systems can be developed for sloping uplands to contain erosion impact. Varying the size and shape of the disturbance will create islands of cultivated land surrounded by natural

vegetation. This will help trap soil from slopes. Agro-ecological diversity also offers potentials for developing diverse systems. Later sections will describe successful examples of these types.

2. *Identifying and Harnessing Location-specific Niches*

Because of variations in aspect and altitude, sloping lands are characterized by wide variations in sunlight availability, soil type and moisture regimes which change significantly within small areas. These variations play crucial role in determining sloping land cover and land use. For example, slope aspect determines that northern face of the landscape will be covered with the forest while the southern face will have grassland. It is important to realize that “*sloping uplands are less suited for uni-dimensional land use*” but more suited to multiple strategies that consider unique characters of smaller sites within the whole landscape. Farmers have been evolving farming systems by identifying these special attributes of micro-sites and harnessing the niches.

A number of examples can be quoted to confirm that in the past contributions, actual and potential, of sloping upland farming systems to food security, poverty reduction, biodiversity – agro-biodiversity and environment have been under rated. In order to ensure long-term security of sloping land use investment it is necessary to legitimise agriculture and forestry use of sloping uplands and make farmers eligible for collective action.

3. *Ensuring a Balanced Relationship between People and Sloping Uplands*

There is evidence that population growth supported by needed technological and institutional tools can lead to better conservation of sloping uplands (Tiffin, *et al.*, 1990). Conversely, there are examples that show that depopulation can lead to bad farming practices and upland degradation (Sugaya, 1998). Factors that influence farmers’ decision-making for sustainable use of sloping upland include land tenure relations, market access, access to technological and institutional innovations and local ecological conditions. Some researchers (Scherr, *et al.*, 1995) suggest that population growth in these areas may induce people to invest in sloping upland improvement. By doing so, they create opportunities for farming these lands more productively so as to improve the returns from investment in farming. Evidence indicates that the factors, which contribute to poverty, also encourage farmers to intensify farming on sloping lands but employing better land husbandry practices. One of the key reasons why farmers do not employ sustainable farm management ways is because of lack of property rights. In Asia, shifting cultivators, which are a sizable chunk, have this problem (Partap, 1998). Further in several countries of Asia, land property rights are gender discriminating, which is crucial for sustainable land management. There are obvious benefits of developing and enforcing clearer rules that define rights and obligations among local people on the use of local land resources. In this context, there is increasing evidence that private ownership encourages improvements in land quality, whereas insecure land tenure will encourage less care and degradation on sloping farmlands.

There is gap in our understanding about economics of agricultural intensification and limits to economic well-being of people living on the marginal sloping uplands. Another important factor is the use of indigenous knowledge and skills. Unless farm research focuses on enhancing sloping upland farming systems productivity by incorporating indigenous knowledge and skills of local communities, which are so diverse in Asia, there will always remain a gap in the efficient use of scientific methods for evolving sustainable production systems on the sloping uplands.

REVIEW OF LESSONS FROM SUCCESS STORIES

The examples of technological approaches described here have successfully demonstrated their application on the marginal uplands, both cropland and support land, in one or the other area of the HKH region. Terracing is among the most widely known traditional practice used for farming the sloping uplands across mountain regions of Asia and the world. Countries like Nepal and Bhutan are outstanding examples of well-built terracing systems for rice farming (Das and Maharjan, 1988; and Thinley, 1991) and so are terraced rice fields of Cebu in the Philippines. Within the humid middle mountains of central and eastern Himalayas, terracing is essential for crop cultivation on sloping lands over 20°. In recent decades, some institutions evolved alternatives to stone walls and terracing systems using contour hedgerow technology. Called green terracing or “Sloping Agricultural Land Technology”, it uses nitrogen fixing plants and grasses to build the contour hedgerows. While successful adoption of this alternative for Soil-Water-Nutrient Management (SWNM) has been reported in some cases but wider adoption is yet to be seen (Partap, 1998).

Studies by Ojha (1997) highlight the fact that further expansion of terracing is unlikely to have positive effect any more and therefore evolving economically and ecologically sustainable production systems for the sloping uplands should be given new attention rather than promoting terracing. In this context Partap (1998 and 1999) closely examined the issues of ecological and economic sustainability of some new approaches and the value of the rationales behind them to build sustainable production systems. Following information on these success stories has been extracted from Partap (1998 and 1999).

Fruit Farming on Marginal Upland

It is an example of the small and marginal subsistence mountain farmers of Himachal Pradesh who made successful efforts to improve their food security and livelihoods by diversifying to fruit farming on their marginal sloping farmlands. Himachal Pradesh is a small mountain State in the Indian Himalayas with altitudes ranging from 350 m to 6,975 m. Its five million population is largely spread on the marginal sloping uplands, hills, and mountains. The subsistent farming communities living on the small parcels of land cultivated mountain crops and reared livestock to sustain their livelihoods. However, the past two and a half decades have seen a rapid economic transformation here. Improvements occurred in the farm economy and ecology through fruit crops farming, particularly apples and other temperate fruits. The majority (75 percent) of the apple farmers of Himachal Pradesh are small and marginal owning up to 0.5-2 ha of sloping farmland and they used their marginal land for apple farming. Consequently, 80 percent of the fruit farming in Himachal, today, is on the marginal lands.

It is now acknowledged as successful example of appropriate land use for the hilly and mountain areas (Verma and Partap, 1992; Partap, 1995; and Partap, 1998). Two and a half decades past, the fruit farming is now giving farmers up to US\$4,500 per ha with net returns up to US\$2,700. Because of adoption of this production system on large scale, the net domestic product of Himachal Pradesh increased 200 times and net per capita income 26 times. The concerns of food security, poverty, economic well-being and quality of life have been addressed to a great extent (Sharma, 1996). Evidence shows that fruit farming on the marginal and sloping uplands is definitely a better option, which provided following key benefits to upland people (Sharma, 1996; and Partap, 1995):

- * It promoted productive use and management of marginal land resources: small landholdings were posing a challenge to farmers to make optimum use of their privately owned marginal lands, known as poor crop land/cultural waste/*ghasni*, i.e., fodder land, etc. The salient feature of fruit farming in Himachal is that more than 80 percent of the fruit farming has been promoted on barren, uncultivated marginal agricultural and non-agricultural sloping land. Study by Sharma (1996) concluded that because of good ground cover soil erosion from the sloping fruit orchards was also minimal.
- * It helped convert non-viable subsistent farming into viable farming through harnessing of appropriate niche potentials of marginal mountain lands: in Himachal the percentage of small and marginal farmers became over 80 percent during the past three decades. Food grain-based subsistent farming gave too low incomes to these marginal farmers. Meeting both farm expenditure and consumption expenditure of the household was just not possible and farming became a non-viable and unavoidable option.

However, fruit farming reversed the trends in favor of food security and improved livelihoods of the marginal farmers. These incomes are much higher than the grain crops farming on these land parcels. While this fruit-based production system helped alleviate poverty from these mountain households, it also helped promote no tillage farming on the sloping farmlands. Unless cropped, most orchards have a good grass cover on the floor, which supports soil conservation and fodder for livestock, taking pressure off from the forests. Fuel wood needs of the families were also met largely from the pruning of the fruit trees, thus saving the forests. Likewise, fruit farming improved the employment opportunities for the landless and women. Those not having their own orchards also benefited, by way of increased employment opportunities. Need for more people for postharvest handling operations created employment opportunities. Labor wages in fruit farming areas increased 10 times and that benefited the poor and landless (Sharma, 1996).

The people of the area now afford better access to healthcare, housing and communication facilities. There is increased consciousness of the need for family planning and better education to children. Most farming families have changed to improved breeds of livestock and lesser numbers for stall feeding because

fodder is now available from orchards. Additionally, orchards have helped reduce pressure on forests for fodder, fuel wood, timber and open grazing in these areas. Thus, fruit farming not only brought economic benefits but also contributed to ecological stability on farm as well as of the surrounding environment.

In fruit farming an organic relationship has been developed between people and environment. What is interesting is that farmers are investing 30-40 percent of their income in technologies and practices concerning soil and water conservation on marginal lands. There are good examples of several villages where the process of improving land husbandry continues with ever more efforts as capacity to invest more is increasing (Sharma, 1996). These efforts over the past few decades have seen increase in the area of economic forests (Chinese term for fruit tree farming) in Himachal Pradesh. Encouraged by the experiences, the people and government agencies of Himachal Pradesh are continuing their efforts to support local people's efforts for afforestation part of their high mountain cold dry zone marginal lands with fruit trees.

Forest Floor Farming with Perennial Plantations

Sikkim is a small mountain State in the Eastern Indian Himalayas, where altitudes range from 300 to 8,500 m. Four different ethnic groups, i.e., Bhutias, Lepchas, Nepalese and Limbus inhabit the State. Here 90 percent of the 400,000 people live in villages. Only 12 percent of the geographical land is under cultivation and density of population on cropland is as high as 470 persons/km². There is however vast area of privately owned non-agricultural marginal land, common property land and good forests. The subsistence dryland farming on sloping croplands should be presenting the poverty-cum-resource degradation scenario for farmers of north Sikkim. However, ethnic mountain farming communities of Sikkim had chosen a wild high value spice – cardamom (*Amomum subulatum*) as cash income source. The farmers started farming it under the forest floor like any perennial crop. For decades, cardamom is now their high-value cash crop grown under the shade of natural forests as well as under alder afforestation.

Cardamom farming underneath nitrogen fixing alder trees and other forests on sloping lands of Sikkim is a unique traditional production system, which has tremendously improved farm economy. Farmers of Sikkim have been able to achieve not only food security but also a reasonable standard of quality of life because of cardamom farming (Sharma and Sharma, 1997). The household income from cardamom ranges from US\$700 to 860 per ha per annum. It requires no external inputs and the dry crop produce – fruits – are marketed in simple gunny bags.

During the past 20 years over 76 percent farmers replaced the food grain production system on the sloping farmlands with cardamom and alder tree plantations (Sharma and Sharma, 1997). The study indicated that in 1996 cardamom-alder forestry plantation provided permanent green cover to about 23,000 ha, i.e., 23 percent of farmland. The contribution of cardamom farming to livelihoods ranges between 40-88 percent, depending upon the number of livelihood options farmers are adopting in different areas (Sharma and Sharma, 1997). However, among the various options for farmers planting cardamom and alder trees is a preferred option (Sharma and Sharma, 1997).

The ecological stability of the cardamom production system has been ensured by the evergreen perennial nature of the plant species and need for forest cover to provide shade to it. On ecological accounting cardamom production system seems to be more suitable for the sloping marginal lands (Sharma and Sharma, 1997). The plantation combination of alder trees and cardamom as well as cardamom plantation in natural forests is helpful in stabilizing sloping croplands. The system adds to SWNM initiating a process of soil fertility improvement. For example, nitrogen additions to soil @84 kg/ha/year are far greater than removal through cardamom fruit harvest @3 kg/ha/year. Similarly, phosphorus is added @4 kg/ha/year and removed @0.5 kg/ha/year (Sharma and Sharma, 1997). Net primary biomass production of cardamom crop is 10,843 kg/ha/year but biomass removal is only 454 kg/ha/year (Sharma and Sharma, 1997). Rest of the biomass is added back into the land. This high degree of nutrient efficiency and soil fertility improvement makes cardamom production system a rare example of a production system, which has inherent quality of automatically enriching the nutrient resource base of the farmland. It indicates the technical feasibility of developing economically productive and ecologically stable production systems on marginal sloping uplands. Four key factors, which make cardamom farming on marginal sloping lands useful, are as follows:

- * It is ecologically adapted to farming on sloping uplands. Plants maintain permanent green cover on forest floor.

- * Cardamom farming ensures ecological stability to fragile mountain slopes by requiring farmers to maintain a good forest cover preferably of nitrogen fixing alder trees.
- * Cardamom is farmer-domesticated, low volume-high value non-perishable cash crop.
- * It generates employment for minimum of 80-100 days per ha.

Globally almost 90 percent of cardamom is produced in Sikkim and its neighboring valleys of Nepal and Bhutan alone. Therefore, the region enjoys comparative advantage in marketing.

Afforestation Combining Forestry System with Benefits of Horticulture

The rehabilitation of degraded lands is generally aimed at providing green cover leading to the ecological stability. Afforestation strategies for non-crop sloping uplands, which satisfy both strategic ecological needs and widen livelihood options for the local farming communities, are not many. While looking for successful experiences, one is reminded of one such initiative made by China. It is about using local nitrogen fixing wild thorny bush – sea buckthorn (*Hyppophae*) for ecological rehabilitation of most degraded lands. The plant survives under extreme climatic conditions of -40°C to +40°C and from minimum moisture conditions to continuous water availability alongside the riverbanks. Because of its ability to fix nitrogen it helps improve nutrient status and initiates a process of ecological succession. Ministry of Water Resources in China used it for controlling soil erosion in the loess plateau planting thousands of ha of sea-buckthorn in the watersheds and riverbanks.

In Western Liaoning province alone, which is located in northeastern China, there is vast degraded area of 33,188 km² where erosion was continuing @2,500-8,000 mt/km²/year. Livelihoods were hampered by acute fuel wood crisis, fodder and grazing land (Lu, 1992). The province launched a major program of afforestation using sea-buckthorn in the mid-1970s. By 1988, lush green sea-buckthorn forests were already covering 113,300 km² area, of which 30 percent were mixed forests rejuvenated by sea-buckthorn. Innovative policy interventions were made, by way of leasing 10 ha of sloping marginal land to each household for planting shelter-belt forests of sea-buckthorn. Today, these plantations seem to have successfully rehabilitated the marginal land by converting it into a healthy forest ecosystem. Farmers interest in sea-buckthorn is not only in the easy availability of fuel wood, fodder/grazing land but more importantly the cash income through collection and sale of abundantly available tiny sour fruit berries to the flourishing agro-industries. They produce all kinds of products – from beverages, medicines to cosmetics. The province produces more than 25,000 mt of sour yellow fruit per year for sea-buckthorn fruit-based industry. It is a unique example of improving economic productivity of marginal mountain landscapes to alleviate poverty of local farming communities with excellent ecological impact. Sea-buckthorn has become the backbone of the household economy, providing opportunities to those constrained by limited access to agricultural land and surplus labor. It provided new opportunity to the women, children and the old. The annual gross earnings of Jianping county farmers were over US\$800,000 in 1996 (ICRTS, 1997).

The large-scale plantations of sea-buckthorn in China have become a source of the sour fruit for the agro-industry. It is best example of strategies where people have high stakes in raising and maintaining good forest cover on the otherwise unproductive marginal lands. The evidence documented by Lu (1992) highlights that for fragile and marginal mountain uplands, the environmental gains of sea-buckthorn far exceed the commercial benefits. There are over two hundred industries in China, which use sea-buckthorn fruit to produce a range of products from beverages, cosmetics to medicines.

Investments in sea-buckthorn forest plantations and R&D for the agro-industrial use of fruits have made great impact on improving local ecology, household economy as well as regional economy. By 1997 China had sea-buckthorn forest covering more than two million ha of barren marginal lands prone to severe wind and water erosion. The loess plateau basin and other marginal upland areas are beneficiaries of sea-buckthorn-engineered rehabilitation of natural ecosystem and agro-ecosystem and farm economy. Today, total value of the sea-buckthorn products produced by Chinese agro-industry exceeds US\$25 million a year (ICRTS, 1997).

Lessons from the Success Stories

Fruit farming on marginal farmland in Himachal Pradesh, cardamom plantations in the forests as well as conversion of sloping farmlands into forests for planting cardamom and afforestation of support land with

sea-buckthorn in China, in all the three cases the technological options reflect understanding and incorporation of niche perspective. In these examples, marginal land was adopted as a given condition and agricultural development options were searched accordingly. Several commonalities in the goals and benefits of these three cases are listed in Table 3. These are protection and productive use of marginal farmlands and support land, soil and water management and harnessing of specific niches.

The three examples convey a message that marginal lands are not constraints to productivity if appropriate technological choices are made. Marginal lands have specific niches (comparative advantages). A proper understanding of the niches can provide clue to the potentials of marginal lands under given agro-ecological environment. The three production systems use perennial plantations of different types with equal advantage – be it modern varieties of apples or a farmer domesticated perennial spice cardamom or a wild thorny shrub – sea-buckthorn. All the three production systems were aimed at combining economic sustainability with ecological stability of the landscape and local environment.

These approaches indicate promising scopes for diversification of sloping upland agriculture to perennial plants-based production systems. While making use of marginal sloping lands fruit farming enhances farmers' access to more farmland. Cardamom farming highlights two points; one is that local biodiversity can be a good source of niche-based crops for marginal lands. The perspective behind the marginal land crops is that these are the plant resources adapted to edaphic and climatic conditions of marginal lands. These may not be the crops coming from experimental stations of research institutions but local plants whose economic potentials have been determined by the market or industry. Sea-buckthorn story provides insights to technological scopes for combining soil and water conservation efforts on marginal and fragile land with food security and poverty alleviation. Sea-buckthorn case is a unique example, which explains that forestry systems can be designed in such a way that while serving the purpose of good forests they can also provide benefits of horticulture plantation to local people. Sea-buckthorn initiative also explains how forests can be made to serve as fruit trees farming in terms of offering livelihood opportunities.

The experiences described above add a new dimension to the thinking process about linking marginal mountain land management to improving livelihoods. The trends unfolded by these case examples, define a role for the biodiversity/agro-biodiversity in enhancing use value of marginal land for sustainable mountain development strategies. Albeit in other contexts, scholars have indicated the need for adopting this alternative land use perspective (Jodha, 1992, 1995, 1996 and 1997; Critchley and Reij, 1996; and Partap, 1998).

For wider use of the perspective on managing livelihoods sustainably on marginal sloping uplands, it will need a change of mind sets from considering marginal sloping uplands as constraints to livelihood opportunities and poverty alleviation to that of lands of opportunities. In this context, each of the three technological approaches is a witness to new experimentation. Political commitment leading to strong institutional support is a common thread to the success of these initiatives.

SUMMARY OF ISSUES EMERGING FROM SLOPING UPLAND FARMING IN ASIA

The issues in sustainable management of uplands are as diverse as the areas themselves, transcending different physical, topographical characters; racial ethnic and cultural diversity; bio-resources diversity; and administrative systems of different countries. Since sloping lands are the key land resource of uplands/mountains, a number of common issues and recommendations identified by Banskota, *et al.* (2000). The preceding discussion on sloping lands of Asia and the good and bad experiences of resource management, and the neglect and poor understanding of appropriate approaches raised several issues, which are summed up in this concluding section of the paper.

- * Consideration of an upland perspective that is essential for formulating slopeland-sensitive development strategies, with respect to marginality, fragility, diversity and niches. This will help not only to ameliorate the impact of marginalization of affected communities but also to achieve social equity by building on the comparative advantages of sloping uplands.
- * It is important to recognize that development issues in the sloping uplands, such as sustainable livelihoods, upland agriculture, poverty, marginal and fragile environments, gender and inaccessibility are intertwined and call for an integrated development approach.

Table 3. A Comparative View of Sustainability Factors of Success Stories of Upland Farming

S.No.	Marginal Land Use Experiences, Goals and Impacts	Fruit Farming, Himachal	Cardamom Farming, Sikkim	Sea-buckthorn Forests, China
1.	Protecting and improving marginal farmlands for productive use	*	*	-
2.	Improving support lands for productive use	*	*	*
3.	Better soil water and nutrient management	*	*	*
4.	Economically productive farming system as primary goal and ecological benefits are by product	*	*	-
5.	Ecological restoration/rehabilitation as primary goal and economic benefits are by product	-	-	*
6.	Emphasis on biomass production	-	-	*
7.	Stability-oriented location-specific choice	*	*	*
8.	Harnessing niche for tradable item	*	*	*
9.	Use of indigenous knowledge practices systems	-	*	-
10.	External R&D inputs public interventions triggered successes	*	-	*
11.	Sole dependence on local resources	-	*	*
12.	Replicated successful experience from similar environment	*	-	-
13.	New generation crops from local wild biodiversity and adapted to marginal lands	-	*	*
14.	Larger-scale community-level participation – a prerequisite to upgrade scale of niche product	*	*	*
15.	Land ownership necessary prerequisite for success	*	*	*

Source: Partap, 1999.

- * Synergy between national interest and local needs with hierarchies of interventions to achieve consistency in implementation of NRM and development programs needs to be created. It calls for recognizing roles of different stakeholders.
- * An enabling policy environment is essential in order to recognize and strengthen potentials developed at the grassroots level and to encourage people-based initiatives in different areas.
- * Policy support is also needed in order to promote R&D into niche-based products, market opportunities, harnessing indigenous knowledge systems, and ensuring intellectual property rights to tribal and ethnic communities.
- * Farming alone is unable to meet the food and livelihood needs of the families inhabiting sloping uplands; therefore they employ multiple livelihood strategies through diversification of household activities. However, these options are also giving diminishing returns and farmers are looking for new alternatives.
- * It has been increasingly recognized that marginal lands will have to play an important role in ensuring food security in the upland areas. This will require decentralized and innovative approaches for diversifying crop production.
- * It is evident that subsistence agriculture is undergoing transformation in several areas in the uplands, more and more people are benefiting from crop diversification, horticulture farming and other high-value cash crop. However, diversification is not feasible without addressing the issues of food security in terms of availability of food, purchasing power, and efficient distribution system.
- * There is potential for skill-based enterprises. However, these need to have an upland orientation with emphasis on value-addition of niche-based products.
- * The significant trend witnessed by the Asian uplands in recent times is the change in demographic patterns (growing younger population and increased male out-migration in search of cash income opportunities in the cities, both within the countries of the region and beyond. This has led to a shortage of men in the labor force and increasing farming-related work load for women.
- * While intensification of agriculture is continuing with expansion of cropped lands, marginalized farmers have limited access to agricultural technologies and inputs and this in turn is contributing to the decreasing productivity of marginal sloping upland farms.
- * Breakdown of isolation and opening up of uplands to the wider market economy have both positive and negative impacts on the Natural Resource Management (NRM) and livelihoods of small upland farmers. However, because of the strong highland-lowland linkages, uplands cannot be looked at in isolation. Important challenge is to identify the different linkages and develop the comparative advantages that the uplands offer.
- * In the absence of appropriate NRM strategies on the part of the governments, conflicts of interest regarding use of natural resources are growing between the State and ethnic minorities, which are largely dependent on these resources for their survival.
- * Although commercialization of forest products can help upland communities achieve sustainable livelihoods but for maintaining sustainable use of these bio-resources, institutional steps are needed to maintain the balance.
- * Problem is not only of degradation of natural resources but also of continuation of improper management. Equally important is the need for transparent and well-articulated policy framework for the use of upland resources so as to ensure increased investment with proven strategies for regeneration of resources.
- * Undesirable land use changes and natural resource degradation in many upland areas are a result of long political turmoil in these areas. Peace and political stability appears a precondition for rational and equitable use of upland resources.
- * Unclear land rights and inappropriate land use policies have often led to land use patterns that have endangered biodiversity and damaged upland environment.
- * There is a growing recognition that development efforts should ensure gender equity through mainstreaming gender needs and concerns.
- * It is being recognized that diversification of upland agriculture can provide better choices and quality options for sustaining livelihoods of upland farmers dependent on sloping lands. But what is necessary in this process is to develop a clear understanding of the ecologically and economically sustainable

farming options. There have been instances of successful infusion of environmental and development goals, as shown by the success stories and similar approaches need to be promoted.

- * Even though upland production systems are becoming increasingly unsustainable both economically and ecologically, yet the national policymakers have not been sufficiently sensitive to the specific upland conditions and constraints faced by uplanders in coming out of the poverty trap.
- * At national level there has been a general lack of recognition of the niches that uplands offer to increase income generation opportunities without any serious damage to environment. Therefore, there has been lack of appropriate policies to promote such activities.
- * National, provincial and local governments should evolve specific strategies, policies and programs to foster faster growth by facilitating diversification of sloping upland farming from subsistence food crop centered production patterns to production for the market based on comparative advantages.
- * Changes are needed in law where it denies access to and use of sloping upland resources that are basic to the livelihoods of local people. Shifting cultivators and agro-pastoral communities of Asian uplands need that attention more than any one else.
- * SWNM strategies largely focusing on soil aspect need to reorient focus to give more attention to managing access and scarcity of water for sloping land farming. Investments in low-cost farmer-friendly technologies for rainwater harvesting will be most welcome step.
- * R&D support is required for identifying the existing and potential niches of sloping lands under different agro-ecological zones and microclimates.
- * Initiatives focusing on inter-country transfer of knowledge and information about successful technological and institutional innovations is needed.
- * R&D efforts are required to develop products and technologies in which uplands have comparative advantage.
- * In the uplands it is necessary that appropriate combination of use and regeneration of natural resources is permitted rather than imposing a ban on use of natural resources.
- * High priority needs to be given to efforts to develop human resources appropriate to use of opportunities offered by improvement in access and greater penetration of markets in upland areas in the process of globalization.

RECOMMENDATIONS FOR SUSTAINABLE FARMING ON SLOPING UPLANDS

Global initiatives in upland areas, like past efforts of APO (1998) and this meeting, are driven by the objectives of reducing poverty among the inhabitants, enhancing their food security, and promoting sustainability in the management of natural resources. Instruments used to achieve these goals include technological and institutional innovations to enhance productivity and the sustainability of use of land and other natural resources. The technological innovations generated by CGIAR centers and NARS are largely specific to particular biophysical contexts, and so far the context has been largely the favored agricultural landscapes. For upland poverty reduction, contextual specificity in technology generation is actually the key to targeting agricultural technology research. Focusing the research on technological innovations for marginal sloping uplands would be an effective way of achieving the goal of upland poverty reduction. If, in addition, marginal sloping uplands were more susceptible to resource degradation, then the objective of sustainable NRM would also be well-served by focusing research on these areas. Also, if the upland poor themselves are a source of environmental degradation, and as poverty shortens time horizons and constrains the adoption of instruments that would enhance conservation, then appropriate technological innovations generated specifically for marginal sloping uplands can help achieve win-win outcomes, with synergy between the goals of poverty reduction and sustainable NRM. Finally, if we believe that there has been an initial under-investment in technological research for improving agriculture on marginal sloping upland areas, as compared to Green Revolution technologies for flatland, then a high un-captured potential return to research on marginal upland agriculture may exist.

Four recommendations have been made for reshaping international agricultural research efforts to meet the needs of marginal upland/slopedland areas (CGIAR, 1999). First, recommendation calls for emphasis on sharpening strategic focus on poverty alleviation, particularly in setting priorities for research related to marginal sloping uplands. Second, it stressed the need for establishing new forms of partnership in order to

effectively address their role in a broader poverty alleviation strategy related to those who live in uplands. One would concur with the findings of the study that determinants of poverty in marginal areas poverty are multiple. That poverty reduction consequently requires focusing on an array of sources of income that goes beyond agriculture. It is also true that this can be achieved via partnership with organizations engaged in combating poverty with other instruments. APO and its partner national agencies may be partially addressing this recommendation using different means. But for achieving the goal, greater efforts may be needed by including participatory research, gender analysis for technology development and institutional innovations for on- and off-farm employment of upland poor.

We seem to be not well-equipped about right information about: (1) the extent and magnitude of the impacts of marginal land agriculture on the degradation of natural resources, production, and food security; and (2) the linkages between poverty and resource degradation. CGIAR commissioned study (Malik, 1999) confirmed the fact that our understanding of the intricate process of poverty and marginal lands degradation is extremely limited. Our knowledge is largely driven by the perceptions of those analysing the phenomena. The lack of clear conceptualization, the observed heterogeneity in potentials of marginal uplands and the diverse perceptions of those attempting the exercise are the factors responsible for it. The implications of above findings to international and national agricultural research systems are as follows:

- * Need for targeted research on marginal uplands at the eco-regional level.
- * Given the lack of proof of causal effects between poverty and upland degradation, it can be assumed that threatening upland use practices and technologies cause resource degradation irrespective of who uses them. The targeting of degraded land does not selectively target poverty in most instances.
- * The evidence indicates (Partap, 1998 and 1999) that there are sloping upland areas that may in fact have a significant potential for research-driven productivity increases, and that the returns on investment in these areas may even surpass favored areas. Targeting of resources on these uplands should consequently help the allocation of resources in terms of productivity gains (Tibet highland plateau is one such example).
- * Lessons should be drawn from the success stories, specifically, in identifying those factors which complement R&D efforts to enable poor farmers to adopt technological innovations in upland marginal areas.
- * In this respect, innovations with a perspective on the poor and marginal lands, may promise higher rates of return if Green Revolution technologies are applied here. For example, biotechnological innovations that complement pesticide use (genetic resistance), fertilizer (nitrogen fixation), tillage practices and water (drought resistance) and possibly Genetically Modified Organisms (GMOs) raise new hopes for evolving productive and sustainable agriculture in upland.
- * While deciding research investments for marginal sloping uplands, the comparative advantage of the sub-regions and landscapes need to be carefully established. Evidence gathered from Asian uplands (Partap, 1998 and 1999; Gim, 1998; Chang, 1998; Kim, 1998; and Takatsuji, 1998) points at the potential of agroforestry, and of the production of cash crops. These options help harness the niche of sloping uplands with comparative advantage. In their efforts to reduce poverty in uplands/hills/mountains/highlands, the international R&D agencies need to consider extending their current programs to include activities with high potential for poverty reduction using sloping uplands.
- * Because of conventional focus on soil related aspects, inadequate attention has been given to research issues related to sloping uplands potentials in relation to water, infrastructure development and markets. So, it is important to address water/sloping land/poverty linkages beyond soil conservation programs. Water insecurity appears to be a main poverty feature in uplands where sloping lands dominate. Improvement efforts for sloping lands should continue explicitly the scope for supply and demand of water, tide over water scarcity through managing excess availability, for the excess is cause factor of degradation, the management of its use, and access to water especially to the poor upland farmers.

The limited cropland in the uplands and increasing demands of growing population are becoming one of the bases of unsustainability of agriculture. Relatively underutilized abundant marginal support lands offer hope for more space for upland agriculture. Today, the issue may be less of whether or not to use the

marginal uplands for farming, but of how to use these land resources in better and sustainable ways. New knowledge about technological possibilities for evolving sustainable production systems for marginal uplands is emerging. The production niches and biodiversity have potentials to convert marginal uplands into productive production systems. Examples of cardamom and sea-buckthorn are only indications of the vast scopes marginal mountain lands offer. Practical needs of the upland farmers for survival and strategic national interests in environmental conservation should ultimately attract institutional initiatives, local political commitment and international support for wider implementation of the above discussed approaches on ecologically sound and economically desirable upland agriculture on marginal lands.

However, countries of the Asian region have so far done little to develop dynamic comparative advantages that agriculture in uplands offer. New roles are envisaged for governments and NGOs for designing and implementing strategies. Governments may need to formulate policies favoring use of marginal uplands for certain types of agricultural production systems that can support livelihoods of local people. More secure land rights may be one of the necessary preconditions to stimulate investments among farmers. Investments will also be required in research technology and development to create a basket of choices of suitable production systems capturing every niche of diverse agricultural systems of upland societies.

Benefits of the new perspective to upland agriculture and farmers are many. The solution to the cropland crisis in the uplands appears technically possible. Given the political commitment, cropland scarcity-based food insecurity and poverty of the small and marginal farmers can have a solution. Farming can be made a very profitable and sustainable enterprise on marginal uplands. There are a variety of potential niches and production systems that can flourish on marginal uplands and developing these can also help conserve biodiversity. The technical perspective avoids promoting ways of farming where marginal productivity of mountain lands is projected as a constraint. It is so with farming practices promoting intensive land use and modern crop varieties. There are examples to indicate that investing adequately in local bio-resources-based enterprises and agro-industrial technologies have potentials to transform local and regional economies with an ecologically stable environment.

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3. TECHNOLOGIES FOR SUSTAINABLE MANAGEMENT OF STEEP LANDS IN ASIA: HARMONIZING ECONOMIC AND ECOLOGICAL SUSTAINABILITY

Dr. Anthony S. R. Juo

Professor of Agronomy

Department of Soil and Crop Sciences

Texas A&M University

Texas

U.S.A.

INTRODUCTION

At the Opening Session of the APO Study Meeting on Sustainable Farming Systems in Upland Areas held in New Delhi, I suddenly remembered my first visit to India 20 years ago attending the International Soil Science Congress. At the Congress Banquet, the President of India in his opening address cautioned the problems of deforestation and watershed deterioration in India, and called for a nation-wide movement of tree planting. The head of the Russian (then U.S.S.R.) delegation was the second to speak and he began with: “*Mr. President, Russia and India have a common friend: science and technology*”. Then, the head of the Chinese delegation was the next on the program and he started by saying: “*Mr. President, China and India have a common enemy: the problem of overpopulation*”. These three distinguished men touched upon three issues that are still critical to Asia’s sustainable development today. Now, 20 years later, we have witnessed the remarkable economic growth throughout Asia resulting from the success in science and technology education and its subsequent applications to agriculture and industry. But in terms of managing the region’s natural resources and stabilizing population growth, Asia, as a whole, has been less successful.

Continuing deforestation of upland areas in Asia and elsewhere has become a worldwide concern about erosion, flooding, siltation of rivers and reservoirs, and disruptions of coastal aquatic ecosystems. Two main forces have contributed to the degradation of uplands; namely, high demand for timber from the urban economies downstream, and increasing land pressure of the rural communities upstream. Worldwide, there are many densely-populated mountainous regions in Asia, Africa and Latin America where human and livestock populations have long exceeded the ecological carrying capacity of the land. Agricultural development in densely-populated steep lands has been caught between two seemingly contradicting interests – the economic development of the downstream communities and the ecological integrity of the entire watershed. This paper discusses prospects of technology adoption to increase agricultural productivity in upland areas with special emphasis on harmonizing economic and ecological sustainability.

TECHNOLOGICAL ISSUES

The most important step of converting sloping land for agricultural use is the reduction of slope length. While terracing and vegetative barriers help shorten slope length and retain runoff, the construction of drainage systems to divert surplus runoff during heavy storms is equally important. Livestock grazing can cause serious damage to improved slopes and even more seriously on unimproved slopes and therefore, should be either excluded or carefully controlled. Grazing on steep slopes can cause soil slumping and landslide. Hence, fodder produced on the improved slopes should be cut and transported to the feeding area near the farm compound.

Modern and ancient technologies for sloping land management have been reviewed by several authors (Sheng, 1977; Das, 1977; Morgan and Richson, 1995; Juo and Thurow, 1998; and Tonnes, *et al.*, 1998). Widely promoted biological and physical measures are:

- * maintaining natural vegetation or forestry on the summit and upper slopes for watershed protection.
- * inter-planting trees (fruit or leguminous trees) or grass strips with annual crops along contours to retain runoff, control soil erosion, produce fodder and increase farm income.
- * construction of bench terraces on gentle slopes usually with deeper soils.
- * construction of stone retention walls on rocky, steeper slopes usually with shallow soils.

Ideally, land with slopes greater 15 percent in the humid and sub-humid regions should be kept under forest cover for watershed protection. However, in densely-populated regions, cultivation has expanded to slope above 30 percent. To prevent soil erosion and watershed degradation on sloping lands, the choice of appropriate land modification technologies is determined by soil and climate conditions as well as socioeconomic constraints of the site in question. At any rate, maintaining an effective surface cover (live or dead) during the onset of rainy season is of paramount importance for controlling runoff and erosion.

Tonnes, *et al.* (1998) illustrated six types of terraces and their recommended use: (1) the level bench terraces are mainly used for rice and other irrigated crops; (2) the reversed-sloped bench terraces are used for rainfed crops; (3) natural terraces (stone retention walls, grass barriers, contour bunds) are used for upland crops on slopes >12 percent; (4) inter-mittent terraces are used for upland crops on slopes <36 percent; (5) convertible terraces are used for mixed farming on slopes <36 percent; and (6) orchard terraces are designed with benches 1.75 m wide and individual basins (Figure 1).

In order to design and construct physical and biological soil conservation measures on sloping land, many empirical mathematical formulae for establishing terrace or vegetative barrier spacing have been used. The formulae developed by United States Soil Conservation Services for calculating vertical and horizontal spacings are (Elswaify, *et al.*, 1982):

$$\begin{aligned} VI &= XS + Y \text{ and} \\ HI &= (XS + Y) (100/S) \end{aligned}$$

where

- VI: vertical interval in ft.
- HI: horizontal spacing.
- X: a variable from 0.4 to 0.8 depending upon rainfall intensity. Soils in the wetter regions are assigned a value of 0.4 and soils in the dry regions have a value of 0.8.
- S: land slope, ft/100 ft.
- Y: a variable from 1.0 to 4.0 depending upon soil erodibility and soil water intake rate and ground cover provided by the crop (soils with low water intake rates and little ground cover have value of 1.0. Soil with high water intake rate and adequate ground cover are assigned a value of 4.0).

In Taiwan, as quoted by Morgan (1986), an empirical formula used for determining vertical interval of inward sloping bench terrace is:

$$VI = \{(Wb \times S) + (0.1S - U)/(100 - [S \times U])\}$$

where

- VI: vertical interval in meter.
- Wb: width of bench in meter.
- U: slope of the riser expressed as a ratio of horizontal distance to vertical rise usually 1.0-0.75.

It should be pointed out that development of such empirical equations require site-specific data on rainfall erosivity and soil erodibility and must be verified. Without verification, it may lead to either under- or over-designing of terrace or barrier spacing.

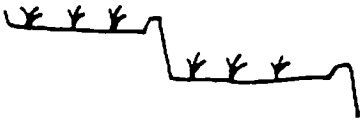
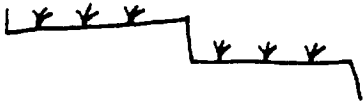


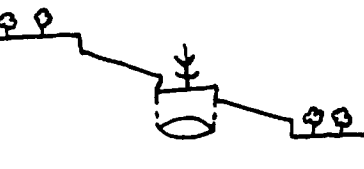
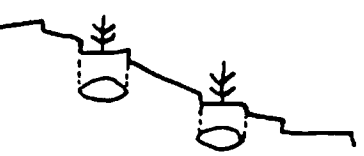
Type	Cross-sectional View	Use
Conventional Systems		
1. Level bench terraces (irrigation terraces or rice paddies)		Mainly for rice or irrigated crops
2. Reverse-sloped bench terraces		Rainfed crops and/or irrigated crops in dry season
Simpler and Less Expensive Systems		
1. Natural terraces (stone retention walls, grass barriers, contour bunds, <i>fanya juu</i>)		Upland crops on slopes <12 percent. Terraces form naturally after several years.
2. Intermittent terraces		Upland or irrigated crops on slopes <36 percent; inter-spaces can be terraced over several years.
3. Convertible terraces		Mixed farming uses or for flexibility in future land use; slopes <36 percent, trees planted in individual basins.
4. Orchard terraces with benches 1.75 m wide and individual basins		Tree crops or fruit trees on steep slopes >46 percent.

Figure 1. Cross-section Views of Six Types of Terracing Designs

Source: Tonnes, *et al.*, 1998.

Historically, bench terraces, manually constructed over an extended period of time were common practices of converting sloping lands for crop production. Famous ancient sites are the 2,000-year old rice terraces of Batad and Banaue in the Philippines, the rock terraces of Machu Picchu, Peru, and the Cinque Terre in Italy. These extensive terrace sites were either owned by a powerful ruler or collectively owned by a tribal community. In modern times, because of changes in land tenure system and high labor inputs for manually constructed terraces as well as the high risk of soil erosion when using heavy machinery, sloping

land conversion increasingly favors biological measures. These include contour grass strips, alley cropping or hedgerow farming, and other agroforestry systems such as inter-planting fruit or spice-producing trees with annual crops. Notable international and national efforts to promote technology development and transfer in sloping land areas are:

- * the Alley Cropping Network of the International Institute of Tropical Agriculture (IITA) (Kang, *et al.*, 1999).
- * the Vetiver Grass Network of the World Bank (National Research Council [NRC], 1993).
- * the Asian Sloping Lands Network coordinated by the International Board for Soil Research and Management (IBSRAM, 1995 and 1999).
- * the Sloping Agricultural Land Technology (SALT) Initiative of the International Centre for Integrated Mountain Development (ICIMOD) (Partap, 1998).
- * various national sloping land forestry and agroforestry extension programs, notably India and China.

It should be pointed out that transfer and adoption of soil conservation technologies are site-specific. The choice of technology is determined not only by soil and climate conditions, but by socioeconomic constraints as well. Economic incentives often play an important role in new technology adoption. In the case of adopting agroforestry for soil conservation, Scherr and Current (1999) reviewed lessons learned from various agroforestry extension projects and concluded that many agroforestry practices can be profitable, depending upon conditions of input, market, and quality of management. For small farmers, subsidies for planting materials are instrumental in the initial stage of promoting new species and practices.

Moreover, successful transfer of soil conservation technologies must involve farmers and local communities in the planning process. Hurni (1986) developed a stepwise approach and guidelines for extension agents to arrive at recommended options on soil conservation measures. Information required for developing a locally useful guideline for soil conservation include: (a) individual soil conservation measures either recommended or of proven applicability; and (b) agro-climatic and ecological parameters influencing the applicability (crops, traditional soil conservation practices, soil quality with reference to erosion hazard, and natural vegetation). The stepwise approach demonstrates how the design process is implemented in the field:

- * **Step one** involves site identification and description (agro-climatic zone, rainfall regime).
- * **Step two** involves determining slope gradient, soil texture and soil depth; and selecting level structures and cut-off drains suitable for the site. Then, with farmer or local community participation, select a package from several technically suitable options on the basis of local socioeconomic constraints. For example, Option 1: level bunds at 2 m vertical intervals with a cut-off drain in between; Option 2: alley cropping; and Option 3: micro-basins or micro-catchments.
- * **Step three** develops detailed descriptions of implementation and provides technical assistance to the farmer or the local community.

During recent decades, there have been increasing numbers of research and extension activities in densely-populated steep land regions. The following examples demonstrated that adoption of ecologically suitable conservation technologies has helped reducing soil erosion and sustain crop production in some densely-populated upland areas in Asia:

Mountainous Area of Northern Thailand

The area has 500-2,500 m in elevation, converted from tropical rainforest for slash-and-burn agriculture. Rainfall (1,000-2,500 mm per annum) is concentrated between July and September. Slash-and-burn agriculture primarily is practiced on top and mid-slope and irrigated rice terraces are constructed on foot slope. Man-made soil erosion is high in slash-and-burn fields. Major upland crops are maize and opium poppies and land is cultivated for 3-6 years before returning to bush fallow for 5-20 years. Soil degradation due to intensive cultivation and fuel wood gathering in slash-and-burn fields have prevented secondary forest from recovering even after 20 years of fallow (Hurni, 1985).

Agroforestry trials on farmers fields conducted by United Nations University and Chiang Mai University reduced soil erosion in upland area by one-fifth as compared to the slash-and-burn field, thus helped improved productivity of the upland fields. Further nationally and internationally assisted soil conservation and agroforestry extension programs have been implemented in these remote areas. Large numbers of tree crop propagation centers have been established to distribute planting materials and to transfer appropriate soil conservation technologies to target farmers (Thailand Department of Agricultural Extension, 1999; and IBSRAM, 1995 and 1999).

Kakani Area in Nepalese Middle Mountains

The study area reported is 10 km northwest of Kathmandu with elevation between 1,000-2,000 m. Rainfall is concentrated in the monsoon months from June to August. Relief is extremely steep with average gradient of 50 percent. Soils on slopes are deep, fertile and well-drained. Erosion under natural vegetation is low except for a few landslides. Local inhabitants have developed a refined system of terraces themselves many years ago that have transformed the entire landscape except areas under government forest reserve.

In general, controls of soil erosion have been excellent because of the traditional terracing systems on suitable soils (deep fertile soils, high infiltration rate, etc.) Only one percent of the total area has catastrophic level of erosion (landslide). Evidences of soil erosion also occur on common grazing land and settlement areas. However, the Kakani geo-ecosystem is an open system, where highland-lowland interactions through runoff are predominant because most of the sediment yield leaves the watershed and causes serious damage to the Indian floodplains downstream. From this viewpoint, even one percent landslide could become significant in the long run. Hence, technical and financial assistance from government and downstream beneficiaries may be needed to prevent further erosion (Hurni, 1985).

Land Use in Small Watersheds in Sri Lanka

Perhaps a typical upland-lowland integrated land use system can be found in some small watersheds in the mid-country of Sri Lanka where deep and highly permeable soils are better suited for such intensive system of land use. In this region, a single catchment of only 5,000 ha can include tea plantations on highland at 2,500 m with 2,500 mm rainfall, then mixed farming in the middle altitudes with lower rainfall, then rubber plantations down to about 500 m and finally rice paddies in the valley bottom. However, in other watersheds where soil conditions are less favorable, severe water erosion in the upper catchment and watershed deterioration have been reported when forests were cleared for tea and rubber plantations during the last century (Hudson, 1981; and Burns, 1947 as cited by Elswaify, *et al.*, 1982).

Farming on Sloping Lands in the Philippines

Large amounts of soils are eroded annually from the hilly uplands under slash-and-burn agriculture in the Philippines. Since 1980, hedgerow or alley cropping has been promoted by the Ministry of Agriculture as a soil conservation technique on sloping land for permanent upland rice production under the SALT Initiative. On high base-status soils, upland rice yield increase under *Leucaena leucocephala* alley cropping ranged from 23 to 100 percent compared to tilled field after slash-and-burn. The yield increases were attributed to both control of soil erosion and nitrogen input from the *Leucaena* leaves applied as a green manure. On strongly acidic soils, acid tolerant tree species, such as *Alnus japonica*, were recommended in northern Luzon (Garrity, *et al.*, 1993). On highly permeable oxisols (bulk density less than 1.0 kg m⁻³ throughout the soil profile) in Claveria and Mindanao, both grass barriers and hedgerow cropping were shown to be equally effective in controlling soil erosion and building terraces over time on slopes ranging from 25 to 35 percent. Because low soil water retention capacity of oxisols, soil moisture competition between trees and annual crops may be a yield-limiting factor in alley cropping. Even for the highly permeable oxisols, soil loss in the ploughed bare fields without vegetative barriers ranged from 100 to 600 mt/ha/year on slopes ranging from 25 to 35 percent. Thus, rapid downhill topsoil movement due to tillage on hillsides has serious implications on sustainable crop production and environmental quality (Agus, *et al.*, 1997; Thapa, *et al.*, 1999a and 1999b; and Thapa, *et al.*, 2000). It is well known that oxisols have low bulk density and friable structure that provide adequate physical condition for seed emergence. Thus, excess tillage must be avoided on oxisols. Weed control can be achieved by hand hoeing and residue mulch.

Although various physical and biological technologies are developed to improve agricultural productivity of sloping lands with different slope gradient and soil quality, but the ultimate carrying capacity of uplands is determined by the hydrological and biological integrity of the entire watershed. In the case of large watershed, a critical question would be: what proportion of the upland area should be converted for cultivation? During a recent visit to a densely-populated hillside farming community in Central America, an old farmer told me that a nearby seasonal stream was once perennial 20 years ago, and a spring that once supplied drinking water year round at the edge of his farm also ceased to flow during the dry season. Such changes in watershed hydrology due to increased deforestation and farming activities in many upland regions worldwide clearly indicated the need for technological and policy interventions as well as education to create public awareness.

In Asia, there has been increasing awareness of the needs for land use planning and policy legislation for upland area. Notable long-term efforts supported by national governments include:

- * China's agroforestry and soil and water conservation programs on the Loess Plateau in the northwestern region where soil erosion has been the cause of flooding and siltation of the Yellow River for over two thousand years (Chu, 1986). This nationally supported effort of reforestation has since produced significant results in controlling wind and water erosion on the Loess Plateau, reducing risks of flooding of the Yellow River downstream, and more importantly, improving farm income and quality of life of the rural population (Chen and Liao, 1992).
- * India's nation-wide integrated watershed management program that includes watershed development for rainfed areas, soil conservation in catchments of flood-prone rivers, and watershed development in shifting cultivation areas. Major activities in steep land areas include planting economic trees on ecologically fragile and degraded slopes, public education of soil and water conservation and women participation in decision-making process.

ENVIRONMENTAL AND ECONOMIC ISSUES

Soil erosion in upland areas not only degrades productivity of farmland, but also causes flood and siltation of rivers and reservoirs downstream. This has been a major form of man-made water pollution in the world for many centuries. In the United States, a survey of 95 reservoirs conducted during the early 1950s indicated that 40 percent of them would be filled with silt in 50 years (Elswaify, *et al.*, 1982). In spite of governmental and public efforts to combat soil erosion from farmland, rangelands and commercial forestry during 1970s, about 750 million yd³ of sediments were dredged from waterways and reservoirs annually (Elswaify, *et al.*, 1982). Since 1980s, there has been increased public support on environmental protection and natural resources conservation in the country. Subsequent legislation and implementation of Federal- and State-funded soil and water conservation programs on farm and range lands and forest protection on sloping lands have since effectively reduced the rate of erosion (United States Department of Agriculture [USDA]/Natural Resources Conservation Services [NRCS], 1996). According to the USDA, the amount of cropland still requiring conservation treatment to maintain productivity and prevent erosion declined by 25 percent between 1982 and 1992 (Table 1). This was attributed to the producer's adoption of soil-conserving crop management practices, such as conservation tillage as well as the land retirement – a Federal Government-sponsored Conservation Reserve Program that allows unproductive land under fallow for a number of years to rejuvenate soil fertility and the loss of income is compensated by the Federal Government.

Table 1. Land Area Needing Conservation Treatment by Land Use between 1982 and 1992
(Unit: Million acre)

Land Use	Cropland	Pasture Land	Forestland
1982	270	69	212
1992	204	58	157

Similarly, the relatively high siltation rate of reservoirs in India (Patnaik, 1975) was also attributed to soil erosion from farmlands upstream (Table 2).

Table 2. Siltation in Selected Reservoirs in India

Reservoir	(Unit: Million m ³)				
	Bhakra, Punjab	Panchet, Bihar	Tungabhadra, Karnataka	Niza Sugar, Andhra Pradesh	Ukai, Gujarat
Annual rate of siltation	41.6	11.8	50.8	10.8	26.8

Source: Patnaik, 1975.

Numerous published reports have shown that siltation of rivers not only affects quality of drinking and irrigation water of the downstream communities, it also disrupts the ecology and productivity of coastal aquatic ecosystems. As shown in Table 3, annual sediment load and estimated soil erosion in five large river basins could be related to human activities in upland areas of the watershed and sub-watersheds.

Table 3. Estimated Annual Soil Erosion of Large River Basins

River	Country	Upstream Human Activity	Annual Suspended Land (mt/km ²)	Annual Soil Loss (mt/ha)
Kosi	India	High	55,480	2,774
Ganges	India, Nepal, Bangladesh	High	27,040	1,352
Mekong	China, Lao PDR, Thailand, Vietnam	Moderate	4,280	795
Nile	Uganda, Kenya, Ethiopia, Sudan, Egypt	Low	740	214
Amazon	Bolivia, Ecuador, Colombia, Peru, Venezuela, Brazil	Low	1,260	63

Source: Holeman, 1968 as cited by Elswaify, *et al.*, 1983.

Impacts associated with sediments deposited in bays, estuaries, lakes could be economically and environmentally damaging. A major environmental effect is the disruption of aquatic ecosystems due to high level of nutrients (nitrate and phosphate), pesticides and other industrial wastes. Flooding and siltation could cost infrastructure damages to urban areas downstream, hydroelectric power generating facilities and coastal commercial shrimp and fish production. For example, in southern Honduras, sedimentation is increasing in the rivers that feed into the coastal plain and estuaries where large commercial shrimp farms are located. A major source of this sediment is soil erosion caused by the slash-and-burn farmers on the steep lands upstream. The high sediment load in the water compels shrimp producers to make expensive investment of pumping and dredging equipment and costs of energy and labor. In order to maintain their water supply channels at acceptable depth, a large shrimp farm (approximately 2,000 ha size) dredges approximately 1,000 m³/day of suspended silt from its settling reservoir, by pumping 1.6 million m³ of water per day. The sludge is then pumped into a holding pond and evaporated before more sludge is added. The total annual cost for sediment disposal is US\$229,183. Moreover, the opportunity costs associated with occupying potential shrimp production sites with this method of waste disposal is a significant threat to the long-term sustainability of the industry (Samayoa, *et al.*, 2000).

Thus, soil and water conservation in upland areas affects the economic welfare and environmental quality of the human communities downstream. People living in the upland areas generally have fewer economic opportunities than those in the valleys and coastal lowlands. Rapid industrialization and urbanization in lowland areas during recent decades have further widened the economic gap between upstream and downstream communities. There is an urgent need for increased investment in soil and water conservation in uplands assisted by both national government and the private sectors downstream. If the poor communities in the densely-populated uplands were left helpless, erosion in the hills would further undermine the quality of life of both urban and rural inhabitants downstream.

To protect watershed integrity, a holistic approach linking upland agricultural and conservation activities with downstream agricultural and industrial development must be established. In other words, upland soil conservation activities generate a variety of costs that must be shared by both upland and lowland interests. In many developing nations, government resources to support upland soil and water conservation are usually scarce. Thus, national governments are often forced to invest soil conservation primarily for increase and sustain crop yields while little resource is allocated for maintaining hydrological and ecological integrity of the entire watershed (Thurow and Juo, 1995). For example, the loss of human lives and infrastructure caused by the catastrophic floods and landslides during the recent Hurricane Mitch in Central America could have been significantly reduced if land use in the upland areas were better planned and jointly implemented by the upland and downstream communities.

The advancement of computing technology enables both planners and practitioners using Geographical Information System (GIS) and remote sensing techniques to determine site-specific ecological and economic feasibilities for steep land use and conservation. Various watershed management models, land use guidelines, and decision support systems for erosion prediction are being developed which integrate downstream agricultural and economic development with upstream land use, restoration and conservation. However, use of these technologies for planning and policy formulations presently are limited to technologically advanced nations (Fedra, 1993). Regional and worldwide applications depend upon continued national and international efforts in collection and analysis of relevant soil, climate, socioeconomic and remote sensing database.

A decision-making model for steep land use and management has been developed by International Centre for Tropical Agriculture (CIAT, 1999) for planners and inhabitants of watersheds and micro-watersheds. The model consists of nine decision support tools:

- 1) Participatory method for identifying and classifying local soil quality indicators at micro-watershed level
- 2) Photographic analysis of land use tendencies in hillsides
- 3) Participative analysis and monitoring of natural resources in a watershed
- 4) Methodologies for analyzing groups of interest for collective management of natural resources in micro-watersheds
- 5) Identifying levels of well-being to construct local profiles of rural poverty
- 6) Atlas of the watersheds of interest
- 7) Identifying and evaluating market opportunities for small-scale producers
- 8) Use of simulation models for ex-ante evaluation
- 9) Developing organizing processes at local level for collective management of natural resources.

These GIS-based tools integrate biophysical and socioeconomic information in decision-making process and are designed to accomplish the following tasks: catalyzing partnership; building common knowledge base; create common vision; commitment to action; monitoring progress; and measuring impact. Evidently, use of these tools requires some level of computing expertise.

More recently, researchers at Texas A&M University are developing GIS models to predict landslide hazard in the event of catastrophic rainstorms using soil and land use information and remote sensing aerial photography taken before and immediately after Hurricane Mitch in southern Honduras (H. Perotto and B. Wu, personal communications). Soils on sloping lands in southern Honduras are prone to slumping and landslide. Results of GIS analyses showed that percentage of areas affected by landslides was significantly influenced by slope and type of groundcover or land use. Incidences of landslides occurred frequently on bare soil and cropped fields. Land under forest cover even on steep slope (greater than 30 percent) had little or no incidence of landslide. Such predictive models are valuable tool for planning soil conservation measures in steep land areas and to prevent flood and siltation downstream.

SUMMARY AND CONCLUSIONS

Degradation of steep lands has become a worldwide concern about erosion, flooding, siltation of reservoirs and rivers, and disruption of coastal ecosystems. There are many densely-populated steep land

regions in Asian countries, where human and livestock populations have long exceeded the ecological carrying capacity of the land.

Technologies for increasing agricultural productivity and control runoff and erosion of steep lands include biological and physical or mechanical measures. Widely promoted biological measures are forestry, agroforestry (e.g., alley cropping), and contour grass strips (e.g., vetiver strips). Common physical measures include stone retention walls and various types manually and mechanically constructed terraces. The choice of appropriate land modification technologies must be determined by soil and climate conditions and socioeconomic constraints of the site in question. At any rate, maintaining an effective surface cover (live or dead) during the onset of the rainy season is of paramount importance for controlling runoff and erosion.

Historically, bench terraces, manually constructed over an extended period of time were common practices of converting steep land for agriculture. Modern approach to steep land use increasingly favors biological measures such as alley cropping and contour grass strips. Notable international and national efforts are: (a) the Alley Farming Network of IITA; (b) the Vetiver Grass Network of the World Bank; (c) the Asian Sloping Land Network coordinated by IBSRAM; (d) SALT Initiative of ICIMOD; (e) China's reforestation program on Loess Plateau; and (f) India's national program of integrated watershed management for rainfed agriculture.

Evidently, sustainable management of steep land for agricultural production cannot be achieved by onsite technological improvement alone. It must be supported by government and private institutions that are capable of implementing conservation policies, providing technical and financial assistance to steep land communities, and generating public awareness of the effects of upstream (onsite) land degradation (deforestation, soil erosion) on short-term economic benefits and long-term ecological and environmental consequences downstream (offsite).

The advancement of computing technologies enables both planners and practitioners using GIS and remote sensing techniques to determine site-specific ecological and economic feasibilities for steep land use and conservation. Various models and decision support systems for erosion prediction and watershed management and land use policy guidelines are being developed which integrate downstream agricultural and economic development with upstream land use, restoration and conservation. However, regional and worldwide applications of these models depend on continued efforts in building relevant soil, climate and socioeconomic database.

The widening economic gaps between upstream and downstream communities in many densely-populated regions could be socially and environmentally explosive. If the poor communities in the steep lands were left helpless, excessive deforestation and erosion in the hills would further undermine the economic welfare and environmental quality of the societies in the plains and valleys. This is not merely a technological issue but a political one as well.

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4. AGROFORESTRY-BASED LAND MANAGEMENT SYSTEMS IN INDIAN HIMALAYAS

Dr. A. S. Dogra

*Principal Chief Conservator of Forests and
Director, Kandi Area
Government of Punjab, and*

Jitendra Sharma

*Conservator of Forests and
Subject Matter Specialist
Integrated Watershed Development Project
both Punjab, Chandigarh
India*

INTRODUCTION

The importance of forests in meeting the economic and ecological security needs of the society is now very well recognized. The State of Forest Report, 1999 by Forest Survey of India estimates the forest cover in India as 633,397 km². This is a mere 19.27 percent of the total geographic area and is well below the 1988 National Forest Policy's objective of having 33 percent of area under forests.

The country's forest cover is broadly categorized into three main classes; namely, dense forest, open forest and mangroves. The other land classes include scrub (lands with small or stunted trees with less than 10 percent crown density) and the non-forest lands. It is pertinent to note that dense forests (canopy of over 40 percent or above) constitute only 59.21 percent of total forest area of the country. FAO estimates indicate that India's wood-based raw material requirements in the year 2010 will be around 344 million mt of fuel wood and charcoal, 37 million m³ of saw timber, 5.7 million mt of paper/paper boards and 1.3 million mt of wood-based panels (FAO, 1993). Another study, carried out under the National Forestry Action Program (NFAP) of Government of India, indicates a negative wood balance of 599.6 million m³ by the year 2015. In order to bridge the gap between the demand and supply projections and to increase the area under forest/trees, NFAP proposes to improve forest density and establish plantations on non-forest and farmlands. It is, therefore, increasingly realized that the agroforestry has the economic scope as well as technological potential to contribute significantly towards sustainable rural development in upland areas.

AGROFORESTRY DEFINED

Generally speaking, agroforestry is a combination of trees, agriculture and other land use technologies with the objective of achieving increased land productivity, sustainability, equity, and other social goals (Kumar, 1994; and Tejwani, 1994). Currently, the definition proposed by International Centre for Research in Agroforestry (ICRAF) has gained wide acceptance. It defines agroforestry as a collective term used for "land use systems and technologies where woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence". A successful agroforestry system (AFS) should meet high standards of productivity, sustainability and adoptability (Raintree, 1986).

Productivity Criterion

Well-designed AFSs can contribute to the improvement of rural welfare through a variety of direct "production role" (food, fodder, fuel and fiber) as well as through a whole range of indirect "service role" (soil and water management, fertility, improvement, microclimate amelioration, etc.) The direct beneficial impact of trees to the farmers is in increasing the total output from land by adding a tree crop to one or more lower layers of crops (Arnold, 1983; and Dhanda and Singh, 1997). Associated with this benefit is the advantage of diversifying the range of outputs from the farm in order to reduce risk to subsistence or income

due to failure of any one individual crop. Thus, while the productivity of Indian forests is a mere 0.7-m³/ha/year, it is possible to obtain 15-20 m³/ha/year from plantation of eucalyptus and 30-40 m³/ha/year from those of poplar in the alluvial plains of northwest India.

A third category of economic benefit arises when tree crops provide higher returns from the land than conventional alternative crops. Some examples are eucalyptus farming for sale on irrigated lands in Gujarat and on marginal lands in southwest Punjab (Dogra, 1984; and Sandhu, 1988). Similarly, *Acacia* grown in the arid areas of Rajasthan (India) and *Albizia falcataria* grown for sale on agricultural land in Mindanao, the Philippines, as pulpwood, produced higher returns to farmers than the agricultural cash crops these trees displaced.

Even then the principal economic constraint encountered by farmers in introducing trees into their production system is usually slated to be competition for use of land for crops or pastures. Competition for land in this connection is often discussed in terms of available choices. If land is to be devoted to tree growing it will no longer be available for crops or pasture production (Arnold, 1983). In many situations, trees can be integrated within agro-ecosystems in ways which result in supplementary or complementary increases in yields and incomes (Tewari, 1986; Shah, 1987; Ghosh, *et al.*, 1999; and Dhanda and Singh, 1997). The economic advantages of agroforestry were summarized by Arnold (1987) as low capital and labor costs, increased value of outputs, diversified range of outputs from a given area in order to: (a) increase self-sufficiency; and (b) reduce the risk to income from diverse climatic, biological or market impacts on particular crops/products.

Sustainability Criterion

In a simple production-oriented system, sustainability can be considered as maintenance of optimum system in perpetuity, without degradation of natural resource base on which that production is dependent. Since sustainability deals with the long-term productivity of a system, there are three main issues to be considered: productivity changes over time; the time-frame in question; and the cost (ecological, social, economic, and/or agronomic) associated with maintaining productivity (Nair, 1990).

Many tropical agro-ecosystems exhibit a range of degree of “leakiness”, and trees provide an efficient mechanism to plug such leaks (Nair, 1984). Improvement in soil organic matter status, biological nitrogen fixation and reduced hydrological output of nutrients from the system are some of the cardinal aspects (Kumar, 1994). Sharma (1996) has reviewed the important role of tree species like *Casuarina*, *Leucaena*, *Prosopis cineraria*, *Acacia nilotica*, and *Sesbania grandiflora* in soil improvement under agroforestry. Dagar and Singh (1993) reported that silvipastoral AFS comprising *Prosopis juliflora* and *Leptochloa fusca* grass was found most promising in terms of firewood and forage production and for soil amelioration in sodic soils. However, there may be temporary nutrient depletion, adverse chemical/biological effects and shading effects also in such systems (Nair, 1989).

Unfortunately, most farmers even in the developed countries have short time horizons and fail to perceive the importance of conservation practices designed to increase the long-term productivity of the production system. The relatively long production period of most tree species is one of the important economic constraints to adoption of agroforestry by poor farmers. However, there is enormous scope for combining long-term sustainability aspects with short-term production benefits in agroforestry by giving preference to fuel wood, fruit and fodder production and to fast-growing species that yield outputs of value early in their production cycle (Arnold, 1983). This was one of the major lessons of experience in the World Bank-assisted Integrated Watershed Development Project (IWDP) (hills) that was implemented in the Shiwaliks of north India from 1990 to 1999 (World Bank, 1999b).

Adoptability Criterion

With reference to the “cultural appropriateness” criterion, the adoptability criterion is simply a practical way of operationalizing all those socio-cultural, ecological and economic considerations, which affect the acceptability of an agroforestry innovation to the intended users (Raintree, 1986). The IWDP (hills - II) that was launched with assistance of the World Bank in 1999 in Shiwaliks hills of five north Indian States follows the “bottom-up” approach to watershed/rural development (World Bank, 1999a). All the stakeholders are being encouraged and assisted to organize themselves in to village development committees, user groups and self-help groups. These groups/committees then interact with the project staff to identify their needs and prepare development plans for implementation. They are also being given the responsibility

for post-project operation and maintenance of assets including the agroforestry plantations developed during the project period.

Agro-ecological Zones of India

One of the essential characteristics of AFS is their site-specificity. Although the distinct agroforestry practices that constitute the innumerable AFSs in different places are only a few, the same practice takes various forms in different places depending on site-specific biophysical and socioeconomic conditions (Nair, 1989 and 1990). In a vast country like India, it is difficult to come up with a universally acceptable demarcation of agro-ecological zones. Nair and Dagar (1991) have identified five major agro-ecological zones in India. The essential characteristics of different zones and the major agroforestry emphasis in each are summarized in Table 1.

Table 1. Major Types of AFSs and the Nature of Their Benefits in Different Agro-ecological Zones of India

Major Types of Existing AFS	Major Types of Benefits of Agroforestry
A. Himalayan Region <ol style="list-style-type: none"> Fruit trees in combination with agricultural crops and fodder trees Fodder trees with pastures Trees and grasses for soil conservation Cash crops in forests 	Production of fruits and fodder Fodder Soil conservation, fuel, timber, fodder -
B. Indo-Gangetic Plains <ol style="list-style-type: none"> Trees for soil reclamation (sodic/saline/degraded soils) Fodder trees in degraded grazing lands Trees on boundaries of agricultural fields Fodder banks Block plantations 	Reclamation of degraded soil, production of fuel wood and fodder Fuel, fodder Fuel, timber, fodder, cash, shade minor products - Soil conservation, fodder, fuel, cash, lumber
C. Arid and Semi-arid Region <ol style="list-style-type: none"> Multipurpose tree species (MPTs) in agricultural fields Trees for soil reclamation Fodder banks Windbreaks Trees in pasture lands 	Fodder and fuel wood, cash, minor products Reclamation of soil, fuel, fodder, minor products - Sand dune stabilization Soil conservation, fodder, fuel
D. Humid and Sub-humid Region <ol style="list-style-type: none"> Home gardens Plantation-crop combinations MPTs in agricultural fields Trees and grasses for soil conservation 	Production of multiple outputs Cash economy Minor products Soil conservation
E. Coastal and Island Region <ol style="list-style-type: none"> Plantation crop combination Multistoried cropping Home gardens Trees with aquaculture Trees on pasture lands Mangrove plantation Shelter belts and windbreaks Boundary tree on agricultural fields 	Production of multiple outputs, cash - ditto - - ditto - Fish, fuel, fodder Fodder, soil conservation Shore protection, fuel, fodder Environmental protection Shore/beach stabilization, fodder, fuel, minor products

Source: Adapted from Nair and Dagar (1991).

TYPES OF AGROFORESTRY SYSTEMS

Agroforestry is practiced in almost all ecological regions in the tropics. On the basis of their comparative composition, three basic types of AFSs are recognized:

- * Agri-silvicultural (crops with trees)
- * Silvipastoral (trees with pasture and animals)
- * Agrosilvipastoral (crops, trees, pastures and animals).

Other specialized AFSs can also be defined (for example, apiculture with trees, aquaculture involving trees and shrubs, and multipurpose tree lots).

Agri-silviculture refers to the land use system wherein agricultural crops are integrated with trees on the same land management unit either in temporal or spatial combinations (Kumar, 1994). Examples abound and include shifting cultivation (improved fallow), *taungya*, alley cropping, multipurpose trees either as wood lots or as scattered trees on farmlands or on farm boundaries, crop combinations involving woody perennial plantation crops, shelter belts, energy plantations and, so on. In all these practices, forest trees are regenerated and managed for their ability to produce not only wood but also leaves and/or fruits that are suitable for food and fodder.

Silvipastoral land management systems are those in which forests and forest plantations are managed for concurrent production of wood and livestock. Besides, they also refer to situations wherein trees are scattered in pastures and grasslands, and cut and carry fodder production systems involving woody perennials and the like.

Agro-silvipastoral land management systems are those in which land is managed for the concurrent production of agricultural and forest crops and for rearing of domesticated animals. It is in fact, a combination of agri-silviculture and silvipastoral systems and thus represents one of the most intense and complex forms of agroforestry.

Description of all the AFSs is clearly outside the scope of this paper. We would, therefore, confine ourselves to the description of important AFSs in north India.

AGROFORESTRY SYSTEMS OF WESTERN MID-HIMALAYAS

The fragile ecosystem of the Himalayan region is characterized by small and fragmented landholdings, severe soil erosion, fertility depletion, low and uncertain crop yields, fuel and fodder scarcity, deforestation, poverty and illiteracy. The pressure on the land from livestock is high and cattle, sheep and goats mainly depend upon illicit open grazing in the forests. In addition, this region supports migratory livestock belonging to nomadic graziers. The entire belt is prone to landslides caused by the removal of vegetation cover, cultivation on steep unstable slopes, improper disposal of surplus water and unstable geological formations. Acceptable research packages are not available for pasture improvement. The life situation for farm women is becoming increasingly difficult as water resources; fuel wood and fodder supplies diminish. The ratio of food to population growth is low in the hill states of this region (Grewal, 1996).

In the Himalayan uplands, the main considerations would be management of land and water resources in a specific manner through appropriate vegetative measures to achieve the objective of enhanced production on a sustainable basis. Singh, *et al.* (1990) have recognized three subtypes of systems in the hill region: forest-based systems; agriculture-based systems; and horticulture-based systems. Agro-silvi systems in this region envisage growing of trees and woody perennials on terrace risers, terrace edges, field bunds, in the fields as intercrops, and as alley cropping. The common fodder tree species in the mid-Himalayas are: *Grewia optiva*, *Bauhinia variegata*, *Morus serrata*, and *Celtis australis*. For timber and fuel wood the common trees are *Toona ciliata*, *Melia azadarach*, and *Bombax ceiba*. Agricultural crops like wheat, peas, potatoes, cauliflower and mustard are grown in winter; and maize, potato, pepper, beans, etc. in summers during the first few years after plantation. The farmers of this region are also interested in integrating cash crops like ginger, turmeric, potato, and chilies with fruit trees. The common fruit trees are peach, apricot, and plum. The local grasses that dominate forest lands or open pastures are *Chrysopogon fulvus*, *Heteropogon contortus*, *Eulaliopsis binata* and *Dicanthium annulatum*.

However, the agri-silvicultural system having predominantly annuals had the lowest productivity 20.4 mt/ha/year with only 27 percent contributed by trees (Toky, *et al.*, 1989). The study revealed that agri-hort-silvicultural system was highly diverse in vegetation with 13 tree species and five agricultural crops mixed together. This system showed productivity of 25.8 mt/ha/year out of which 68 percent was contributed by trees and remainder by annuals.

In Jammu and Kashmir cultivation of pulses and vegetables is also becoming very popular in the established orchards of apple, peach, and almonds. Some farmers also intercrop maize and oats on orchards. Homestead gardens are also common where farmers take up combination of 10-15 species of fruits, ornamentals and multipurpose trees along with vegetables.

AGROFORESTRY SYSTEM OF LOW HILLS OF SHIWALIKS

The problems of the Himalayan foothill region of north India (8 million ha) are particularly serious. Rainfed agriculture has failed to meet the basic requirements of food, fodder and fuel wood, and this has diverted human and livestock pressure to nearby hills and forest areas. The denudation of natural forests started about 150 years ago and has assumed alarming proportions now. The enforcement of law has been inadequate and the situation further deteriorated after independence due to social and political pressures.

The principal land use in the foothills is rainfed agriculture in the shallow valleys and forestry on the hill slopes. The erratic distribution of 1,000-1,500 mm of annual rainfall, lack of irrigation facilities, fertility depletion due to heavy soil erosion, small and fragmented landholdings and the scarcity of food, fodder and fuel wood are the major problems (Grewal, 1996).

More than 50 percent of the precious rainwater is lost as runoff. Due to risk of crop failure, farmers feel reluctant to invest in costly seeds and chemical fertilizers. They are reluctant to accept new innovations unless clearly and amply demonstrated. Large herds of cattle are added to the farming system to supplement low income. The acute scarcity of fodder compels them to let loose their cattle for grazing in the adjoining forests thereby causing more degradation and erosion.

AGROFORESTRY EXPERIENCES OF A WATERSHED MANAGEMENT PROJECT

Two World Bank-assisted projects; namely, the Kandi Watershed Area Development Project (1980-88) and IWDP (hills)-I from 1990 to 1999 helped State of Punjab to achieve a major breakthrough in stabilizing rainfed farming and techniques for treating non-arable lands for small timber, fuel wood, and fodder products. It was possible to achieve good degree of success due to close interaction with the village population by catering to local needs of fuel wood, fiber and fodder; and development of sustainable approaches to management of these lands. IWDP (hills)-I was taken up in the Shiwaliks of Punjab, Haryana, Himachal Pradesh, and Jammu and Kashmir on the sloping, degraded non-arable lands, which otherwise yielded little by way of fuel wood and fodder. Trees and grasses were planted with the active involvement of local people. The main tree species planted were *Acacia catechu*, *Dalbergia sisoo*, *Albizia lebbek*, *Acacia nilotica*, *Embolia officinalis*, and *Melia azadarach*. Between tree lines *bhabhar* grass and bamboo were planted and in silvipasture areas local fodder grasses *Dholu* (*Chrysopogon fulvus*) and *Sarala* (*Heteropogon contortus*) were encouraged. As a result of these interventions the yield of fodder grasses went up by 5-6 times in treated areas and the production of *bhabhar* increased from almost nothing in the untreated areas to 12-17 quintals per ha in treated areas. Since the start of project the income of the farmers from *bhabhar* grass has gone up by about five times. Impact evaluation of IWDP (hills)-I has clearly brought out the economic benefits of afforestation, enrichment planting and silvipasture in the two layered AFSs described above. The economic analysis of the systems is given in Table 2.

Mittal and Singh (1983) reported that in the Shiwalik hills reduction in yield of maize, black gram, and cluster beans was compensated by relatively higher fodder and fuel wood production of *Leucaena*. The net returns in monetary terms were higher as compared to growing of *Leucaena* or crops alone.

In the Doon valley, a 10-year study by Khybri, *et al.* (1988) with *Grewia optiva*, *Morus alba*, and *Eucalyptus hybrida* with paddy and wheat rotation concluded that all the three species had a depressing effect on crop yield. However, the net income was not evaluated for the different combinations of trees and crops.

Table 2. Economic Analysis of Agroforestry under IWDP (Hills)-I Punjab (1990 prices)

S.No.	Component/Model	NPV ^a at 12% Discount Rate (Rs.)	IRR ^b at 12% Discount Rate (percent)	Benefit Cost Ratio (BCR)
1.	Afforestation (<i>Khair</i>)	1,994,848	14.00	1.18
2.	Afforestation (<i>Kikar</i>)	223,225	12.97	1.07
3.	Afforestation (misc.)	73,734	12.34	1.02
4.	Enrichment planting	1,546,578	17.73	1.39

Source: Singh, 1998.

Notes: ^a Net productivity value; and ^b internal rate of return.

In another study at Dehradun it was observed that incorporation of *Eucalyptus hybrida* and *Leucaena leucocephala* in the agri-system resulted in considerable reduction in runoff and soil loss even though this led to reduction in the yields of wheat and maize crops (Table 3). Association of grass with eucalyptus gave lesser runoff and soil loss as compared to *Leucaena* and grass.

Table 3. Average Runoff and Soil Loss under Different Land Use

Treatment	Runoff (percent)	Soil Loss (mt/ha)
<i>Chrysopogon fulvus</i>	12.7	8.65
Maize alone	27.5	28.27
Maize + <i>Leucaena</i>	21.4	17.83
Maize + eucalyptus	20.8	13.51
<i>Leucaena</i> + grass	17.6	10.51
<i>Leucaena</i> alone	2.4	1.74
Eucalyptus + grass	6.3	3.52
Eucalyptus alone	2.1	1.20
Cultivated fallow	38.2	56.58

Source: Singh *et al.* (1990).

In another study by Khybri, *et al.* (1988) at Dehradun, reported by Singh, *et al.* (1990), it was observed that net income from *Leucaena*-wheat-paddy system was higher than from the field crops alone.

Eucalyptus and Bhabhar Grass

Singh, *et al.* (1990) established several AFSs in the Shiwalik foothills to study their efficacy in achieving production and conservation goals. *Eucalyptus tereticornis* and *bhabhar* grass (*Eulaliopsis binata*) were raised together on a light textured soil in 1985. The plant population of 2,500 trees/ha was adjusted in a paired row technique in the north-south direction. In the intervening 2 m space *bhabhar* grass was planted at 50 cm x 50 cm. The above system not only conserved soil and water but also gave much higher returns than traditional rainfed crops. After seven years the net annual returns from trees and grasses were Rs.10,659 and 6,239/ha/year, respectively against Rs.700/ha/year from rainfed field crops (Grewal, 1995).

Poplar, Leucaena and Bhabhar Grass

In a study (Singh, *et al.*, 1990) on 40 m x 40 m plot having 2 percent slope, sandy loam soil and a pan of gravel at 1.5 m depth *Populus deltoids* (G-3) was planted at 4 m x 4 m in February 1986. *Leucaena* at 2 m x 2 m was added to the system in July the same year and *bhabhar* grass was planted at 50 cm x 50 cm. The three plant species occupied the top, middle and lower canopy of the composite vegetation system. The above system resulted in a mean runoff of 4.76 percent and soil loss of 1.6 mt/ha/year against 25-30 percent runoff and 5-10 mt/ha/year soil loss from similar slopes under traditional farming systems. The average net returns from grass alone were higher than from field crops. The returns from poplar wood would be extra.

Acacia Species and Bhabhar Grass

Several *Acacia* species were planted on degraded marginal lands (boundary soil with 30-40 percent slope) at 3 m x 3 m in 1976. *Bhabhar* grass was later introduced in 1982 at a spacing of 75 cm x 75 cm under

these species. After six years study (Singh, *et al.*, 1990) all these systems demonstrated their superiority over traditional rainfed crops on poor quality soils not only in terms of higher financial returns but also in terms of better soil and water conservation. Grewal, *et al.* (1996) reported that after 10 years *bhabhar* grass yield was highest under *Acacia nilotica*. They recommended that eroded slopes can be best managed under *A. nilotica* and *bhabhar* grass association.

Studies by Mathur and Joshi (1975) showed that on the basis of average yield of grass for three years, *Dalbergia sissoo* and *Chrysopogon fulvus* was the ideal combination.

Horticulture-based Agroforestry Systems

Dayal, *et al.* (1996) have developed a horticulture-based AFS for small farmers by integrating plants yielding a number of products and having synergistic effects on each other. *Subabul* (*Leucaena leucocephala* Lam. De Wit 'K8') was raised for fuel, fodder and live hedge on the border row, followed by lemon (*Citrus aurantifolia* Christm. Swingle) "*Baramasi*" on the peripheral row, papaya (*Carica papaya* Linn.) and okra (*Hibiscus esculentus* Linn.) as understorey crops in the main plot. During first five years (1985-89) the system provided well spread out, handsome net returns (Rs.15,000-21,000/ha/year) with limited irrigation and Rs.10,000-18,000/ha/year for three years (1990-92) under rainfed conditions, compared with Rs.4,900-9,800/ha/year with limited irrigation and Rs.1,740-4,600/ha/year under rainfed conditions, from agricultural crops (maize-wheat).

In the Doon valley of Uttar Pradesh, Singh, *et al.* (1990) reported that both *rabi* and *kharif* crops can be grown with peach. On the basis of five-year data, they reported that turmeric and ginger do particularly well.

Agroforestry in the Alluvial Plains

In the alluvial region comprising about 11 million ha in Punjab, Haryana and parts of Uttar Pradesh the mean annual rainfall varies from 700 to 900 mm. The soils are very deep, well-drained, light to medium in texture, low to medium in fertility and slightly sloping (0-1 percent). About 80-90 percent of the sown area is irrigated. Rice-wheat is the principal crop rotation, with mean rice and wheat yields of 3.2 and 3.7 mt/ha, respectively in Punjab and 2.8 and 3.5 mt/ha, respectively in Haryana. The gradual lowering of the groundwater table by 0.3-0.5 m each year and through excessive irrigation of the light soils, physical and chemical degradation and soil fertility depletion are the major challenges. The crop yields at the farm level have stagnated during the last 5-6 years, despite the higher yields being obtained on experimental plots.

Eucalyptus-based Agroforestry Models in Alluvial Plains

Over the years eucalyptus trees have been grown in the region in association with agricultural crops as windbreaks around the orchards, as boundary plantations and as avenue plantations. However, cases of adverse effects on agricultural crops are also reported. Mathur, *et al.* (1984) calculated the economic feasibility of *Eucalyptus hybrida* plantations on the farmlands of Uttar Pradesh at varying spacing both with and without irrigation. The results of the studies indicate that cultivation of eucalyptus at wider spacing (6 m x 1 m) with a rotation of eight years in combination with agricultural crops gives the maximum net present value of Rs.18,702/ha and B:C ratio of 2.28.

Dogra (1984) reported that in Punjab eucalyptus plantations on farmlands farmland are highly economic giving returns of 35-38 percent without intercropping and 85 percent with intercropping. The common agricultural crops grown with it are wheat, *taramira*, and sarson. It is concluded that on good quality lands where irrigation is available intercropping must be practiced, as the opportunity cost of land is high (Table 4).

Ahmed (1989) improved upon a previous analysis (Mathur, *et al.*, 1984) of a eucalyptus/agricultural crop combination wherein the trees were planted on bunds around agricultural fields. He included, as cost of wood production, the negative effect that the trees had on crop production (Table 5). This was an important step that led to more accurate picture of the economics of the AFS.

Ahmed collected data on *Eucalyptus tereticornis* planted at spacing of 1.8 m on bunds surrounding agricultural fields in the State of Haryana, India. His aim was to determine which of the three rotation ages 8, 9 or 10 years, was economically optimal. His data showed that the trees have no effect on crop production in the first two years. Negative interactions begin in the third year and increase through the 10th year when

52 percent of agricultural production is lost. A summary of Ahmed's initial data and the results of his analysis are presented in Table 5 and Table 6, respectively.

Table 4. Economics of Eucalyptus Plantations Grown on Agricultural Land in Punjab

Land Site Type	I	II	III	IV
Description of site	Undulating un-irrigated land	Fair quality irrigated land (no intercropping)	Average quality irrigated land	Good quality irrigated land (intercropped)
Annual rent of cropland per ha	400	600	1,000	1,200-1,500
NPV at 6 percent	26,802	31,794	42,732	47,811
NPV at 15 percent	8,050	9,714	13,012	17,458
IRR (percent)	35	38	37	85

Source: Dogra (1984).

Table 5. Returns from Eucalyptus Planted around Agricultural Fields

Rotation Age	Eight Years	Nine Years	10 Years
Total return from wood production	7,544.00	8,988.75	10,507.50
Total loss in crop production	1,928.00	2,881.80	3,934.00
Loss in return from crops with 10% cum. interest	2,305.20	3,491.65	4,905.00
Net return from wood production	5,238.80	5,497.10	5,602.50
Average annual net benefits	654.85	610.79	560.25

Source: Maille, 1991.

Table 6. Economic Analysis Excluding Benefits from Crop Production

Rotation Age	Eight Years	Nine Years	10 Years
NPV (Rs.)	2,478.5	2,354.2	2,166.56
BCR	12.75	12.15	11.26
IRR (percent)	46.6	37.9	30.9

Source: Maille, 1991.

Ahmad's analysis was further refined by Maille (1991) who observed that apart from negative interactions the benefit resulting from crop production should also be considered in such joint production systems. He also pointed out in order to compare three different rotations an infinite series of rotations rather than a single rotation must be considered. Table 7 shows the highest NPV occurs at eight years rotation age.

Table 7. Revised Economic Analysis including Benefits from Crop Production

Rotation Age	Eight Years	Nine Years	10 Years
NPV of a single rotation (Rs.)	11,827	12,159	12,356
NPV of an infinite set of rotations (Rs.)	22,169	21,113	20,109
B/C ratio	9.20	7.20	5.89

Source: Maille, 1991.

Negative effects of eucalyptus plantation have also been reported. A study was made on the effect of east-west tree line of three and a half years old *Eucalyptus tereticornis* on soil physical parameters adjoining mustard and wheat crops in Hissar, Haryana. The study concluded that the species is not suitable for row plantations in deep water table conditions of semiarid regions.

The price boom in eucalyptus was evident in Punjab, Haryana and western Uttar Pradesh up to about 1984. However, in the late 1980s the prices crashed and this led to very sharp decline in planting of eucalyptus on farmlands. A number of reasons are offered for collapse of the market, chiefly among them, over production and marketing constraints. In recent years farmers have slowly restarted taking interest in eucalyptus plantations, particularly in southwest Punjab. In fact farmers are looking for quality stock from proven clones. Dhanda and Singh (1997) reported that in Punjab where farmers plant eucalyptus on all four sides of a field can earn extra yearly income of about Rs.1,122 per acre. It was computed after compensating for the loss in the crop yield. They concluded that boundary plantations of eucalyptus are profitable in the AFS and are being followed by Punjab farmers.

Poplar-based Agroforestry Models

The characteristics of poplars having straight clean bole, leafless state during winter months, combining well with agricultural crops, good economic returns in short rotation, i.e., 6-8 years and availability of bank loans for planting have made the versatile poplars the most popular tree species for planting under AFSs in the States of Punjab, Haryana, Uttar Pradesh, Himachal Pradesh and Arunachal Pradesh. Farmers are cultivating agricultural crops under poplar throughout rotation period and consider poplar tree as assured wealth for meeting their future needs. The spacing for poplar plantation is generally kept 5 m x 4 m or 5 m x 5 m, which allows tractor ploughing and other cultivation operations without any difficulty. The agricultural crops, which are generally grown as intercrop with poplar are sugarcane, wheat, potato, gram, mustard, pea, soybean, lentil, sorghum, maize, ginger, turmeric, and vegetable crops like tomato, chilies, radish, etc. Considering the fast rate of growth, ease of establishment, easy marketability and multifarious uses, poplars have been grown under various systems viz. agri-silvicultural, agri-silvi-horticulture, etc.

The poplar species has done well in the flood plain areas of Sutlej, Beas, and Ravi rivers in Punjab. Commercially it is one of the most viable agroforestry species for Punjab's irrigated plains where its growth and yield are perhaps higher than anywhere else in north India. In good quality sites trees on farmlands have attained a height of 30.8 m after six years and the maximum recorded mean annual increment of 58.4 m³/ha (Dogra, 1999).

Poplar is becoming more and more popular with the Punjab farmers with 48 percent of the farmers opting for it during 1990-95 as against 32 percent during 1985-90 and only 3 percent in the early 1980s. Due to pest manifestation, the clone G-3 has now been discarded. Common clones used now are G-48, S7, C8 and Udai. There is an urgent need to continuously breed and evolve new clones to replace ageing clones as a hedge against possible pest attack. Dhanda and Singh (1997) studied poplar plantations in Ludhiana district in central zone of the State close to river Sutlej. Their findings are summarized in the following paragraphs.

Growth performance of six five-year old, three six-year old, and two nine-year old agroforestry block plantations of poplar have been compared. The overall benefit measured in timber volume (over bark) production at five-year was 295.43 m³ in case of table land plantation (Mean Annual Increment [MAI] being 40.6 m³), the relative gain being 45.6 percent in case of riverbed plantations. This clearly shows that farmers are harvesting well-managed and intercropped plantations of poplar at a short rotation of 5-6 years.

Timber volume production of poplar wood ranged from 9.6 m³/ha to 446 m³/ha in one-year to nine-year old plantations giving a MAI of 49.41 m³/ha/year and nine-year in well-managed and inter-cultivated poplar plantations on tablelands of Ludhiana district of Punjab. The overall relative performance from return point of view measured as timber volume was higher by 208 percent in case of resident farmers (146.13 m³) than the absentee owners (47.36 m³) at five years age.

The authors studied three types of AFSs (AFS-I: wheat and fodder taken as intercrops for seven years and no crop in eighth year; AFS-II: sugarcane crop for first three years and no crop taken afterwards; and AFS-III: sugarcane for first three years and then wheat and *khariif* fodder for the remaining period of rotation with poplar trees as perennial component were compared). Four efficiency measures used were: present net worth (PNW), BCR, annuity value (AV), and IRR. In terms of PNW and AV, the AFS-III was the best, followed by AFS-II and then AFS-I. The PNW of Rs.45,660.28 was obtained in AFS-III at a rotation of seven years, which declined to Rs.43,660 and Rs.35,804 at rotation of eight and six years, respectively. The AV of Rs.8,915/acre was the highest for AFS-III at a rotation of seven years, whereas the BCR was the highest for AFS-II (3.19-3.34) at seven- to eight-year rotation. Comparing all the AFSs and using IRR (in percent)

as the economic parameter (most commonly used) AFS-I stands at rank-I, giving 37.99-40.58 at a rotation of 6-7 years.

In case of boundary plantations with paddy and wheat, the authors concluded that poplar plantation on all four sides of field gave the highest IRR of 73.5 percent.

Marketing and Future Needs of Agroforestry Tree Species

Eucalyptus was grown by the farmers in a big way in the alluvial plains in late 1970s and early 1980s. Unfortunately the prices had crashed by about 1986 and since then there had been a steep decline in the plantation of the species. Saxena (1996) has offered a number of reasons for the collapse of the market: overproduction, lack of market information with the farmer, government's timber transit rules, etc. Perhaps most or all of these reasons were operating to depress prices of farm-grown eucalyptus wood. But the real issue that agroforestry projects of 1970s and 1980s overlooked was the local needs for trees and tree products. A farmer does not grow trees to meet his requirements for fuel or to restore the environmental benefits. He primarily grows trees to increase his income. Income from trees, in turn, depends on the market demand. Thus, trees in the farming systems are more usually seen not as part of forest resource, but in the context of farm household livelihood needs and strategies. In other words, farmer production has to be matched with demand (Arnold and Dewees, 1998). The authors observe that action is required in three policy areas.

Subsidies and Fiscal Measures

Unlike the 1970s and 1980s, the high cost of planting stock does not constrain many farmers from growing trees. In fact there is evidence that stabilizing planting stock can have negative impacts on emergence of sustainable seedling production and growth of private nurseries. In the alluvial plains, for instance, farmers are willing to pay the market price for the best clonal seedlings of poplar and eucalyptus. Even otherwise, the cost of plants is only a small proportion of the total investment in tree planting. In case where establishment costs are high, farmers may be extended credit to grow trees or trees may be inter-planted with crops to produce intermediate yields.

Instead of stabilizing the establishment phase of a plantation, it would be more appropriate to improve the demand and the market prospects for tree products.

Fuel Wood Markets

The government needs to address the conflict within its overall strategy to provide forest products. A logical long-term solution could be to phase out state production in these markets where farm level production has a comparative advantage. In this way, in the short-term, the market position of the farmer can be improved by removing or relaxing regulatory constraints that the forest administration imposes on the farmers.

Regulation/Controlling Private Production and Sale

Often motivated by the need to prevent illegal operations, many states control commercial sales of private tree products, requiring producers or traders to obtain permits to harvest, transport and sell round wood. The resulting cumbersome and costly bureaucratic procedures tend to make procedures dependent on intermediaries who have the skills and resources to navigate the procedures. The complexities, cost and poor market information (and therefore uncertainty) can prove to be a major distortion of market forces, and a disincentive to small producers for growing trees for sale.

In almost all States in northwest India, harvesting and transport regulations have been liberalized to exclude the fast-growing exotics that are normally grown by the farmers.

Public Investment in Research and Support Services

Applied research must respond to the needs, opportunities and constraints faced by the farmers. There is a need to improve the genetic quality of planting material of species identified as suitable, refine existing agroforestry practices/models to meet farmers' needs and develop mechanisms to transfer technology from research institutes to farmers and other user agencies.

Extension services should assist the farmers in choosing from a menu of options best suited to their needs and provide information for marketing of agroforestry products.

ACKNOWLEDGMENTS

The authors are thankful to Dr. S. S. Grewal, Associate Director (Training), Ballawal Saunkhri Centre of Punjab Agricultural University and Mr. K. K. Sharma of Indian Council of Forestry Research and Education, Dehradun for providing useful inputs in design of this paper. They are also thankful to Mr. R. A. Chaman Lal, and Mrs. S. A. Roseline, Office of Director, Kandi Areas for useful secretarial assistance for completing this work.

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1. REPUBLIC OF CHINA

Dr. Tzong-Shyan Lin
Professor
Department of Horticulture
National Taiwan University
Taipei

GENERAL SITUATION OF AGRICULTURE

Agriculture played a key role in the early stages of economic development in the Republic of China, Taiwan. Over the past decades Taiwan has developed from an agriculture-based economy to a newly industrialized one. Agricultural contribution of GDP dropped from 32.2 percent in 1952 to 2.6 percent in 1999. The role of agriculture has shifted from a purely economic contribution to one of food security and environmental conservation (Council of Agriculture [COA], 1997). Agricultural growth has slowed down during the last decade even though agriculture still provides more than 70 percent of food security for 22 million people. The total value of agriculture in 1999 was about US\$13 billion. Crops, livestock and fisheries comprised 43.6, 33.2, and 23.0 percent, respectively, of the total value of agricultural products, whereas forestry comprised only 0.15 percent. Share of value of different crops, i.e., fruits, vegetables, rice and specialty crops is 35.4, 23.4, 21.6, and 7.6 percent, respectively.

MOUNTAINS OF TAIWAN

Land Resources

Taiwan, the main part of the current Republic of China, is a mountainous island with a total land area (excluding 78 small islands) of 36,020 km². The main topographical feature is the great central mountain range dividing the island.

While one-fourth of the island is plain area, the rest three-fourths is hilly and mountain region (Table 1). Hilly region refers to mounds with altitudes from 100 m to 1,000 m and include areas with more than 5 percent slope even below 100 m. About 53 percent of the land has slopes steeper than 20 degrees. A high percentage of hilly and mountainous regions has led to complicated geographical landscapes and limited human activities in Taiwan.

Table 1. Land Area of the Republic of China, Taiwan

	Area (ha)	Percentage
Plain region	961,980	26.7
Hilly region	983,542	27.3
Mountainous region	1,656,520	46.0
Total	3,602,042	100.0

Source: Department of Agriculture and Forestry, 1999.

In contrast to alluvial soil in the plain regions, the soil in the hilly regions has reddish- and yellowish-brown lateritic soils. Reddish-brown lateritic soils are generally clay loam over one meter thick. They are strongly acidic in nature. Yellowish-brown lateritic soils are commonly shallow, rarely exceeding one meter in depth. These soils are gravelly, generally deficient in nutrients, and vulnerable to soil erosion. These soils dominate cropland areas. On the other hand, the gray-brown podsollic soils, reddish-brown podsollic soils and lithosol belong to forest soils (Chang, 1956).

Climate

Even though Republic of China lies across the boundary between tropical and subtropical regions, but because of the high mountains there is a great variation from tropical to temperate conditions. Consequently, deciduous fruits can be grown at altitudes. The mean temperature in the plains is about 26-28°C and 15-20°C in the summer and winter, respectively. Temperatures can rise as high as 38°C in the summer in the plain regions and occasionally falls below freezing point in the winter at 3,000 m (FAO, 1970).

Rainfall is affected by topography. Generally, rainfall increases from the coast towards the higher altitude of the central mountain range. The annual precipitation varies from 1,000 to 4,000 mm. Rainfall is relatively high in the mountainous region and the northeastern corner of the island. Rainfall is also plentiful all over the island between May and September and almost 70-80 percent of the total annual rainfall occurs during this period. The most significant feature of the weather is typhoons, which invade the island almost every year between July and October. The gusty winds sometimes reach 150 km per hour and are accompanied by torrential rains. Summer rainstorms and typhoons often cause serious flooding and soil erosion. The highest rainfall record in a 24-hour period is 1,164 mm (FAO, 1970).

IS TAIWAN PREDESTINED FOR UPLAND EXPLOITATION?

Five hundred years ago, Taiwan was full of natural resources. Aborigines sparsely inhabited the island. The population was estimated to be not more than half a million. Since the middle of the 16th century, the Chinese people have immigrated to Taiwan and settled in areas suitable for farming. Originally, they colonized the wild country of western plain regions. They built irrigation systems and cultivated rice in paddy fields (Table 2). They harvested camphor trees (*Cinnamomum camphora*, Nees and Eberm.) on hilly sides to distillate camphor oil. With increasing population the immigrants expanded their farming to hilly areas (Table 2). They converted forestland into cropland for producing staple foods and grew crops such as upland rice, sweet potatoes, tea, and longan (*Euphoria longan*, Seud.) both for domestic consumption and export. In this process population reached three million at the end of the 19th century and the area of arable land increased to 350,574 ha (Table 2).

Table 2. Changes in the Area of Arable Land in the Last Four Centuries (1624-1998)

(Unit: ha)					
Year	Dynasty	Irrigated Cropland	Rainfed Hilly Cropland*	Total	Percent Increase
1624-62	Dutch	-	-	11,883	-
1662-83	Ming	-	-	29,150	145
1683-1895	Ching	208,275	142,299	350,574	1,103
1895-1945	Japanese	504,709	311,308	816,017	133
1945-98	Chinese	450,616	408,139	858,755	5

Source: Wu, 1993.

Note: * Rainfed field composed mainly of hilly region.

During the Japanese occupation of Taiwan from 1895 to 1945, its forest resources were their major targets. They expanded the camphor industry. They built railroads and cableways for exploiting old natural forests, especially the high elevation conifers. By 1940, production had nearly tripled. A maximum timber production of about 470,000 m³ was acquired in 1941 (Zehngraff, 1951).

Besides camphor oil and timber production, intensive farming was progressively implemented on both plain and hilly regions. The area of arable land (both irrigated paddy cropland and rainfed cropland) doubled within 50 years and reached a plateau (Tables 2 and 3). Area of tea plantations, banana and pineapple increased dramatically in the uplands (Tables 4 and 5). By 1938, the cropland in the plains and uplands had reached 20,839 ha and 9,605 ha, respectively. About 60-70 percent of fresh banana were exported to Japan. Pineapple fruits were processed as canned products and once dominated the international market.

Table 3. Changes in the Area of Arable Lands of Taiwan from 1890s to 1990s

Year	Area (ha)			Percentage		
	Irrigated Cropland (A)	Hilly Rainfed Cropland (B)	Total (C)	(A/C)	(B/C)	Cropland/ Total Land
1898	236,212	165,627	401,839	58.8	41.2	11.2
1908	322,800	327,438	650,238	49.6	50.4	18.1
1918	341,479	390,776	732,255	46.6	53.4	20.4
1928	391,714	415,040	806,754	48.6	51.4	22.4
1938	526,829	330,977	857,806	61.4	38.6	23.8
1948	526,384	336,772	863,156	61.0	39.0	24.0
1958	533,674	349,792	883,466	60.4	39.6	24.6
1968	535,288	364,638	899,926	59.5	40.5	25.0
1978	501,061	401,082	902,143	55.5	44.5	25.1
1988	483,514	411,460	894,974	54.0	46.0	24.9
1998	450,616	408,139	858,755	52.5	47.5	23.8

Source: Department of Agriculture and Forestry, Taiwan Provincial Government, 1999.

After 50 years of Japanese rule, Taiwan was restored to Chinese sovereignty in 1945. It has been the seat of the Government of the Republic of China since the fall of the Chinese mainland into communist hands in 1949.

In 1946, the population was 6.1 million, which further increased in 1949 when 1.5 million more people came from the mainland. By 1967, Taiwan population was about 14 million. Although immigration and the birth rate decreased subsequently, the population still increased to 22 million in the 1990s. With the second highest population density (>600 persons/km²) in the world and quite limited arable land (Tables 2 and 3), intensive cultivation on uplands became an inescapable choice in Taiwan for satisfying food requirements and economic development. As mentioned above, uplands in Taiwan are very susceptible to soil erosion. Therefore, sustainable farming on uplands has been a continuous challenge to our people.

Table 4. Changes in Planted Area of Several Food and Cash Crops from 1930s to 1990 (high percentage of the plants of each crop is cultivated in the uplands)

	(Unit: ha)						
	1938	1948	1958	1968	1978	1988	1998
Upland rice	25,177	26,219	28,161	11,889	2,893	109	-
Sweet potato	134,558	224,247	228,699	240,437	123,942	15,351	9,759
Tea	44,461	44,461	48,258	37,113	30,379	25,595	20,659
Cassava	6,550	10,501	12,344	25,042	19,507	2,133	46
Citronella	-	1,087	19,115	11,164	4,044	-	-
Mulberry	-	39	3,828	1,059	1,677	317	50
Bamboo sprout	-	-	-	4,994	19,487	30,688	30,325
Betel nut	519	415	673	1,470	2,448	24,266	56,111

Source: Department of Agriculture and Forestry, 1999.

Table 5. Changes in Planted Area of Different Fruit Trees in Taiwan from the 1930s to the 1990s
(30-100 percent of the crops of each fruit species are planted on uplands)

	1938	1948	1958	1968	1978	1988	1998
Banana	20,839	15,445	13,838	48,953	11,115	11,456	10,241
Pineapple	9,605	5,661	8,383	16,426	11,556	7,580	8,349
Mango	580	423	436	1,652	12,009	18,541	20,814
Sugar apple	-	-	-	-	-	5,245	5,542
Longan	2,782	2,435	2,054	3,242	4,917	12,165	11,808
Litchi	-	-	-	2,317	6,649	15,097	12,051
Ponkan	2,090	1,627	2,676	8,050	12,720	14,353	9,546
Tankan	1,434	1,452	2,969	12,559	11,496	10,159	5,902
Liucheng	-	-	-	-	9,211	16,265	8,042
Valencia orange	-	65	108	3,208	1,130	223	109
Wentan pomelo	272	336	321	1,147	1,136	3,128	6,719
Plum	960	1,010	1,078	2,041	2,500	9,500	5,161
Peach	239	312	282	695	1,498	2,565	3,206
Japanese apricot	-	-	-	2,992	4,733	8,485	10,428
Pears	-	-	-	2,946	8,960	10,117	8,985
Apple	-	-	-	-	2,036	2,548	927
Loquat	95	70	48	505	2,681	1,378	1,148
Persimmon	408	304	294	342	771	1,699	1,966

Source: Department of Agriculture and Forestry, 1999.

STRATEGIES FOR SUSTAINABLE UPLAND FARMING

Upland farming has been a recognized issue of national importance due to its role in sustainable development. The strategies having been used for upland farming during the last several decades can be summarized as follows:

- * Emphasis on soil conserving farming systems
 - * Farming of high value cash crops
 - * Increased economic incentives, subsidies and long-term low interest loans for improving farming practices and productivity
 - * Inter-agency coordination for promoting integrated development of upland farming systems
 - * Focus on improving education, research and extension systems for sustainable upland farming.
- (Koh, 1984; and Koh, *et al.*, 1991).

EFFORTS FOR SUSTAINABLE UPLAND FARMING

Institutional Structures

- * To promote soil conservation, a committee was formed in 1954 by the Departments of Agriculture and Forestry, Provincial Government of Taiwan
- * The Soil Conservation Field Office was set up in 1955 followed by offices in each county
- * The Mountain Agriculture Resources Development Bureau (MARDB) was established in 1961 under the Taiwan Provincial Government. It marked the beginning of an island-wide implementation of the upland farming program (Koh, *et al.*, 1991). MARDB is responsible not only for soil conservation but also for the development of agriculture and range resources in the slopeland region. MARDB was reorganized to form Soil and Water Conservation Bureau (SWCB) in 1983 and then affiliated to the COA. By the end of 1999, a total of 158,450 ha of sloping farmlands were practicing soil conservation measurements through the assistance of the SWCB.
- * Prior to the end of 1978, the Chinese-American Joint Commission of Rural Reconstruction (JCRR) served a promotional and advisory role and provided financial and technical support for sustainable upland farming programs. With a couple of reorganizations, the Council of Agriculture was set up in 1984. The COA took over the role of JCRR in upland areas farming (Koh, *et al.*, 1991).
- * The Statute on the Conservation and Use of Slope Land Resources first promulgated in 1976 and revised in 1986, provided legal basis for conservation work on officially designated uplands (Koh, *et al.*, 1991). A new Soil and Water Conservation Act was promulgated in 1994. All these initiatives contributed to wider use of soil conserving farming practices, which today cover an area of 980,000 ha of slopeland.

Upland Use Based on Land Use Capability Classification

Detailed surveys and classifications with regard to upland use planning have been done for the nation. It helped in identifying potentials as well as limitations (Shen and Pien, 1984).

- * An island-wide soil and land-use survey of marginal land was conducted in the 1950s and the 1960s. The preliminary report on land use classification for uplands was first published in 1954. The slope limit suitable for farming and pasture was recognized up to 55 percent.
- * "The Criteria for Land Use Capability Classification of Slope Lands" was promulgated in 1979. Since then, land is classified into six classes according to the factors of slope, effective depth, degree of soil erosion, and characteristics of parent materials (Table 6). The first four classes are suitable for farming and pasture, whereas the fifth class is good for forestry only, and the sixth class requires intensive conservation practices (Hsu, *et al.*, 1991).
- * The aerial survey done between 1983 and 1987 identified 992,711 ha of area as slopeland. It is 27 percent of total land area of the nation. Out of this only 449,424 ha of slopeland are suitable for agricultural use (Table 7). According to the latest statistics published by SWCB in 1999, the area of slopeland is 969,617 ha, of which 423,873 ha is suitable for farming. Upland farming supported by the Integrated Soil Conservation and Land Use Program is limited to this region.

Table 6. Criteria for Land Use Capability Classification

Effective Soil Depth	Slope Percentage					
	<5	5-15	15-30	30-40	40-55	>55
	Grade I	Grade II	Grade III	Grade IV	Grade V	Grade VI
Deep >90 cm	I	II		III		V
Moderately deep 50-90 cm			III			
Shallow 20-50 cm	II	III	IV		IVa V ^a	
Very shallow <20 cm				IVa V ^b		

Notes: ^a Suffering from serious soil erosion; and ^b on hard bedrocks or gravel strata.

Suitable for cultivation and pasture: I = no limitation in use; II = moderate conservation practices necessary; III = intensive conservation practices necessary; IV = very intensive conservation practices necessary; and IVa = suitable for perennial crops.

Not suitable for cultivation: V = suited for forests only.

Unstable, severely eroded land: VI = requiring intensive conservation practices.

Table 7. Slopeland Distribution Based on the Classification of Land Capability and Land Use Suitability in Taiwan

Classification		Area (ha)	Percentage
Land Use Suitability	Land Capability		
Land suitable for cultivation and animal husbandry	Classes I and II	81,619	8.22
	Classes III and IV	367,805	37.05
	Sub-total	449,424	45.27
Land suitable for forestry	Class V	428,579	43.17
Land requiring intensive conservation and other lands	Class VI and non-classified	114,708	11.56
Total		992,711	100.00

Source: The aerial survey report made by the Agro-Forestry Survey Institute of Taiwan Forest Bureau, May 1988 (cited in Hsu, *et al.*, 1991).

Research

Some highlights of basic research on sustainable farming are listed below:

- * *Soil erosion prediction technology*: Relative erodibility of major slopeland soils, determinants of soil loss tolerance. Quantitative studies on factors affecting soil erosion to derive an empirical soil loss equation.
- * *Improvement of conservation measures*: Hillside ditch combined with cover crop has successfully replaced bench terracing (Liao and Wu, 1987).
- * *Labor-saving, cost-effective management practices*: Cover crop is beneficial for ground protection and nutrient enhancement. Improvements were made in transportation systems, automatic irrigation system, pest control, windbreak, gully control, and mechanization of many slopeland operations, including development of small, multipurpose transporters for use by upland farmers (Koh, *et al.*, 1991).
- * Techniques for adjusting production period of fruits by means of varietal improvement and technical innovation.

- * Sustainable farming practices such as fertilizer application based on soil and leaf analysis, integrated pest management (IPM), and soil conservation practices.

Education and Extension

- * The Soil Conservation Program initiated since 1954. A training center was built in 1957 to provide training in soil conservation, slopeland agriculture and integrated planning and management of slopeland resources (Landon, 1962; and Koh, *et al.*, 1991).
- * The Department of Soil and Water Conservation was established at the National Chung Hsing University in 1964 to provide academic programs. National Taiwan University offered programs in forest hydrology and watershed management since 1975. Meanwhile, soil and water conservation and slopeland utilization courses are also available at the universities and colleges. It is adequate to meet the needs of sustainable slopeland farming in Taiwan (Koh, *et al.*, 1991).
- * A voluntary participation approach supported with adequate technical assistance and economic incentives is part of extension. Technical assistance includes field demonstration and training classes to help farmers acquire knowledge and techniques in sustainable slopeland farming. Economic incentives initially included food and cash subsidies. Later, free construction equipment with experienced operators, and a low interest (or interest-free) loan plan has been offered to farmers for adopting sustainable farming practices (Koh, *et al.*, 1991).

Integrated Approach and Team Work

- * The “Integrated Soil Conservation and Land Use Program” was established to enhance the overall benefits of sustainable slopeland farming. Programs of soil conservation, proper cropping pattern and management, adequate transportation, irrigation and drainage system, facilities for pest control, farm mechanization, and the introduction of a joint operation and management system were fulfilled to improve land use and maximize production with reduced costs (Chen, 1984; Hsiao, *et al.*, 1995; and Hsu, *et al.*, 1991). This integrated approach has been implemented since 1966 (Koh, *et al.*, 1989). By the end of 1993, an area of 194,900 ha of sloping farmlands covered under this program.
- * The COA initiated “Integrated Management of Citrus and Mango Orchards on Slope Lands Program” between 1991 and 1997 for reducing production and marketing costs. A team of technical advisors with expertise in orchard planning, soil and water conservation, plant nutrition, plant pathology and entomology, agricultural machinery, farm management, fruit-tree culture, postharvest and marketing was invited to work with farmers. The team worked towards reducing costs and creating sustainable farming on the slopeland (Lin, *et al.*, 1998).
- * Since slopeland farming is an important component of watershed management, Forestry, Water Conservancy and Soil Conservation Joint Technical Committee was established in 1963 and reorganized as “Watershed Protection and Planning Commission” in 1983. It promoted cooperation and coordination among various agencies involved in supporting different aspects of sustainable slopeland farming and watershed management (Koh, *et al.*, 1991).

PRINCIPAL MEASURES APPLIED FOR SUSTAINABLE FARMING ON SLOPELAND

Soil Conservation Practices

1. *Mechanical Conservation*

- * Hillside ditches: These comprise series of shallow ditches built along the contour lines of a hillside slope at proper intervals. The broad-bottom ditch permits in-field passage of workers and machinery operation. Also, the ditches combined with cover crops (grasses) are as effective as bench terracing in checking runoff and soil erosion (Liao, 1979; and Liao, *et al.*, 1989). Therefore, the improved hillside ditches combined with cover crops have been implemented over 42,000 ha of sloping farmlands in Taiwan (Liao, 1981).
- * Bench terraces: Bench terraces are a series of nearly level platforms built along contours at suitable intervals. Despite high construction costs, it is generally considered as the most effective method for conserving soil. It is suitable for sloping farmlands with considerable depth of soil and for the farms

where intensive cultivation can be undertaken. Because greater cuts and fills are required for each area, bench terracing is now being recommended for high erosive soils (Wu, 1998).

- * Stone walls: Farmers pick up stones from the farm to build stonewalls at desired heights at a suitable spacing along contour lines. It reduces soil and water loss and traps soil washed down from above, thus gradually building up bench terraces and hillside ditches in later years.
- * Grass barriers: Contour planting of suitably spaced strips of grasses on slopeland can trap soil from being washed downhill. As a result, slopeland gradually converts into bench terraces.
- * Grassed waterways: Earth watercourses on the slope farm are planted with dense grasses to control soil erosion.

2. *Agronomic Conservation*

Agronomic conservation measures are not only for soil erosion control but also for improving soil properties, water infiltration and storage and saving labor.

- * Contour farming: It is the basic requirement for upland farming. It consists of ploughing, furrowing and planting along the contour lines of a slope.
- * Cover crops: Besides staple crops, the farm is planted with grasses to cover ground surface with dense foliage to reduce soil erosion and improve the soil. Bahia grass (*Paspalum notatum*) is strongly recommended for its high vigor and good covering (Liao, *et al.*, 1987). Foliage of the cover crop is used for mulching underneath the tree canopies.

The recommended soil conservation practices for crops grown on slopeland are shown in Table 8.

Table 8. Recommended Soil Conservation Practices for Major Crops in Taiwan

Crops	Hillside Ditch with:				Bench Terraces		
	Cover Crop and Mulching	Hillside Contour and Close Planting	Ditch Grass Barriers	Stubble Mulching	Reverse Slope	Level	Outward Slope
Citrus	XX						X
Tea	X	X			X	X	X
Mango	XX						X
Litchi	XX						X
Pineapple		XX		XX			
Banana	X		X		X	X	X
Apple	XX				X	X	X
Mulberry	XX						
Upland crops					XX	XX	X

Source: Liao, *et al.*, 1991.

Note: XX = very suitable; and X = suitable.

Integrated Fruit Production Practices: Citrus and Mango as Example

1. *Orchard Planning and Layout*

Good orchard planning and layout are critical for efficient orchard management. The following criteria should be satisfied:

- * Is the location of the orchard good for sustainable farming?
- * Are the spacing and layout of the fruit trees suitable for mechanical farm operations?
- * Are there suitable roads or paths for machinery?
- * Is the canopy structure of fruit trees optimal for light interception and light distribution?
- * Is the orchard layout and management system suitable for soil and water conservation?
- * Are water resources, including irrigation system, sufficient for profitable yields and high-quality fruits?

Other improvements include the improvement of road and pad systems, and the thinning of fruit trees in dense orchards. It gives farmers good access to trees and improves fruit quality. Fruit trees are trained and pruned to control tree size and shoot distribution for convenient work and optimal light distribution. Machinery used includes vehicles, speed sprayers, chippers, and drills used for transportation, pest control, pruned-shoot chopping, and deep application of fertilizers.

Orchard layout follows the rules of soil and water conservation listed above. Hillside ditches follow contour lines. Where necessary, retaining walls, crib walls, parabolic ditches, paved cross drains and chutes are built to control soil erosion. Farmers are encouraged to plant grass cover on slope orchards to reduce erosion and increase the supply of organic matter.

The irrigation system, either sprinkler or drip irrigation, is laid out in the orchard. Water is either pumped out of a nearby source or comes from a reservoir.

2. Improvement of Cultural Practices

- * Adjustment of fruit-production period: Taiwan farmers these days commonly use practices for adjusting or extending the production period of fruit crops in Taiwan. By using appropriate cultural techniques, the time of flowering, fruiting, and harvest is regulated. It enhances farming efficiency and increases profits of the farmers. The main techniques include: planting different varieties of citrus, litchi, and mango; different planting seasons for banana and pineapple; different planting regions through various heat units for litchi, banana, and betel nut; girdling for mango and wax apple; pruning for grape, sugar apple, carambola, and guava; flooding for wax apple; plant growth regulators such as ethephon for pineapple; and top-grafting for pears.
- * Increase of pollinator population during blooming period to increase fruit set in mango.
- * Appropriate fruit thinning for increasing fruit quality.
- * IPM: Appropriate training and pruning of the fruit trees to limit their size makes spraying easier, and facilitates ventilation among branches to check pest multiplication. The removal of dead or infected shoots or wood should be carried out to prevent further spreading of pests. Accurate identification of pests is an important aspect of IPM, as is the timely and efficient application of pesticides. The right amount of pesticide is applied at right time. Mango producers are encouraged to apply protective agents such as copper at suitable stage, to halt the multiplication of pests. Another effective practice is to bag fruits earlier, to halt inoculation of anthracnose spores. Citrus trees grown in Taiwan are seriously infected by citrus tristeza closterovirus (CTV), citrus tatter leaf capillovirus (CTLV) and greening disease and result in short life span and low yield. Approaches adopted to manage the infection include availability of pathogen-free mother stock and propagation and planting of healthy seedlings, preimmunization with CTV avirulent strains, field sanitation, and insecticide spray supplement with the release of the parasitoid (*Tamarixia radiata*). Also, the infected trees are eradicated as early as possible (Su and Chen, 1990).
- * Appropriate fertilizer applications: The technique of “soil and tissue analysis for nutrient diagnosis” is used as a guide to fertilizer applications. An island-wide soil testing and plant analysis service network has been established since 1987 (Chang, 1996). Public agricultural experimental stations are involved in this service. Soil and leaf samples are collected from the orchards and sent to the laboratory, where they are analyzed. Soil samples are tested for their organic matter content and pH values. Both soil and leaf samples are analyzed for their mineral contents. Compared with standards, farmers are suggested to correct their fertilization practices. Mechanized deep placement of fertilizer instead of broadcasting is encouraged to ensure that the fertilizer is absorbed by the root system and leaching losses are minimal.

3. Improvement of Fruit Handling

The first step in improving the postharvest handling of fruits is to establish a maturity index, so that fruits are harvested at the optimal stage of maturity. Harvested fruits must be handled carefully to reduce mechanical injury. The next step is to improve packing sheds to increase the efficiency of sorting, sizing and packaging. Conveyors or rollers are set on the working line to facilitate the movement of fruits. Sorting of fruits must be based on established grading standards, according to the requirement of consumers. Staff must be trained in sorting and sizing. Efficiency is enhanced if the packing shed has a sizing machine that differentiates fruits by means of size or weight. Smaller packages of 6 or 12 kg are preferred to the traditional 20-kg carton, since this device gives better protection to fruit quality.

4. Marketing Promotion

Government helps marketing promotion. In addition, cartons must have an attractive design. Fruits harvested from orchards with approved practices are marked by a GAP (Good Agricultural Practices) label. Different marketing channels such as various supermarkets are pursued to supplement wholesale markets. Finally, a consumer survey is carried out to know the consumer's preferences.

5. *Keeping Accounts*

Farmers are encouraged to keep an account of daily expenses and income related to orchard operations. Advisors on farm management analyze these accounts and discuss with farmers to find ways for further improvements.

6. *Group Farming*

A group of 10-30 neighboring farmers organize into a single production and marketing team. In some cases some kind of association is organized by the growers of a particular fruit to collective management of farming and marketing.

SIX DECADES OF CHANGES IN UPLAND FARMING

In the past 60 years, the cropping pattern of slopeland farming has changed considerably with the dynamic economic development (Tables 4, 5 and 9). Farming in plain regions was developed for food crops like rice, sweet potato, and vegetables. The focus of farming on slopeland was on cash crops mainly fruit crops. In addition, farmers also grew upland rice, sweet potato, cassava, citronella and mulberry on the slopeland. The importance of these crops has, however, diminished during the last two decades (Tables 4, 5 and 9). According to the survey made in 1988, farming on the slopeland included food crops, cash crops, fruit crops, and forage crops. Cropping occupied about 28 percent of the area of slopeland (Table 10). Although tea has been the most important specialty crop on the slopeland, its area in the 1990s decreased to less than one half of the peak value. On the other hand, the planted area of bamboo for sprout production and betel nut (*Areca catechu* L.) increased significantly in the recent decades (Table 4).

Table 9. Changes in Slopeland Use from the 1950s to the 1980s

Land Use	(Unit: Percent)		
	1956-58 ^a	1975-77 ^b	1985-87 ^c
Rice and specialty crops	30.7	22.8	12.0
Fruit trees	2.2	11.9	15.6
Forest and bamboo	50.9	51.6	57.5
Grasses and idled lands	10.1	4.2	4.3
Others	6.1	9.5	10.6
Total	100.0	100.0	100.0

Sources: ^a Agro-Forest Marginal Land Use Investigation in 1956-58; ^b Slopeland Planning Investigation in 1975-77; and ^c Agricultural Resources and Land Use Investigation in 1985-87 (cited in Hsu, *et al.*, 1991).

Table 10. State of Farming on Slopeland in Taiwan

Land Use		Area (ha)	Percentage
Crop cultivation	Rice	37,504	3.78
	Miscellaneous food crops	20,176	2.03
	Specialty crops	59,624	6.01
	Fruit trees	154,356	15.55
	Forage crops	1,885	0.19
	Sub-total	273,545	27.56
Forestry and grass growing	Woods	458,970	46.23
	Bamboo	111,910	11.27
	Natural grasses	43,013	4.33
	Sub-total	613,893	61.84
Others		105,273	10.60
Total		992,711	100.00

Source: The aerial survey report made by the Agro-Forestry Aerial Survey Institute, Taiwan Forest Bureau in 1988 (cited in Hsu, Chien and Lin, 1991).

The percentage of slopeland used for fruit trees increased steadily (Table 9). Banana, pineapple, and longan have been the major fruit crops on the slopeland since the 1920s. In fact, banana, pineapple and citrus, including ponkan (*Citrus poonensis*, Hort. ex Tanaka), tankan and liucheng (*C. sinensis* Osbeck cv. Liucheng) were the three major fruits of Taiwan from the 1940s to the 1970s. Through the construction of the East-West Cross-Island Highway and the introduction and improvement of temperate fruits, plums, peaches, Japanese apricots (*Prunus mume*, Sieb. et Zucc.), pear, apples and persimmons were planted in high-elevation mountains and their area increased considerably (Table 5).

Through the implementation of the "Integrated Soil Conservation and Land Use Program", the planted area of other tropical and subtropical fruits, such as mangoes, sugar apples (*Annona squamosa*, L.), litchi (*Litchi chinensis*, Sonn.), pomelos and Valencia oranges have increased dramatically since the 1960s.

With advance of economic development, the profits for growing fruit crops on uplands diminish gradually in recent years. Fruit import has increased steadily since the end of the 1970s. Total planted area of cash crops on the slopeland seems to have reached the plateau and in fact the area of some of the crops decreased during the last decade (Table 5). Some of the marginal land orchards are being used for reforestation. Some others are changed to non-agricultural use, such as construction of resorts, country houses and golf courses for promoting tourism.

For accelerating industrialization and economic development in the 1950s and the 1960s, the adoption of intensive use of both land and labor in agriculture was the most feasible choice. With good policy and research, dedicated implementation, and diligent farmers, the cultivation of fruit and specialty crops, with high cash value, on the slopeland has enriched rural livelihood (Wu, 1979). In fact, the fresh fruits like banana and citrus, canned pineapple, and tea were the major export commodities and these crops helped the nation earn a great deal of foreign exchange for economic development in the early decades. However, the exports of these commodities diminished gradually. In place of it farming of tropical, subtropical and temperate fruits on slopeland increased steadily up to 1990. This indicated increasing requirement for fresh fruits in domestic market, which happened with improving living standards in Taiwan.

INTROSPECTION OF DEVELOPMENTS IN UPLAND FARMING

Even though upland farming contributed to economic growth and social welfare, it unavoidably related to the exploitation of natural resources. Several detrimental effects occur and cause deep concerns. The main features are listed as follows:

1. *Declining Biodiversity*

Taiwan is noted for its high degree of biodiversity. However, human interference and exploitation of natural resources, especially deforestation and upland farming, causes the loss or fragmentation of habitats, which is detrimental for wildlife. As a result, the diversity in the ecosystem, species and genes decreased significantly. Biodiversity is an essential element of life-supporting systems. Therefore, biodiversity could have been considered as part of the national assets and steps taken for the conservation of species in both natural ecosystem as well as agro-ecosystems.

2. *Overexploitation of Upland Resources*

It is a sorry state of affairs that much of uplands have been used either illegally or haphazardly with, little regard to slope, soil depth or potential productivity, and erodibility. Soil conservation practices were necessary but most development activities ignored these steps (Dils, 1977). Besides neglecting sustainable farming practices, farmers have been applying too much fertilizers, herbicides and pesticides. In the long-run soil erosion, sedimentation, landslides, debris flow, eutrophication of reservoirs, decreased water-holding capacity, flood hazards, chemical pollution, and deteriorated water quality will become serious public concerns in Taiwan. Also, it is doubtful that the soil fertility of these uplands can be maintained and exploited profitably forever. In fact, with increasing production costs and decreasing competitiveness recently, many slopeland orchards are being forced to scale down their operation. Furthermore, during the past decade, with the rapid development of tourism there has been shift towards non-agricultural land use of the uplands for example, so-called leisure farms in the uplands, construction of new market towns, access roads network, and golf courses. Public became concerned that this process may cause serious troubles if no

control mechanism is established. It led to promulgation of the Environment Assessment Act 1995, which is now being used for checking the overexploitation of uplands.

3. *Monotonous Landscape and Fragile Ecosystem*

Only soil conservation and increased productivity have been emphasized in the past years. Slopeland use capability classification (Table 6) can be applied successfully to differentiate those lands for agricultural use. In this way, slopelands are usually classified only on a small scale instead of regional or even watershed level (Chan, 1999). Without considering overall landscape and ecological network, this agro-ecosystem appears monotonous and is ecologically fragile.

Similar to slopeland farming, large-scale forest exploitation was practiced for timber production in the early and middle part of the 20th century. With diminishing profit for timber production and increasing environmental concern, no timber cutting was allowed from most areas of forestland since 1989. Current policy favors sustainable forest management for soil and water conservation and the richness of biodiversity (Wang, 1997). It is thought pertinent in development planning process to readjust upland use for the sustainable development of Taiwan.

FUTURE PROSPECTS AND CHALLENGES

Sustainability, defined as equitably distributed achievement of social, ecological and economic quality of life is better gained within a more decentralized structure of governance and development. The involvement of the local community is encouraged. The governance is autonomous, democratic and employs culturally sensitive participatory decision-making processes. Both humans and other species have an intrinsic right to co-evolve in local, bioregional and global ecosystem associations. Human agency is reintegrated with ecological processes, especially through careful understanding of carrying capacity, conservation and restoration of native diversity and the health of ecosystem. Furthermore, reliance on locally manufactured and maintained appropriate technology devised through an ongoing program of ecological design research, is favored (Aberley, 1999). In short, health, beauty and permanence are the goals of upland management. Based on these principles of sustainability, some important items can be included in sustainable use of uplands, especially for Taiwan:

- * In the process of pursuing economic development, overdeveloping and utilization of some parts of slopelands and forestlands result in a decline in environmental quality and loss of natural resources. From the standpoint of sustainable development, the expansion in upland development is accomplished only after a very critical analysis, i.e., with environmental impact assessment, of each parcel of land in question. Also, it is necessary to enforce the regulation to prohibit illegal utilization of uplands. Some policies or regulations could be made to encourage the conversion of intensive farming into reforestation on those marginal farms. Even some mechanism can be established to provide proper amounts of financial compensation to farmers who own or cultivate those uplands targeted for retirement (Koh, *et al.*, 1991).
- * Because farming activities in upland areas can affect natural resources and people in downstream or downslope areas, upland use and management is a complicated matter. It involves both technology and socioeconomic factors. Upland use should be considered in the context of other uses of resources that are taking place within the same watershed. A rational approach that incorporates a broad, holistic, and comprehensive perspective in planning and management of water and land resources together, is better known as watershed management (Brooks, 1998). Integrated watershed management means developing and guiding the use of land and water resources to achieve production and environmental protection goals. It requires good planning, monitoring and evaluation systems (Brooks, 1996). It also needs to strengthen the integration and cooperation of different agencies, such as the Forest Bureau, SWCB, and county governments, which are responsible for the management of different sections of a watershed. Research in integrated watershed management requires an interdisciplinary approach that includes biophysical and socioeconomic sciences (Brooks, 1997).
- * Sustainable upland farming and development should be based on bio-regionalism. A bio-region, such as watershed, biotic province, biome, or ecosystem, can be sustained if a society fosters the

institutional capacity of communities to participate and cooperate to preserve the commons. A bio-region represents the intersection of vernacular culture, place-behavior, and community. To get bio-regional, humanity needs to cultivate an ecological consciousness and communal identity, and develop relationships with the neighborhood (McGinnis, 1999). The local people should return to the place “there is”, the landscape itself, the place they inhabit and the communal region they depend on. Because of the infinite relationships possible between humans, ecosystems, and natural resources, no two sustainable landscapes are apt to look alike, particularly if they occur in different baseline ecosystems or cultures. The movement toward bio-regionalism attempts to initiate the uniqueness of local cultures and landscapes in creating a sustainable future, and runs counter to the idea of a widely dispersed, externally imposed aesthetic style (Thayer, 1994). The landscape of Taiwan’s upland is very diverse and characteristic. It is imperative to construct the ecologically sustainable landscape based on bio-regionalism with optimization approach. Agro-tourism or ecological tourism has become an important industry in Taiwan since 1990. The ecologically sustainable landscape of upland will be very attractive for the urban people. Therefore, it is beneficial not only for biodiversity but also for local livelihood.

- * It remains to be accomplished in research and development of highly efficient, effective sustainable farming practices. There is still much to be done in quantitatively assessing the impact of new solutions to potential problems of slopeland farms (Koh, *et al.*, 1991).
- * Because the use of upland influences natural resources and the welfare of downstream people, continuously educating the land users is necessary. Also, it should be extended to the public for increasing awareness of the importance of sustainable upland development. Land ethic, the concept of *Homo sapiens* is a plain member rather than conqueror of the land community, should be deeply implanted in the heart of every individual.

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2. FIJI

Taito Tabaleka Nakalevu

Senior Research Officer

*Department of Land Resource Planning
and Development*

*Ministry of Agriculture, Fisheries and Forests
Raiwaqa*

INTRODUCTION

There is a greater need today for Fiji to address the sustainability of its uplands farming systems. With the increase in population and the move towards export-oriented cropping, marginal lands are now being brought to use. In the long term this will not be sustainable and will only lead to more land degradation, to which small island ecosystems are particularly vulnerable. According to Seru (1994), land used for agriculture from 1956 to 1991 has increased by 200 percent from 178,259 to 393,272 ha. The population has also increased by more than 100 percent from 345,737 to 800,000. It is obvious from these figures that over the 35-year period more and more people have turned to the land for a living. This is alarming for Fiji considering its smallness, geographical harshness and landownership realities. Since most arable lands are now in use, the challenge is to develop an upland farming system that will be able to absorb the intensive agricultural development that is economically sound and socially and environmentally acceptable.

Farming systems research and development in Fiji is very limited in nature and scope. Much of the activities that have been carried out primarily focused on a particular agro-ecological zone of the country (wet zone). It is limited also in the sense that research work in the past was focused largely on taro (*Colocasia esculanta*) and ginger-based farming systems. Farming systems based on sugarcane, which is a major foreign exchange earner for Fiji have been neglected until recently. The traditional subsistence farming systems of the uplands, which are a major cause of deforestation, have been overlooked. With the increasing need for cash income the rural communities of Fiji, now look for farming more land and the only option available is the uplands.

A COUNTRY PROFILE OF FIJI

A country of islands, Fiji consists of approximately 300 islands with a total land area of about 18,378 km² scattered over 230,000 km² of ocean. Approximately 100 of these islands are permanently inhabited. The two main islands, Viti Levu (10,544 km²) and Vanua Levu (5,535 km²) comprise 88 percent of the total land area of Fiji.

Soils

Twyford and Wright (1965) grouped Fiji's soils into 12 major soil groups called the Great Groups (Table 1). However, under the recent United States Department of Agriculture (USDA) Soil Taxonomy Classification, the soils of Fiji fall under nine soil orders. These are: entisols, inceptisols, mollisols, alfisols, andisols, ultisols, oxisols, vertisols, and histosols. The most fertile soils are the alluvial and colluvial soils near or on the flood plains of the country's main river systems. In addition, fertile nigrescent soils are found throughout Fiji's two main islands (Viti Levu and Vanua Levu), particularly in low-lying areas of the dry zone. However, most of the areas that are currently commercially cultivated in the central part of Fiji have humic latosols and ferruginous latosols. These soils, according to Twyford and Wright (1965), are found largely in wet areas of the country and in some areas of the dry zone. These two soils have low levels of NPK, trace elements and other micronutrients. Because of heavy leaching, these soils have deteriorated when

put under intensive cropping. To obtain moderate levels of production from these soils, large inputs of fertilizer are required.

Table 1. Major Soil Groups of Fiji

Soil Groups	
A. Recent soils	1. Coastal sand – occurring on the coastline 2. Alluvial soil – of the river valleys 3. Colluvial soil – of the food slope
B. Wetland soils	4. Gley soil – of poorly drained low-lying areas 5. Saline soil – of the mangrove swamp
C. Black hill soils	6. Nigrescent – in soapstone areas, boulder/rock outcrops
D. Red hill soils	7. Latosolic soil – stony soil of volcanic ash 8. Humic latosols – deeply weathered and highly leached red soils 9. Ferruginous latosols – <i>Talasiga</i> soils, degraded humic latosols (highly erodible, infertile, dusky red soils)
E. Yellow hills soils	10. Red yellow podsolic – yellowish brown deeply weathered soils
F. Organic soils	11. Peat – decomposing plant matter developed under anaerobic conditions in water-logged areas
G. Steep land soils	12. Steep land equivalent of all hill soils in C, D and E.

Source: USDA, 1975.

Climate

Fiji enjoys a mild tropical climate with plentiful rain under prevailing conditions, although there are definite “hot and wet” (October-April) and “cool and dry” (May-September) seasons. Climate also differs between the windward (wet zone) and leeward (dry zone) coasts of the larger islands. Average annual rainfall for the wet zone ranges from 2,800 to 3,600 mm and for the dry zone from 1,300 to 1,600 mm. On all major islands, dense tropical forest covers the wet zone while the drier zones have only savannah cover. Repeated burning of the grass cover has reduced some areas to bare ground (*‘talasiga’* areas) where subsoils are often exposed. Economic planting of exotic pine and tropical hardwood species is now common in such areas.

Economy

Fiji’s economy is agriculture-based with sugar being the most stable income earner for the country. Although proceeds from tourism is now superseding sugar and other crops, majority of the population in Fiji depend on agriculture for their livelihood. The answer to many of Fiji’s problems of unemployment and urban drift is in the development of lands that are in the rural areas. Recently, Fiji’s taro export to New Zealand has increased due to the taro blight disease that devastated the taro production base in Samoa. Increases in export production have also been reported on vegetables and some tree crops (Fiji Post, 2000). The local market has also experienced an increase in taro supply. The Ministry of Agriculture, Fisheries and Forests (MAFF) through the Commodity Development Framework (CDF) and the recent Agricultural Diversification Program (ADP) had assisted in the development of agriculture in the larger rural areas with emphasis on market-oriented cash cropping and food security.

OVERVIEW OF UPLANDS IN FIJI

Fiji is a mountainous country and this is evident in the classification in Table 2, which shows that 75 percent of land in Fiji is mountainous, 14 percent undulating with gentle hilly slopes and 11 percent is flatland. Of these land types, only 19 percent is suitable for sustainable agriculture, 11 percent requires minor and 32 percent major improvement, and 38 percent is unsuitable for agricultural development. Land resources data indicate that good cropland suitable for agriculture is very limited in Fiji. Therefore, some

land types of the uplands will have to be formed if Fiji wishes to meet the food and farming demands of the country. In some cases, people are even using sorts of the (38 percent) unsuitable land type.

Table 2. Upland Area and Land Types

Land Classification	Area (ha)	Percentage
Flatlands (<3°)	200,787	11
Moderate to steep (3-15°)	255,547	14
Steep land (>15°)	1,369,000	75
Total	1,825,334	100

Source: Department of Land Resource Planning and Development.

Farming Systems

The farming systems of Fiji are largely influenced by the weather. They have been evolved to suite two agro-climatic regions, i.e., wet and dry. In the dry zones of the main islands, one finds extensive monocropping of sugarcane in the flatlands as well as on slopes up to 15 degrees. The wet zone is where most subsistence and semi-commercial and commercial planting of immature and mature ginger, taro and other root crops are primarily concentrated. With the recent interest in mahogany (*Sweetenia macrophylla*), plantations have been set up in the uplands in a system known in the agro-forestry circle as the 'taungya system'. In this system, trees and crops are planted together until such time the tree canopies close and crops are withdrawn to let the trees grow to maturity. Mahogany is mainly concentrated in the wet zone and pine (*Pinus caribea*) in the uplands of the dry zone.

ISSUES AND CONSTRAINTS OF UPLAND FARMING SYSTEMS IN FIJI

The issues and constraints to upland farming systems in Fiji vary from land tenure, lack of institutional and infrastructural support to production related problems. Although the problems are numerous, it does not necessarily deter the people from continuing to use the land for their livelihood. A recent report by Leslie and Ratukalou (1999) reiterated the call given by Seru (1994) that land used for agriculture in Fiji is increasing dramatically. What this study revealed is that more people are turning to the land for a living and also more people will need to be fed at present and in future. These developments are encouraging as well as alarming because of the fact that land will have to be made available to the people for their use. The land scenario in Fiji at present is such that, arable lands are scarce. It leaves the only option of encroaching into steeper slopes. This in most instances is out of necessity and the risk of land degradation manifesting itself in declining level of production, erosion, landslips and other related problems is evident. Like most developing countries, Fiji faces the crucial challenge of devising a strategic development plan that will ensure the long-term sustainability of upland agricultural development. Discussed below in some detail are some of the issues or constraints of Fiji's upland farming systems.

Land Tenure

Land tenure in Fiji is very complex and can be confusing to people outside the realm of Fijian landownership. Majority of land is held under customary tenure and owned by a group or clan. In this respect, not much land is free to be given out for development purposes whether agricultural or otherwise. As a result, most of the lands that are under production are being continuously and intensively cultivated. In some instances these farmlands have been degraded beyond repair. With the Agricultural Landlord and Tenants Act (ALTA) coming to an end, there is an air of uncertainty on lands that will be made available for agricultural development. Recent policy changes led to a new situation. According to this new policy Department of Land Resource Planning and Development is purchasing land on behalf of the government so as to develop infrastructure and settle ex-ALTA tenant farmers.

Small and Marginal Landholdings

This is an issue in leasehold situations, where there are several farm families living on a small piece of land. The land in the first instance was leased to the head of the household. Over time, he is forced to

subdivide the land to his sons or daughters when they are married. It is the only way they get the land for farming to earn livelihood for their families. In such instances, land is intensively cultivated and fallow periods shortened. Coupled with the dependency on inorganic fertilizers and the burning of organic matter, the result is intensive use of land, which leads to land degradation, erosion, land slips and declining yields. Ultimate result of course is food insecurity, unsustainable livelihoods and continuing poverty.

Pressure on the Production Base

More demand is now placed on the use of land to meet the needs of rising population and its increasing need for cash income. More cash need is brought about by modernization. Agriculture in particular has changed considerably from traditional communal village-level farming to more commercial, individualistic enterprises on leasehold lands and settlement schemes. The rapidly declining yields of some lands under cultivation and almost complete utilization of available most favorable arable land implies that further expansion of agriculture will take place on marginal lands. It includes both steep forested and non-forested land.

Decision as to how land is to be utilized is a complex issue because of pressures being applied to both public and private land by different government departments and private sector developers. Increasingly, flatland with easy accessibility is now being utilized for housing and industrial purposes. As a consequence, Fiji's valuable land resources are being utilized haphazardly on an 'as the situation demands' basis with very little consideration to strategic national interest for sustainable land use as a whole.

Weak Institutional Infrastructure

According to Leslie and Ratukalou (1999), the government ministries for agriculture, forestry and land use management are under resourced. They commonly lack funding, resources and trained technical staff to undertake and enforce effective environmental planning and management. As a result, even good legislation such as the Land Conservation and Improvement Act are not enforced in practice. At present, Fiji is very much maintaining a reactive role in the whole upland farming systems development. Activities have been focussed on downstream effects, such as coastal zone/floodplain drainage, rather than the primary causal factors responsible for these effects. There is reluctance to exercise legal rights with respect to bad land husbandry practices and a poor awareness of the interdependence of soil conservation on farming systems development.

Infrastructure Development

Physical infrastructure development remains relatively poor in the upland communities of Fiji. This includes roads, and other public sector services such as health centers, police, etc. In the past, agricultural development and associated infrastructure development largely concentrated on the flatland areas where agricultural intensification and mechanization was possible. However, it is now no longer adequate to cater to the increasing food needs of the country's population and for export. Production of taro and ginger are now back in the uplands, with very little infrastructure development, such as farm roads and marketing outlets.

Agro-deforestation

The term agro-deforestation is used in Fiji for the cutting down of trees to make way for agricultural crops (Thaman, 1998). This has happened due to people becoming modernized. They have accepted new values, ideas, needs and aspirations, many of that require money. As a result, the larger rural agrarian community including those living in uplands have focused increasingly on cash-oriented, income-generating crops. They meet the needs of expanding local urban communities as well as for export markets. The resulting rapid expansion of both large and smallholder commercial ventures has created a need for more land and forest clearance to make way for this mostly mono-cultural commercialized agriculture.

This agricultural development process in Fiji has led to expansion of agriculture into the uplands of the country through widespread deforestation. This is a cause for concern, because tropical forests are particularly vulnerable to agricultural clearance, especially where chainsaws or bulldozers have replaced axes and cane knives. Moreover, because of the high degree of specialization of individual species, rainforests have a low ability to recover from large-scale disturbance.

Declining Soil Fertility

Declining soil fertility is a major problem in Fiji's upland farming systems. This is evident in declining yields, decreasing response to fertilizers, poor fallow regrowth, and low earthworm populations. Farmers acknowledge that they have rotated their crops on the same pieces of land for over 30 years, giving the land very little time to rest. A survey carried out by Nakalevu (1997) reported that most people are complaining about problems of nutrient depletion and fertility decline as a major farming problem (Table 3). This is particularly with farming on the sloping lands in the country.

Table 3. Farmers' Perceptions of Agricultural Problems in the Uplands of Fiji

Position	Communal Ranking	Individual Ranking
1	Soil fertility decline	Soil fertility decline
2	Acidity	Erosion
3	Taro beetle	Taro beetle
4	Nematodes	African tulip
5	African tulip	Nematodes
6	Fusarium	Acidity
7	Pandanus insect attack	Pandanus insect attack
8	Vine weed	Vine weed

In a survey also carried out by Nakalevu, *et al.* (1999) in the sugarcane belts, they found out that farmers were getting about 154 mt of sugarcane from 6.4 ha in 1998. This is a dramatic decline from past years as they were usually getting around 350-400 mt per annum. According to the farmers, the combination of drought and declining soil depth due to erosion has severely affected their overall sugarcane production. In village situations, declining yield is now an issue. People argue that this ought not to be the case as they are largely farming to meet food security of families. Survey revealed that the cropping sequence being followed in upland farming systems is damaging the soil. Cassava, a heavy feeder of nutrients and planted 3-5 years in a temporal sequence on the same piece of land is not only detrimental but threatens the carrying capacity of the land.

Soil Erosion

In a participatory rural appraisal (PRA) carried out throughout the country on 11 communities (Nakalevu, *et al.*, 1999), all communities indicated that erosion is a problem they are facing. This is evident from Table 4, which shows a frequency of citation of problems farmers are facing.

During the analysis of the survey, a causal diagram (Figure 1) was drawn up to try and link the various causal factors of erosion in Fiji's uplands. It was found that erosion is a result of activities carried out by farmers coupled with natural biophysical factors (steep slopes, rainfall, and deforestation), biological factors (loss of organic material) and cultural factors (beliefs).

This means that the effects of high rainfall coupled with steep slope cultivation, loss of tree cover and burning lead to soil erosion or large land slips. Also, the choice of crops and the size of landholdings have limited the options that farmers have in terms of their ability to address problems of soil erosion. The causal diagram also indicates that financial constraints (e.g., hand to mouth existence, and very little savings) that farmers face have also limited their choice of crops and technologies that they could have applied to ensure proper land use.

CURRENT STATUS OF UPLAND FARMING SYSTEMS RESEARCH

Farming systems research in upland areas of Fiji is developing very slowly. With the funding provided to the Department of Land Resources Planning and Development many activities have been scaled down drastically. The two internationally supported programs, one by the International Board for Soil Research Management (IBSRAM) and the second by Pacific Region Agricultural Program (PRAP) have withdrawn their farming systems research work in Fiji. These two main programs were instrumental in providing technical backstopping and funding for some of the activities that were carried out in the country. At present, government is providing funding on the soil loss research activities and it is hoped that it will continue to receive support in future.

Table 4. Summary of Problems Identified by Community Members from the 11 Survey Areas (not prioritized)

Parameters	Frequency of Citation
Erosion	11
Lack of information and assistance on proper land use	11
Soil fertility decline	10
High cost of input	10
Lack of infrastructure	8
Lack of market and distribution centers	7
Yield/production decline	7
Sloping land	7
Weather patterns	6
Drainage	5
Flooding	5
Available agricultural land	5
Land tenure	4
Financial assistance for land development	3
Shortage of labor	3
Tools	3
Land rent	2
Logging	2
Firewood	2
Water quality	2
Pests and diseases	1
Planting material	1
Planting season	1

Soil Loss Research

The Fiji soil erosion trial has now completed phase one. The second phase will be the transfer of technology. Some of the data from the uplands of the main island (Viti Levu) are presented in Table 5. Ginger crop planted under farmers practice without any conservation efforts results in most soil loss and runoff. In 1996, during heavy rainfall, soil loss amounted to >50 mt/ha in a cropping cycle. Results point out that vetiver and pineapple intercropping is better in minimizing soil loss. The data also suggest that between vetiver and pineapple treatments, pineapple barriers are less effective compared to vetiver strips in reducing the soil loss, but pineapple does meet the short-term economic requirement of farmers.

Table 5. Annual Soil Loss (all treatments cropped with ginger)

Treatments	(Unit: mt/ha)					
	1992	1995	1996	1997	1998	1999
Farmers practice	0.53	22.60	50.02	25.82	1.73	4.29
Pineapple barrier	0.11	0.64	0.33	19.22	0.89	0.04
Vetiver barrier	0.27	0.42	0.21	0.80	0.04	0.03

Results from the trial have convinced the government that erosion is definitely a problem and more work needs to be carried out in other parts of the country with different farming systems. A recent meeting of MAFF Land Use resolved that more soil loss research would be carried out in the dry zone of the country.

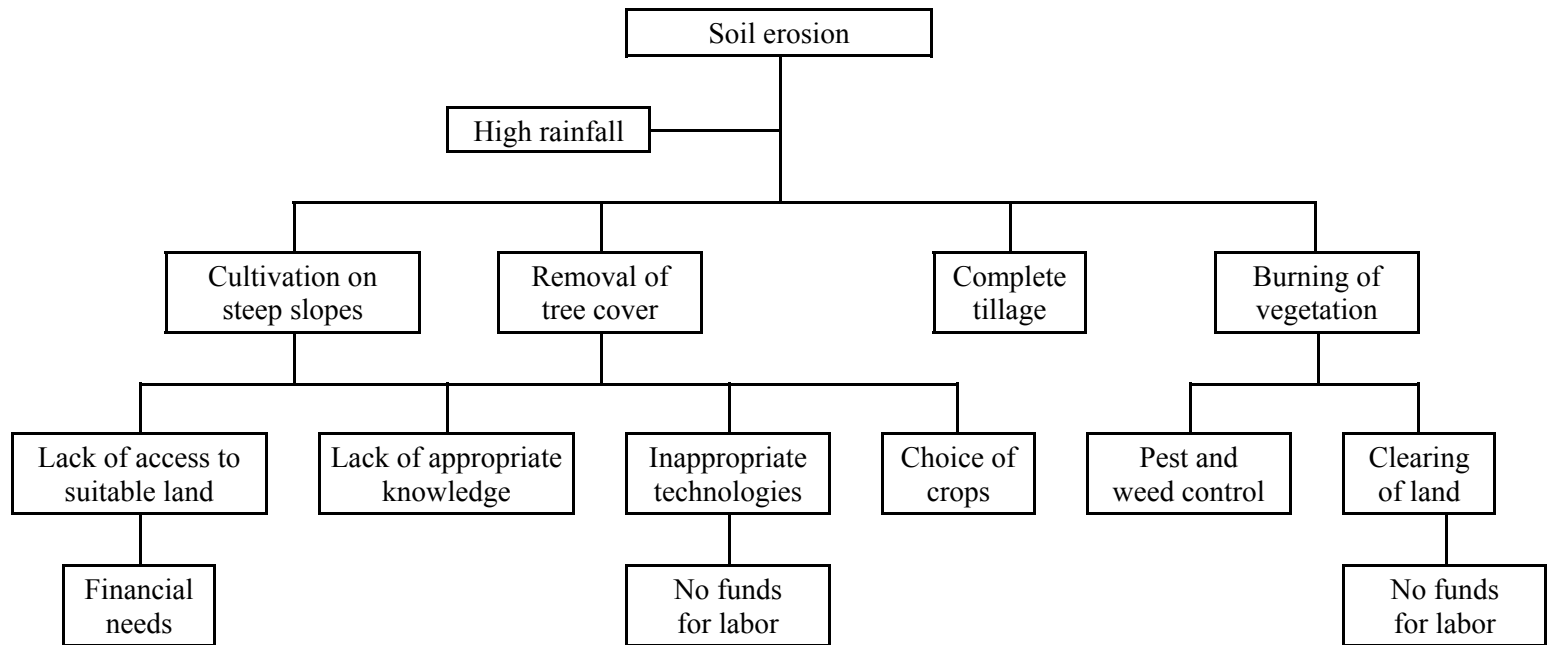


Figure 1. Causal Factors of Soil Erosion in Fiji's Uplands

Using Low Cost Technologies for Improving Soil Fertility

The PRAP brought an agro-forestry dimension into the whole farming systems approach into Fiji's uplands research. Diagnostic surveys were carried out with the people using the PRA and the Tripp and Wooley on-farm planning tool. During PRA sessions, farmers and facilitators shared and exchanged information on the major agriculture-related problems that farmers were facing (Table 3). This diagnostic survey and PRA culminated in an agro-forestry program being carried out in the wet zone of uplands of Fiji and taro (*Colocasia esculanta*)-based farming systems.

Trial results using legume trees to improve degraded lands were promising. Results showed that there was an improvement in taro yield. However, results indicated that improvements on taro yield could not have been caused by legume trees. Soil analysis indicated that there was no change in the nutrient build-up during the two-year fallow improvement period. In fact, there was a decline in available P and N levels in the soil. However, results suggest that improvements in yield from the erythrina plots may be due to the moisture retention capacity of the legume tree. Fiji was facing a drought in that year (1998). Such work has opened up new dimensions to upland farming systems research in Fiji.

RESEARCH ISSUES TO BE ADDRESSED

There is need for more on-farm trials on soil fertility improvement particularly the incorporation of leguminous species to improve regeneration on fallow land now under intensive cultivation. Performance of legumes in moderate to highly acidic soils needs to be closely monitored for a long period of time to determine the sustainability of the system. With the increase in commercial intensive market-oriented farming systems there is a need for the MAFF to devise a sustainable farming system that is compatible with the way farmers are farming at present. With eight years of soil conservation experimentation and two years of technology transfer, the Land Use Section realizes that soil conservation alone is not enough. Soil fertility has to be restored to allow a satisfactory return to farmers' labor investment.

DEVELOPMENT OF INFRASTRUCTURE AND POLICIES FOR UPLAND AREAS

The 1993 National Environment Strategy (NES) report identified several issues of major significance to the sustainability of agriculture in Fiji. The first was the inability of the government to manage natural resources on a sustainable basis, primarily due to inadequate policies, lack of legislation, poor forward planning and weak administration. The report also identified that soil degradation is becoming serious on the marginal hill lands, which are Fiji's agricultural resource base for the future. The Pacific German Regional Forestry Project (PGRFP) is developing a rural land use policy. It is expected that it will eventually lead to the formulation of a national land use policy and plan for Fiji. The document suggests that land needs to be zoned and all lands should be used according to their capabilities. The national land use plan and policy will then guide the development of necessary infrastructure where and when needed.

There is also a realization that planning alone will not be enough. Therefore, Fiji is seriously working towards approaching sustainable upland farming systems from an integrated approach to the planning and management of land resources. The need to improve and strengthen planning and coordination between institutions is fundamental to the whole process. MAFF realizes that in order for the mechanics of the process to function, the land user must be a primary actor. Farmers must have the feeling that the program belongs to them and not to the government. However, this view is not usually accommodated in many development programs.

In light of the above, the MAFF is of the view that upland farming system needs to be planned, implemented and monitored in an integrated, multi-sectoral way to ensure balanced and optimal use of resources. The means to achieve this is forestry, agriculture, industrial and urban development must be synchronized and coordinated. Bruenig (1989) suggests that for any integrated development approach to be successful, strong emphasis must be put on multi-sectoral integration to which all government and private sectors actively contribute through participation, consultation and advice.

CONCLUSION

At the beginning of the new millennium, Fiji faces a crucial challenge of devising a strategic development plan for sustainable agricultural development in upland areas. This will enable effective checking of the advancing land degradation and biodiversity loss. Socioeconomic changes in the rural scene are putting various farming systems in Fiji under increasing pressure. If the government sets no proper strategic guidelines for land use in the uplands, then in the longer-term upland farming will be seriously jeopardized. Also, the downstream environmental consequences of this degradation process will prove catastrophic in small island situation of Fiji, which has limited land resource base.

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3. INDIA

K. R. Dhandapani
Deputy Commissioner
(Watershed Monitoring), and
Bisweswar Rath
Assistant Commissioner
both Department of Agriculture
and Cooperation (DAC)
Ministry of Agriculture (MOA)
Government of India
New Delhi

INTRODUCTION

In India, agriculture is a tradition, which for centuries has shaped the thought, the outlook, the culture and the economic life of the people. Agriculture therefore, is and will continue to be central to all strategies for planning socioeconomic development of the country. Rapid growth of agriculture is essential not only to achieve self-reliance at national level but also for household food security and to bring about equity in distribution of income and wealth resulting in rapid reduction in poverty levels (DAC-MOA, 2000).

Land (soil) and water are the two basic resources required for agriculture. Under different agro-ecological zones characterized by varying temperature and rainfall levels, agriculture is practiced in lowlands and uplands in India. The uplands contrast with the region's lowlands. They are hilly or mountainous areas with steep slopes and generally poor soils (FAO-International Institute of Rural Reconstruction [IIRR], 1995; and Sen, *et al.*, 1997). While dryland agriculture is most common, the upland also contain areas of wetland rice where the topography permits irrigation. Because of their varied topography and poor soils, the uplands sustain lower populations than the more fertile lowlands. The various problems that confront the upland agriculture are as follows:

- * Degradation of natural resources (soil, water, forests)
- * Change in climate, biophysical conditions, population and technology, affecting the natural resources carrying capacity and social and economic development
- * Land tenure
- * Farmers' limited technical skills
- * Marketing of agricultural products
- * Gender issues
- * Gaps in agricultural production processes, marketing and industry in terms of regulations, technology, human resources, and physical infrastructure.

UPLAND-LOWLAND LINKAGES

Following features provide the links between uplands and low lands of India:

- * Population movements
- * Upper watersheds regulate water flow further downstream
- * Erosion causes siltation and flooding downstream
- * Lowlands provide markets for uplands.

A comparison of factors that differentiates uplands from low lands is given in Table 1.

Table 1. A Comparison of Lowlands and Uplands

Lowlands	Uplands
Biophysical Factors Flat Not subject to erosion Uniform Little remaining forests Deep fertile soils Irrigated Mono-crop rice or vegetable Intensive farming Predictable field conditions	Steep slopes Prone to erosion Varied Contain most of the region's remaining forest cover Shallow, infertile, marginal soil Dryland Complex farming systems Extensive farming Unpredictable field conditions
Socioeconomic Factors Good infrastructure Accessible Good extension service Majority culture Little ethnic variation High literacy levels Wage labor Relatively well-off Credit easy to provide Market-oriented Clear land tenure titles Land owned privately	Poor infrastructure Remote Poor extension service Minority ethnic groups Large number of ethnic groups Low literacy levels Family labor Relatively poor Credit difficult to provide Subsistence-oriented Complex land tenure status Much land owned by government
Extension Approaches Complex technology Package of technology Package provided Intensive use of chemical inputs Few NGOs involved Focus on farm system	Technology simple, promoted step-by-step "Menu" of technologies Process facilitated Use of leguminous trees and annual crops, animal manure and composting Many NGOs involved Relevant to overall land use
Vital Technologies Water supply Hybrid species Pest and disease management	Soil, water and nutrient conservation - -

STATE OF INDIAN UPLANDS

Uplands of India are located in the Himalayas, Western Ghats, Eastern Ghats and Vindhya Satpura Hills (Ministry of Agriculture [MOA], 1996). To my information, no systematic survey has been undertaken to delineate uplands in these geographic regions. Out of 328 million ha of geographic area of India, about 93 million ha is mountainous. A major part of uplands, i.e., 51.43 million ha lies in the Himalayan region. The Himalayas are the youngest chain of mountains in the world extending over a length of 2,500 km and a width of 250-300 km, covering an area of nearly 500,000 km². The Himalayan region is broadly classified into three zones, i.e., Great Himalayas (above 3,000 m elevation), lesser (middle) Himalayas, i.e., about 75 km wide belt in between 900-3,000 m and outer (Shivalik) Himalayas with average height of less than 900 m (MOA, 1996; DAC, 2000).

The northwestern Himalayan region is located in the states of Jammu and Kashmir, Himachal Pradesh, Uttaranchal and Shivaliks. The climate varies from hot and sub-humid tropical in the southern low tracts to temperate cold alpine and cold arid in the northern high mountains. The annual precipitation varies from 8 cm in Ladakh (cold desert) to 115 cm in Jammu and 50-350 cm in the hills of Himachal Pradesh. The northeastern Himalayan region spreads over an area of 17.7 million ha covering the hills of Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Assam, Nagaland, Tripura and West Bengal States. The average rainfall varies from 132.2 cm to as high as 1,200 cm with mean value of 280 cm. Out of 4.37 million ha affected by shifting cultivation, about 2.7 million ha is located in this region. The land utilization in these Himalayan States is given in Table 2 which provides the coverage of areas under irrigated and rainfed agriculture.

PAST TRENDS IN AGRICULTURE PRODUCTION

Of the total geographical area of 328 million ha, India cultivates 142 million ha of which 53 million ha is under irrigated conditions. This produces more than 55 percent of the country's food grain requirements, while the 89 million ha under rainfed conditions contributes only 45 percent of the nation's food grains (Sharma, 2000). Over the last 30 years the average spread of irrigation is around 4 million ha per five years. Extrapolating this trend, it is projected that about 20 million ha of additional cultivated area is to be brought under irrigation in the next 25 years. This will leave 69 million ha still under rainfed conditions.

Indian agriculture has, since Independence, made rapid strides in taking the annual food grains production from 51 million mts of the early 1950s to 206 million mt at the turn of the century. It has contributed significantly in achieving self-sufficiency in food and in avoiding food shortages in the country. The pattern of growth of agriculture has however, brought in its wake, uneven development across regions and crops as also across different sectors of farming community. It is characterized by low levels of productivity and degradation of natural resources in some areas. Capital inadequacy, lack of infrastructural support and demand side constraints such as control of movement, storage and sale of agricultural products, etc. have continued to affect the economic viability of agriculture sector. Consequently the growth of agriculture has also tended to slacken during the 1990s. Agriculture has also become a relatively unrewarding profession in the uplands due to generally unfavorable price regimes and low value addition. It is leading to abandoning of farming and migration from rural areas (Sinha, 1994; and DAC-MOA, 2000d).

RAINFED UPLAND FARMING

It is important to recognize that the Green Revolution in India was largely confined to the irrigated areas. The rainfed regions were largely bypassed by it. In uplands irrigated agriculture is practiced only in small pockets, and most of the area is under rainfed conditions. Rainfed agriculture is characterized by low levels of productivity and low input usage. Being dependent on rainfall, crop production is subjected to considerable instability from year to year. More than 200 million of the rural poor live in the rainfed regions. These risk-prone areas exhibit a wide variation and instability in yield. Gap between yield potential and actual yields are very high compared to irrigated areas (Sinha, 1994; and DAC-MOA, 2000d). Dominant rainfed farming systems in the uplands are agri-horticulture, agro-forestry and silvipastoral systems.

WATERSHED APPROACH TO UPLAND FARMING

The Government of India has accorded the highest priority to the holistic and sustainable development of rainfed areas through integrated watershed approach. The integrated management of watershed represents the principal vehicle for transfer of rainfed technology.

A watershed is a geographic area that drains to a common point which makes it a suitable planning unit for technical efforts to conserve soil and maximize the utilization of surface and sub-surface water for crop production. A watershed is also an area that contains socioeconomic, administrative and crop boundaries, lands that fall under different property regimes and farmers whose actions may affect each others' interests. Socioeconomic boundaries however, normally do not match biophysical ones. In watershed management projects, mechanical or vegetative structures are installed across gullies and hills and along contour lines and

Table 2. Land Utilization in the Himalayan States

(Unit: 000 ha)

State	Geographical Area	Total Cropped Area	Area under Horticulture	Area under Forests	Total Irrigated Area	Permanent Pasture and Grazing Lands	Land under Miscellaneous Crops	Cultivable Wastelands	Fallow Lands
Arunachal Pradesh	8,374.3	196.1	8.0	5,750	-	-	35	47	81
Assam Hills	1,522.2	237.8	-	942	-	184	250	107	177
Himachal Pradesh	5,567.3	974.8	149.3	874	173.0	1,158	40	130	68
Jammu and Kashmir	2,223.6	1,025.0	160.0	2,747	405.0	123	75	152	89
Manipur	2,232.7	220.0	22.3	602	65.9	-	24	-	-
Meghalaya	2,242.9	223.7	54.7	812	50.9	17	145	454	312
Mizoram	2,108.1	63.7	7.6	1,303	-	4	3	74	442
Nagaland	1,657.9	181.3	1.5	288	55.5	-	202	62	359
Sikkim	709.6	92.0	-	257	-	69	5	1	13
Tripura	1,048.6	38.0	30.0	578	6.1	-	98	47	81
Uttar Pradesh Hills	5,112.5	1,102.8	170.0	3,436	359.0	272	208	319	57

areas are earmarked for particular land use based on their land use classification. Erosion-prone, less favorable lands are under perennial vegetation. This approach aims to optimize moisture retention and reduce soil erosion. Improved moisture management increases the productivity of improved seeds and fertilizers, so conservation and productivity enhancing measures are complementary.

Excess surface runoff water is harvested in irrigation tanks while sub-surface runoff recharges groundwater aquifers. So, conservation measures in the upper waters have positive impact on productivity in the lower watershed. The watershed approach helps planning all types of land uses in all allocations and seasons. In India this approach has been adopted since early 1970s to develop and improve productivity of rainfed areas in sustainable manner.

SOIL AND WATER CONSERVATION PRACTICES IN UPLANDS

For improving the productivity and production in uplands through soil and moisture conservation, different practices have been followed (FAO-IIRR, 1995; and Sen, *et al.*, 1997), namely; bench terraces, composting, contour tillage/planting, cover crops, crop rotation, diversion ditches, drop structures, grass strips, hedge rows, minimum tillage zero tillage, mulching, ridge terraces, shifting cultivation, soil barriers, soil traps, and water harvesting.

INTEGRATED UPLAND FARMING SYSTEMS MANAGEMENT

Prescriptive models and packages of technology are seldom transferable from site to site. Conditions within watersheds and even within communities are generally too diverse for top-down models to be applied at the farm level. Apart from agro-ecological diversity, there is a diversity of clients to address large- and smallholder farmers, marginal farmers, the landless, rural industry workers, shopkeepers, town people and urban dwellers – all with different socioeconomic and cultural characteristics and needs. Table 3 indicates the checklist of influences for upland resources management, which is self-explanatory.

Agro-forestry is the dominant sustainable farming system, being followed/advocated in upland management (Sinha, 1994; MOA, 1996; and Wari, 2000). It is the deliberate growth and management of trees along with agricultural crops and livestock in systems that are ecologically, socially and economically sustainable. More simply, agro-forestry is the use of trees in farming systems. The villagers in hilly areas normally own 0.1-1.0 ha of the land and adopt sophisticated land management patterns to get all the benefits from limited land, i.e., food crops, fodder, fuel wood, and cash crops. As such, the existing agro-forestry systems in the Himalayas can be broadly classified into three categories, i.e., need-based systems, economy-based systems, and environment-based systems.

Models of agro-forestry systems for upland and lowland conditions with the main emphasis of tree-based agro-forestry systems in the upland and agricultural crop-based systems in the lowlands show that on cultivated lands, the primary system of land management should be horticulture with sequential integration of agricultural crops as horti-agricultural system, horti-silvicultural system and horti-silvi-agricultural system.

POLICY ISSUES AND CONSTRAINTS

Importance of watershed development approach is well-recognized now for sustainable development of uplands (DAC-MOA, 2000b). National agricultural policy of India supports watershed approach for comprehensive development of rainfed areas of the country (DAC-MOA, 2000d). A common approach for watershed development has been formulated to keep uniformity in area development. It is being followed now in all schemes operated in the country (DAC-MOA, 2000a). Detailed operational guidelines have also been developed for use by implementing agencies (DAC-MOA, 2000c).

Some of the policy issues and constraints that confront rainfed farming are as follows:

- * Strengthening people's participation in watershed development
- * Focus on appropriate technologies for watersheds
- * Research aspects of watershed technology and management
- * Resource mobilization for watershed development

Table 3. Upland Resource Management: A Checklist of Influences

Socioeconomic Factors	Production Enterprises	Farm Households	Conservation Practices	Biophysical Factors
Marketing * Markets (local/external) * Merchants/cooperatives * Transport/roads Support Services * Credit, farm supplies * Research/extension Government Policy * Policies/incentives * Rules/regulations Tenure * Land/crop/tree tenure * Distribution of benefits Labor Allocation * Off-farm employment * Age/gender workload * Cottage industry Culture/Attitudes * Food security needs * Prejudices and values	Permanent Vegetation * Grasses * Fodder trees * Fruit trees * Fuel wood trees * Timber/pulp trees * Industrial crops Annual Crops * Grain/legume crops * Tubers * Vegetables/mushrooms * Flowers/ornamentals * Industrial crops Livestock * Draft power * Dairy production * Meat production * Egg production * Fish, snails	* Skills * Values * Age and gender of members * Land size * Education * Family size * Aspirations, goals and priorities * Savings * Tools/equipment * House * Subsistence/cash-based * Nutrition * Tolerance to risk * Debts/liabilities * Social status * Expectations * Other sources of income	Structural Practices * Bench terraces * Ridge terraces * Contour tillage/planting * Minimum tillage * Drop structures * Diversion ditches * Water harvesting * Fish ponds * Check dams * Sediment traps * Soil barriers * Irrigation Vegetative Practices * Mulching * Slash-and-burn/no burn * Composting * Crop rotation * Grasses on risers/slopes * Hedgerows on contour * Cover crops * Windbreaks * Fallow management * Wood lots	Climatic Conditions * Rainfall and distribution * Temperature * Altitude * Risk factors (typhoons, droughts, floods, etc.) Slope * <7 percent * 7-15 percent * 15-30 percent * >30 percent Soil * Acidity * Organic matter * Nutrient status * Depth * Ease of cultivation * Drainage status Biological Factors * Pests/weeds/diseases * Pollinating agents

- * Capacity-building and human resource development
- * Sustainability of projects
- * Monitoring and evaluation and impact assessment
- * Strengthening linkages between land conservation and production system
- * Reclamation of other problem soil
- * Government programs and NGO efforts.

MAJOR WATERSHED DEVELOPMENT PROGRAMS

The following are some of the major watershed development projects being implemented in India:

- * National Watershed Development Project in Rainfed Areas
- * Watershed Development in Shifting Cultivation Areas
- * Soil Conservation in the Catchments of River Valley Projects and Flood Prone Rivers
- * Integrated Wasteland Development Project
- * Drought Prone Area Development Program
- * Desert Development Program
- * Watershed Development Fund.

Besides, several watershed development projects funded by foreign agencies on bilateral basis such as World Bank, Denmark, U.K., Germany and Netherlands Governments are being implemented in the country.

CONCLUSION

The uplands contrast with the regions' lowlands. They are hilly and mountainous areas with steep slopes and generally poor soils. Agro-forestry is the dominant sustainable farming system being followed in uplands management. Watershed development approach is adopted to manage these uplands in the Himalayas, Western Ghats and Vindhya Satpura Hills of the country. Adequate policy measures and common guidelines have been formulated to follow watershed approach in the management of uplands in India.

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4. INDONESIA

Haryanto

*Head of Agricultural Macro Policy Planning Sub Division
Bureau of Planning and Foreign Cooperation
Ministry of Agriculture
Jakarta*

COUNTRY PROFILE

In Indonesia, about 30 percent of the land, i.e., 58 million ha is under agriculture (Table 1). About 13 percent of this land is very productive and is under irrigated rice systems. The lowland agriculture is supported by well-developed infrastructure such as roads, markets, electricity, water supply, agricultural supply shops, health clinics and schools. However, the area under irrigated rice system cannot be increased. Instead, there is increasing trend of using cropland for non-agricultural purposes. Therefore, potential for any future increase in agriculture production will depend on using the remaining 87 percent (around 50 million ha) of upland or rainfed land (Table 1).

Table 1. Distribution of Land Types in the Islands of Indonesia

(Unit: 000 ha)					
Island	Lowland	Upland	Other	Total	Percent of Total Area
Jawa	3,561	5,887	3,771	13,219	6.9
Sumatra	1,923	14,463	30,977	47,363	24.8
Kalimantan	973	7,992	45,035	54,000	28.3
Sulawesi	772	5,821	12,502	19,095	10.0
Papua	9	10,444	31,747	42,200	22.1
Other island	376	5,403	9,290	15,069	7.9
Total	7,614	50,010	133,322	190,946	100.0
Percent of land area	4.0	26.2	69.8	100.0	
Percent of agricultural land	13.2	86.8			

Source: Annual KUF Project Report 1999/2000.

At present, only 18 million ha of the uplands are being used, while more than 30 million ha are either under fallow or wild land. In addition to their low fertility status, the uplands are also characterized by diverse traditional agricultural systems. These uplands often have poor infrastructure, severely limiting farmers' access to agricultural supplies, services and information. The fragile upland soils are vulnerable to degradation when forest cover is cleared.

SUSTAINABLE UPLAND FARMING ISSUES

Growing population pressure and economic expansion have led to deforestation and increase in cultivation intensity that has gone beyond the regeneration capacity of soils. It has led to a decline in soil fertility, increased erosion and land degradation.

In the upland areas physical and social infrastructure is weak and agricultural services have to be provided to scattered farming population. Here no single agricultural technology package can be applied. Besides the government sector, non-governmental sector also plays an important role in addressing the problems of agricultural development. However, there is poor understanding of sustainable agricultural development. So institutional capacity-building is a prerequisite for sustainable development of farming in Indonesia.

MEASURES FOR SUSTAINABLE UPLAND FARMING SYSTEMS

To build sustainable farming in upland areas of Indonesia, efforts have been made to increase the management capabilities of decision-makers, personnel of government institutions and community self-help institutions in-charge of the management of agricultural development. Good example of these efforts is the special focus in Kalimantan area. It is expected that this approach will succeed in contributing to sustainable agricultural production and management of natural resources.

The program gives full attention to the problems and potentials of farm households. The participation of rural communities in planning and implementing the activity is fully encouraged (bottom-up planning). Furthermore, previously developed methods and instruments are consolidated, refined and disseminated.

INITIATIVES ON SUSTAINABLE FARMING IN UPLAND AREAS: EXAMPLE OF KALIMANTAN PROJECT

Introduction

There are many ways to adopt a better approach for developing sustainable agriculture in the uplands. Besides focusing on technical aspects such as application of integrated pest management, it is important to work for improving the management capabilities of decision-makers, government institutions and community self-help institutions.

In this regard, Department of Agriculture and Federal Ministry of Economic Cooperation and Development of the Federal Republic of Germany are jointly implementing the Kalimantan Upland Farming Systems Development Project (KUF). This project started in 1991. The project aims to improve the performance of people in governmental and non-governmental organizations in managing agricultural development. It is hoped that it will improve delivery of services to the target groups. In doing so the project will achieve the project goal that is “*smallholder farmers in upland areas of Kalimantan farm in a sustainable manner and increase their agricultural production*”. The project program has focused on following activities:

- * Improving annual and mid-term agricultural development planning
- * Compiling and using technical information sets (*Kumpulan Informasi Teknis* = Collection of Technical Information or KITs)
- * Supporting agricultural extension
- * Empowering farmers’ groups.

This project is divided into three phases. During phase I (1991-94), emphasis was placed on the development of concepts, methods and tools related to farming systems development. During phase II (1994-97), the project embarked more on the dissemination of new tools and methods through training and backstopping, but still did considerable work on developing, testing and adjusting tools and instruments. The last phase (phase III, 1997-2002) has been focusing on tools adjustment, dissemination, backstopping and institutionalization. A considerable effort was made during the last two years on incorporating new methods and tools into government program that targeted at reviving the economy hit by the serious economic and social crisis of 1997.

Main Activities and Achievements

Output 1: Participatory Annual and Mid-term Agricultural Development Planning

The project supported agricultural development planning in order to revert the current planning process from a top-down to a bottom-up approach. Through the introduction of participatory tools the main stakeholders of agricultural development were involved. New agricultural development planning processes accommodated specific regional requirements as brought in by farmers living in these areas.

At the end of phase II and the beginning of phase III manuals were worked out and tested for annual and mid-term (five years) agricultural development planning. Moderators and facilitators were trained to handle the new methods and they were also coached during fields’ application.

The tools on annual agricultural development planning (in Indonesia called as *Rakorbangtan*) have meanwhile been fully incorporated into the working mechanisms of partner organizations. The tools consist of two- to three-day workshop at district level. It is attended by representatives of agricultural and natural resource line agencies as well as the district planning board and other related governmental institutions. Participants work out and agree on priorities of an agricultural development plan of the district area. While political representatives from sub-district level have been already part of the planning process for the last few years, the involvement of private sector and non-governmental parties has been a new introduction to the planning process encouraged by the project.

There were hardly any activities with mid-term agricultural development planning tool. The main reason for the stagnation was that Indonesia was passing through a transition period during which general elections were performed in May 1999 and a new government formed in October 1999. Even after the formation of the new government there was still quite some insecurity on how the policymakers wanted to proceed. On top of this the government was prioritizing the implementation of various crash programs that aimed at reviving the economy in the short term. Since planning insecurities were high, therefore mid-term development planning under the project did not appear to make so much sense.

For the remaining period of the project two issues might be tackled. One is to support further dissemination of the tools through training courses, backstopping and coaching. The second concerns the decentralization process. The planning tools might need further revisions depending on special requests from districts.

Output 2: Compiling and Using Location-specific KITs

The complete title of **Output 2** reads: “Based on recently developed, location-specific information KITs (compilation of technical information), relevant partners in the agricultural agencies are enabled to compile additional information KITs in a participatory approach with farmers, and the KITs will be utilized in agricultural extension for smallholders in upland farming”.

In agricultural technology development, up till now the thinking has been top-down. Innovations were developed by research while extension had to find the ways of transferring them from research institutions to farmers’ field. This attitude is changing now. First lot of useful innovations made by farmers themselves enrich the indigenous knowledge base. This process of farmers’ experimentation needs to be strengthened. Secondly, if researchers work with farmers from the very beginning, their research work becomes farmer-centered, location-specific, and more successful. This project tries to support this new approach. Three activity groups were supported by the project in this context:

- * Developing information sets on improved location-specific agricultural technologies
- * Conducting the SebarFos on farm trials
- * Supporting application of comprehensive upland farming systems models.

Compiling Location-specific KITs: This activity started in 1995. Meanwhile a number of very encouraging results have been achieved. This project together with three projects worked out a procedure on how information sets called as KITs can be worked out in cooperation with various agricultural development line agencies, extension system, research institutions and the farmers. The procedure itself was laid down into a manual in 1998. Totally, seven KITs have been produced up to 2000. Some fresh ones are:

- * KIT on home gardening developed in South Kalimantan
- * KIT on rubber-based cropping systems in East Kalimantan
- * KIT on soil fertility management for acidic upland soils.

SebarFos On-farm Trials: Improved location-specific technologies are tried by farmers in the on-farm trials, in about 20 plots in four villages of West and South Kalimantan. The on-farm trials were set up in 1997 and consist of two comparisons: one containing the farmer’s practice, while the second one showing improved treatments. The improved treatments comprise measures such as soil conservation (on slopeland), soil fertility management, use of improved seed or planting material, and improved pest management. The on-farm demonstrations vary between villages. However, they all have in common the use of rock phosphate, which is much cheaper than super phosphate and which releases phosphate more slowly and in sustainable way. Because of this common feature of all on-farm trials, they were called SebarFos, meaning disseminating the concept of using rock phosphate (*sebarluaskan fosfat alam*). In South Kalimantan some women farmers have also been included as on-farm collaborators.

Results from the on-farm trials are very encouraging. Yields and farmers' income have gone up by 30-50 percent, respectively. Also income is fairly stable over the three years' period.

SebarFos trials are being implemented on national level in five provinces. Program partners include West and South Kalimantan, West Sumatra, Lampung and Jambi, one national institution, i.e., Center for Soils and Agroclimate (Puslittanak) in Bogor and one international institution, i.e., the Potash and Phosphate Institute (PPI) based in Singapore renders advice.

Since SebarFos was established three years ago, a lot of interest has been raised for rock phosphate and the accompanying technology (new varieties, conservation measures). The new technology has greatly contributed to the intensification of maize production in Tanah Laut, South Kalimantan and to a lesser extent to other crops.

Supporting Adoption of Comprehensive Upland Farming Systems Models: The project has supported the adoption of upland farming systems development models (Model *Usahatani Lahan Kering*) in South and East Kalimantan with good progress. In each model, nearly the entire village is included into support measures. About 100 farmers on 100 ha per village are involved. Support measures extend from farmers' group planning, giving technical training courses on crop husbandry as well as courses in saving and credit operations. Support measures are provided in integrated approach whereby subject matter specialist, extension workers and motivators from NGOs work hand in hand. A good impact on improving agriculture and on the village economy has been observed in the two villages that adopted this development model.

By and large activities under **Output 2** have been successful, and targets have been reached. Thus the direct field activities of the project may come to an end now. However, partner organizations are encouraged to take up the project experiences and to apply them on a larger scale. In this respect, the project should give support within the framework of coaching and backstopping partner organizations in applying methods of participatory technology development.

Output 3: Agricultural Extension Support

The complete title of **Output 3** reads: "The agricultural extension centers (Indonesian: *Balai Penyuluhan Pertanian* [BPP]) and district agricultural officers are enabled to implement exemplarity a farming systems-based and demand-driven extension approach".

Within the framework of activities concerning **Output 3**, the project focuses on revitalizing the agricultural extension service. In 1996, the Ministry of Agriculture (MOA) created important new frame conditions that transferred the extension worker from a sub-sectoral function into the role of general agricultural extension service advisor. This is very much in line with the philosophy of the project. It considers farming household as a unit of various subsystems, which has to be looked at from a holistic point of view. Extension workers have meanwhile been transferred to the newly created district extension centers in all areas, which are supported by the project. The project has been busy in developing tools that identify the needs of the farmers and that develop extension programs from the bottom in a participatory way and in turn support the new extension approach. The main important new tools consist of four sets:

- (a) The identification of farmers' needs;
- (b) Facilitating farmers' groups to work out plans;
- (c) The participatory compilation of agricultural extension programs, and
- (d) The assembly of the extension workers' work plan.

The need to develop a fifth set on participatory monitoring and evaluation has been voiced, but so far no time was found to actually work it out. The four above-mentioned tools were developed and tested as early as 1997/98.

The wider use of the new methods is increasing. In the project area the methods are already used in 60 sub-districts (against an original plan of six) of seven districts. Records show that 250 work plans of extension workers and nearly 300 work plans by farmers' groups were prepared using the new methods. Such methods are also being used outside of Kalimantan in another three provinces with support from other development aid.

The great progress has been achieved so far. The tools, which were planned to be developed at the start of phase III have been successfully developed, introduced and their application is way beyond of what was imagined at the beginning. In this respect, it can be concluded that activities have been successfully accomplished.

Output 4: Empowerment of Farmers' Groups

The complete title of **Output 4** reads: "Partner organizations are enabled to utilize the tested self-help development concept(s) to promote commercially-oriented men and women farmer groups in cooperation with third sector organizations".

The project continued to support self-help development measures of farmers' groups through NGOs as well as through the agricultural extension service for the last year. During the reporting period, three NGOs and several extensions centers supported more than 82 farmer groups with 2,600 members, among which 23 percent were women. These figures are below last year's figures. Some old farmers' groups supported in previous years were reported as sufficiently self-sustainable and did not need any more assistance. After satisfactory completion of work in December 1999, all contracts between the project and the partner NGOs expired.

All training tools that were developed for farmers' group empowerment have been consolidated during the last two years. A handbook was produced that consisted of the following set of six modules:

- * Principle of self-help;
- * Farmers' group organization;
- * Agricultural enterprise organization;
- * Household economics;
- * Simple accounting and financial controlling; and
- * Off-farm income operations.

The consolidated handbook was utilized in training with 30 participants in November 1999. Besides agricultural extension workers, motivators of NGOs and private sector companies participated in the training.

During phase III the project supported substantial number of farmers' groups through NGOs and agricultural extension agencies. Whether these supported farmers' groups became self-reliant is yet to be seen. For many of them the chances are good. The credit and saving of some farmers' groups have not developed yet as expected. However, to a great deal circumstances (high risks and shortage of cash) were unfavorable for credit and saving operation during 1997-98.

By and large activities of **Output 4** have been successfully accomplished. Monitoring and some backstopping of farmer partner NGOs shall continue. The concept of farmers' group empowerment shall be further disseminated to other potential users.

Activities Across Project Output

1. Participatory Result and Impact Monitoring and Evaluation

Since the start of phase III much concern was voiced by the German funding agency as well as from the counterpart side to assess the project's performance with respect to achieved results and impact. Therefore, during 1997 and 1998 a concept for Participatory Result and Impact Monitoring and Evaluation (PRIME) was worked out and implemented. Major field exercises were undertaken in April 1999 and June 2000. In these field activities external consultants as well as various key counterparts from national and regional level were involved as facilitators. They moderated a series of workshops, group sessions and individual interviews of all project stakeholders (people working in governmental and non-governmental organizations responsible for promoting agricultural development among the target group, i.e., small-farmers in upland areas of Kalimantan) to assess the performance of the project. Results from this exercise have been quite positive and laid down in three major reports.

2. Supporting National and Regional Crash Programs

To a certain extent the project continued contributions to national (e.g., *Gema Palagung* 2001) and regional (e.g., *Gerakan Olah Bebaya Bumi Hijau*) crash programs that were designed to quickly revive the economy and to restore agriculture. The project especially supported planning and monitoring activities. During the difficult period, agriculture was indeed an important sector, which brought the economy back on track and to that extent project made meaningful contributions.

3. Supporting New Districts in Kutai, East Kalimantan

German Agency for Technical Cooperation (GTZ) was approached to support the newly formed districts in Kutai and it agreed to take steps in West Kutai. Two major planning workshops have meanwhile taken place. KUF is one of five GTZ-supported projects, which are part of this initiative. Additionally,

several NGOs and private sector companies have agreed to team up. KUF takes the lead with respect to promotion of agricultural development measures. In the remaining time of the project period substantial efforts are envisaged for new Kutai districts, in particular West Kutai.

Project Organization

The project is run through steering committees and working teams at national and regional level. GTZ has maintained offices and staff on each of these levels to keep close proximity with partner organizations. While during phases I and II much emphasis was placed on developing and testing new concepts, methods and tools, this was reduced during phase III. It instead emphasized on dissemination, application and backstopping. Therefore, GTZ staff and resources were reduced to make place for counterpart organizations to take up stronger role.

Actual reduction of GTZ staff and resources started in the beginning of 1998/99. Two of the three expatriate experts finished their assignments. Three local GTZ experts of a total of 10 completed their duties. Permanent offices in the districts of Sanggau and Kutai were closed in September 1998 and the provincial offices in West Kalimantan in December 1998. However, from January 1999 to June 2000 a backstopping office was maintained in Pontianak.

Due to the decentralization process and the new laws concerning decentralization (Law Nos. 22 and 25 of 1999) on the side of the MOA important structural changes have taken place or are about to take place. One development is that the MOA Office at regional level (Kanwil Deptan) will be closed in 2001. On national level Directorate Generals and other main bodies are being reorganized too. NGOs and private sector parties have become more and more important project partners. This has an important bearing on membership and structure of the KUF working teams and the steering committees on all levels. This should all be reflected adequately in a new project structure during the prolongation period of the project.

Counterpart resources (staff and funds) from government organizations as well as from NGOs and private sector parties need to be propped up in order to substitute the gradually reducing role of German agency.

During the next two years the GTZ component will confine itself more towards the role of a backstopper and coach. The remaining expatriate advisors will gradually reduce their role within the GTZ team starting from January 2001 until they leave the project in July 2001, while Indonesian GTZ staff will further move to the fore. Implementation will move fully into the hands of counterparts. Joint results and impact monitoring mechanisms will need to be strengthened.

CONCLUSIONS

- * The main problem to develop sustainable farming systems in upland areas in Indonesia lies with isolated and scattered nature of settlements, farmers and their agricultural activities.
- * Constraints related to the diversity of ecological regimes and socioeconomic environment coupled with poor physical infrastructure in the uplands further slow down the development efforts.
- * Uplands do not need one uniform agricultural technology; it rather needs area-specific approaches.
- * Active participation of upland farming communities, NGOs and government is prerequisite to promote sustainable farming systems development in upland areas.

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5. ISLAMIC REPUBLIC OF IRAN

Valiollah Habibi Bastami

Director

Project for Border Rivers Development in Iran

Planning and Economic Research Institute

Tehran

COUNTRY PROFILE

Iran is a mountainous country with an area of 1,648,000 km². The total area covered by mountains and uplands is estimated to be almost half of the country's area, deserts cover quarter of the total area and the remaining comprises the arable land. Because of its topographical situation, Iran has a diversified range of climatic conditions, but in general it has a continental type of climate, which is true for the major part of its interior. Temperature varies from place to place and season to season. The interior deserts of Iran are amongst the hottest in the world, but mountains play important role both in lowering temperature and generating water for downstream.

Though the average temperature in the country is about 18°C, with maximum and the minimum temperature range +50°C and -30°C. Rainfall is limited to cold months of the year and is distributed unevenly. The average annual rainfall for the country is 240 mm. The exception is the Caspian Sea area, which receives rainfall throughout the year with the average annual precipitation over 1,400 mm.

AGRICULTURE

Agriculture sector plays an important role in the economy of Iran. It is endowed with over 50 million ha of arable land, 130 billion m³ of annual harvest of potable water, 102 million ha of rangelands and forests, abundant aquatic resources, and diverse climates. Iran has skilled manpower and access to new technology.

At present agriculture directly supports about 75 percent of the food requirement of the country and about the same percentage of raw materials needed by industry. It contributes 26 percent of GDP, 25 percent of total non-oil export value, and 24 percent of the total employment.

UPLANDS

Iran is a mountainous country. Mountains and uplands cover almost half of the country. The upland area is characterized by steep slopes and generally poor soil. It is supporting about 90 million ha of rangeland and about 12 million ha of forests, and considerable area of rainfed agriculture. Due to its topographic situation, poor soils and climatic conditions, upland area sustains less population as compared to lowland and the plains of the country. In the upland area, rainfall changes with the change in elevation. In most of the upland area large part of precipitation is received in the form of snowfall. Therefore, uplands are also a source of water supply to the downstream lowland.

Current Situation

Throughout the country, mountains and uplands are an important source of water, energy and biological diversity. They are a source of key resources such as minerals, timber and fuel wood, contributing to food security by providing important agricultural products. In spite of the environmental, economic and socio-cultural importance, most upland areas of the country have been relatively excluded from the mainstream development process in the past decades.

At the same time, their natural resource base has been depleting. Poverty and environmental degradation are now widespread in upland rural communities. Some of the most important factors contributing to problems encountered in Iran's upland areas include:

- * population growth;
- * fragile upland ecosystems;
- * limited cropland;
- * low crop yields;
- * expansion of agricultural land into forestland;
- * disadvantaged market conditions;
- * limited job opportunities to farmers;
- * degrading rangelands and scarcity of livestock feed;
- * lack of proper infrastructure and services; and
- * lack of participation of indigenous people.

These factors highlight the vicious cycle in which upland communities are currently trapped. Lack of opportunities for social development has led to unsustainable exploitation of natural resources. As a result, it invited top-down interventions leading to further misuse of resources. Most experts currently believe that the sustainable development in upland areas of the country is only possible with integrated watershed management.

Farming Systems in Upland Areas

Farming systems depend largely on the conditions under which farmers are operating. For centuries agriculture including farming, horticulture and livestock production has been the source of economy and livelihood of upland farmers of Iran. The main determining factors in farming systems include landholding rules, and management of land and water resources.

Before 1962 land reform, most lands was owned by landlords and worked by tenants. At that time following six types of land ownerships were dominant:

1. State-owned lands;
2. Royal land owned by royal family;
3. Vaflands (endowed for religious purposes);
4. Large landlords;
5. Small landlords; and
6. Collective ownership (as practiced by nomadic people).

Peasants owned less than 5 percent of the total arable lands. After land reforms and redistribution of land to farmers most peasants received very small parcels of land. About 65 percent of the farmers received less than 5 ha, about 27 percent got 5-10 ha, and the rest above 10 ha. Land reforms also led to an increased socioeconomic stratification within the upland rural population.

Smallholders with less than 3 ha of land, made about half the population, and had a quarter of land. About two-thirds of private farming households hold less than 5 ha of land, and each landholding is further subdivided into an average of 15 plots. In fact the size of cropland given to these farmers was not enough to sustain their livelihoods. As a consequence of land reforms, land fragmentation became a big issue. This land fragmentation seriously impedes agricultural development in upland areas where conditions are much worse.

Upland areas of Iran are characterized with steep slopes, severe erosion, depleted forest coverage, degraded rangeland, poor infrastructure as compared to low land areas, and marginal soils mostly under rainfed crops. In most upland areas, cropping is strongly associated with animal husbandry. Due to steepness, most farmlands are prone to erosion. Both grazing and depletion of vegetative cover contribute greatly to erosion and loss of soil fertility.

Farming System Research

Upland farming systems are constrained by complex factors of biophysical, socioeconomic and political nature. Production alternatives and investment on inputs are restricted by recurrent drought and

flood risks. Small fragmented landholdings, water shortage, seasonal inadequacy of labor and manpower, unfavorable market pressure, lack of sufficient credit and other support services including price policies have suppressive effect in the farming systems' productivity. Lack of appropriate agricultural technologies has further weakened farmers' capacity to improve farming systems.

Taking into account the low productivity of agriculture in the uplands, the systems approach in agricultural research is an imperative. The agricultural research is being pursued through a network of centers involving the agricultural research and extension organizations.

Past Research Efforts

Various agricultural research institutions, prior to the present organization, conducted research rather independently and usually within the framework of the research stations. Each station pursued crop specific research in different disciplines with the norms and regulations of supporting agencies. Different projects were conducted separately as independent schemes without interdisciplinary approach and multi-sectoral consideration. Though some experiments were conducted in farmers' fields, farmer participation in research process was minimal. In limited instances they were used as source of information for surveys and interviews.

It may be noted that the socioeconomic component of farming system was inadequately addressed, because most of the government institutions lacked expertise in this area. The training component on research methodologies and system prospective was poor. There was also lack of communication not only among research, extension and support services, but also within research teams. Therefore, these drawbacks led to adoption of holistic approach through multidisciplinary contribution to upland farming system development.

ISSUES NEEDING ATTENTION

Based on recent estimations, the amount of soil erosion in Iran is about 33 mt/ha which means that considerable area of cultivated land is lost each year because of soil degradation. Land fragmentation and rapid population growth especially in upland areas have accelerated soil and environmental degradation. In addition, increasingly new marginal land area is being brought under cultivation and this new land is mostly in upland at higher elevations.

Development of rainfed farming in marginal upland areas and deforestation have accelerated the problem of soil degradation. The high rate of soil degradation indicates that there is no concrete policy to encourage farmers to conserve soil, while increasing population are putting pressure on the land resource base. Costs associated with soil erosion and natural resource degradation are very high. Such costs can be classified into two broad groups namely; on-farm costs and off-farm costs.

On-farm Costs

This type of problem is basically associated with the farming systems and with loss of soil nutrients and productivity. The costs involved are usually borne by the farmers themselves. Such costs provide personal incentives for adoption of practices to combat soil erosion.

Off-farm Costs

These costs are associated with the problems that are created outside the farmers' land, such as sedimentation of dams and waterways in the downstream sides and contamination of drinking water. The costs of such problems are transferred to other members of the society.

Though for many years soil conservation was a main issue in the country and many heavy structures have been built in upland areas to prevent on-farm and off-farm damage, there are many reasons, why soil conservation projects in Iran have not been so successful. The farmers often have been viewed as one of the factors to be changed or, in more extreme cases, constituting the problem so to be removed. Farmers are seldom interested in programs that have few short-term benefits, uncertain long-term benefits and involve additional costs and risks. Soil conservation should be an integral part of general agricultural development and should start with improved farm and production. Therefore, there should be fundamental changes in philosophy and the approach used by soil conservationists and research institutions. The new approach should aim at land husbandry, rather than soil conservation.

The change in approach will involve a change in mind-sets. Farmers and their environment should be the focal point of these programs rather than treating land only for soil conservation.

Farming Systems Development Approach

The traditional approach of soil conservation in Iran is a top-down method. It adopts purely technical approach treating soil erosion symptoms through applying technical strategies.

New government policies envisaged in third development plan, however, give top priority to farmer's participation requiring a bottom-up process. It is understood that part of the reason for advocating this bottom-up method in the new soil conservation approach was a result of past failures in getting farmers to adopt soil conservation practices.

6. REPUBLIC OF KOREA

Dr. Jin-Chae Yoo

Professor

Department of Agricultural Economics

Chungbuk National University

Chungbuk

INTRODUCTION

Unlike in several other countries of Asia where agriculture is expanding, especially so in the uplands, in Korea industrialization, urbanization and enhanced incomes of people have started a reverse process. The agricultural land has reduced by 346 thousand ha in Korea during the last 33 years (1965-98), by the rate of 10.5 thousand ha per year. In uplands, farming was abandoned in over 217 thousand ha during same period. Cropland abandonment was at 6.6 thousand ha per year. Population of farmers decreased by 11.4 million during the same period. But, agricultural capital input increased drastically. Farm machinery increased 21.9 times over 28 years (1970-98) and fertilizer input increased by 2.5 times during the same period (Table 1). Korean agriculture became more intensive through increasing use of machinery, chemical fertilizers and pesticides (Table 2).

Table 1. Agricultural Land Use Pattern in Korea

(Unit: 000 ha)

Year	Agricultural Land			Forest	Others	Total
	Paddy	Upland	Sub-total			
1965	1,286 (13.1)	970 (9.9)	2,243 (22.9)	6,614 (67.2)	973 (9.9)	9,763
1970	1,273 (12.9)	1,025 (10.4)	2,285 (23.3)	6,611 (67.1)	939 (9.6)	9,768
1980	1,307 (13.2)	889 (9.0)	2,183 (22.2)	6,568 (66.3)	1,135 (11.5)	9,820
1990	1,345 (13.6)	764 (7.7)	2,095 (21.3)	6,476 (65.2)	1,341 (13.5)	9,847
1997	1,163 (11.7)	761 (7.7)	1,912 (19.4)	6,441 (64.8)	1,571 (15.8)	9,860
1998	1,157 (11.6)	753 (7.6)	1,910 (19.2)	-	-	9,941

Source: Ministry of Agriculture, 1999.

Note: Figures in parentheses are percent to total.

Table 2. Population and Farm Input

	No. of Farmers (000)	Farm Machinery	Chemical Fertilizer
1965	15,812 (55.1)	-	
1970	14,422 (44.7)	153	162
1998	4,400 (9.5)	3,349	406

Source: Ministry of Agriculture, 1999.

UPLAND FARMING

Current Status

In the upland, the area of food grains such as barley and wheat, beans, potato, and miscellaneous cereals has substantially shrunk. On the other hand, area under cash crops, i.e., vegetables and fruits has remarkably increased (Table 3).

Table 3. Two Decades of Changes in Cropping Pattern

		(Unit: 000 ha)			
Crops		1970	1980	1990	1998
Grain	Rice	1,203	1,233	1,244	1,059
	Barley	833	360	160	83
	Wheat	97	28	0.3	1
	Soybean	358	244	188	120
Special Use Crops	Sesame	25.8	48.7	58.3	52.8
	Potato	54	37	21	23
	Sweet potato	127	55	19	16
Fruits	Apples	21	46	49	35
	Pears	7	9	9	25
	Grapes	6	8	15	30
	Peach	12	10	12	12
	Seville oranges	6	12	19	26
Open Culture	Radishes	66	49	35	32
	Cabbage	71	48	44	41
Horticulture		4	18	40	82

Source: Ministry of Agriculture, 1999.

The cultivation of particular type of vegetables such as red pepper, garlic, green onion, onion, etc. has increased to the extent that it now accounts for 20 percent of the total upland area. Overproduction of horticulture has led to the problem of marketing and lesser incomes resulting from fall in prices.

Because of continuous farming of vegetables, the land productivity is falling. Since vegetables have low absorptivity of nutrients and supply little organic matter, they have added to problems of soil salinity, loss of nutrition, and frequent disease infestation such as blight, harmful insects, and eelworms. The excessive use of pesticides has led to environmental contamination, poor food safety and human health problems (Table 4).

Table 4. Comparative View of Crop-wise Farm Inputs in Korea

Plant	Rice	Soybean	Red Pepper	Strawberry	Apple
Seed	50 kg	65 kg	1 liter	90,000 (plants)	1,600 (hill)
Labor (hour)	347	635	214	8,106	3,210
Fertilizer (kg)	212	94	451	358	435
Chemical pesticide (kg)	7.6	-	-	21	-
Management expenses (₩ 000)	1,979.6	998	3,467	26,701	8,667

Source: K. T. Jong, *et al.*, 1996.

The production trends of grains (barley and miscellaneous grains), leguminous grains, and potatoes have disturbed crop rotation system, otherwise important from soil fertility viewpoint (Tables 5 and 6).

The farming system has also undergone a change. Food crop-oriented farming system such as barley + beans and barley + sweet potatoes, which dominated the system previously have been abandoned in favor of cash crop-oriented farming systems. More popular crop combinations are tobacco + radish, strawberry + cucumber, red pepper + vegetables, etc.

SUSTAINABLE UPLAND FARMING PROBLEMS

Upland farming systems should reintroduce grain crops like beans, corn, and barley before and after the growing of vegetable cash crops. The change is needed to curb the accumulation of soil salinity. The crop rotation system, which allows grain crops' farming for 1-2 years after 3-5 years of vegetable farming needs to be introduced by all means. The paddy fields, which were converted into greenhouse farming, also need

Table 5. Crop Rotation System by Region in Korea

Region	Grain Crops	Potatoes	Miscellaneous Cereals	Beans	Vegetables	Industrial Crops
Kyonggi province	Barley, wheat	Potato, sweet potato	Corn, millet, barnyard grass	Soybean, grass bean, pea, cowpea, French bean, red bean	Lettuce, Chinese cabbage, cabbage, spinach, leak, radish, pumpkin, garlic, onion, cucumber, tomato, pepper, carrot, strawberry, stone-leak	Flax, sesame, sunflower, cotton
Kangwon province	Barley, wheat	Potato, sweet potato	Corn, millet, Indian millet, barnyard grass	Soybean, pea, cowpea, red bean	Chinese cabbage, cabbage, radish, cucumber, pepper	Sesame, peanut, sunflower, tobacco
Chungbuk province	Barley, wheat	Potato, sweet potato	Corn, millet, Indian millet, barnyard grass	Soybean, grass bean, pea, cowpea, French bean, red bean	Lettuce, spinach, radish, pumpkin, garlic, pepper, strawberry	Sesame, tobacco
Chungnam province	Barley, wheat	Potato, sweet potato	Corn	Soybean, pea, French bean, red bean	Chinese cabbage, radish, pumpkin, garlic, pepper, strawberry, stone-leak	Sesame, tobacco
Cholbuk province	Barley, wheat	Potato, sweet potato	Corn, millet, buckwheat	Soybean, French bean	Lettuce, Chinese cabbage, cabbage, spinach, radish, garlic, cucumber, pepper, carrot, strawberry, melon, watermelon, stone-leak	Flax, sesame, peanut, cotton
Cholnam province	Barley, wheat	Potato, sweet potato	Corn, buckwheat	Soybean, French bean	Lettuce, cabbage, spinach, radish, garlic, onion, cucumber, tomato, pepper, stone-leak	Flax, sesame, peanut
Kyongbuk province	Barley, wheat	Potato, sweet potato	Corn, buckwheat	Soybean, pea, French bean	Chinese cabbage, cabbage, spinach, pumpkin, onion, cucumber, tomato, pepper, carrot, strawberry, watermelon	Flax, sesame, peanut, rush
Kyongnam province	Barley, wheat	Potato, sweet potato	-	Soybean, pea	Chinese cabbage, garlic, onion, cucumber, strawberry, watermelon, melon, stone-leak	Flax, sesame, tobacco
Cheju province	Barley, wheat	Potato, sweet potato	-	Soybean	Chinese cabbage, spinach, pumpkin, onion, pepper	Sesame

Source: K. T. Jong, *et al.*, 1996.

to be cropped sometimes with rice. It will change pure greenhouse farming to rice + greenhouse vegetable farming. However, adoption of selected farming face resistance/reluctance of farmers, because farmers are reluctant to adopt the new crop rotation systems due to low profitability of grain farming. It may be necessary to adopt direct payment system, which internalizes the external economy of the winter crop rotation system. This may facilitate shifting to vegetable + grain crop rotation systems.

Table 6. Transformed Crop Rotation Pattern in Uplands of Korea

Dominant Crop System		Crops and Cropping Pattern
Beans	Beans	Pea-green bean
	Wheat and barley	Green bean-wheat, soybean-wheat
	Potatoes	Potato-soybean, sweet potato-pea
	Vegetables	<u>Two-crop Farming:</u> Green bean-garlic, soybean-onion <u>Three-crop Farming:</u> Soybean-radish-cucumber (stone-leak) <u>Four-crop Farming:</u> Radish-Chinese cabbage-onion-soybean
	Miscellaneous cereals	Soybean-corn
	Industrial crops	Soybean-tobacco
Potatoes	Wheat and barley	Sweet potato-wheat, sweet potato-barley
	Miscellaneous cereals	Potato-corn
	Vegetables	<u>Two-crop Farming:</u> Potato-garlic, potato-tomato <u>Three-crop Farming:</u> Potato-radish-potato
	Industrial crops	Tobacco-sweet potato
Miscellaneous cereals	Wheat and barley	Corn-wheat
	Vegetables	<u>Two-crop Farming:</u> Corn-radish, corn-Chinese cabbage <u>Four-crop Farming:</u> Corn-radish-radish-Chinese cabbage
Vegetables	Wheat and barley	Cucumber-barley
	Vegetables	Pepper-spinach
	Industrial crop	Sesame-garlic, sesame-onion, Chinese cabbage-sesame-radish
Industrial crop	Wheat and barley	Sesame-wheat, sesame-barley

Source: K. T. Jong, *et al.*, 1996.

MEASURES FOR PROMOTING SUSTAINABLE FARMING IN UPLAND AREAS

Techniques for the Low Input-High Profitability Crop Production

- * Techniques for integrated management of nutrition
- * Techniques for integrated control of insects and pests
- * Better ways for mulching and culture.

Introduction of Crop Rotation

- * Growing green manure crops like hairy vetch, rye, rearing the green field
- * Soil preservation by adoption of surface crops
- * Promoting varieties with high resistance.

RESEARCH AND DEVELOPMENT FOR UPLAND FARMING

Best Management Practices

Use of best management practices (BMP) is a measure to reduce non-point source pollutants. It has site-specific characteristics, so BMPs differ one region to another. To attain certain water quality standards,

farm management practices, cropping systems and cultivation practices will have to be reassessed and adjusted accordingly (Table 7).

Table 7. Efficiency of BMPs to Protect Underground Water Pollution

BMP	Degree of Effectiveness*		
	Pesticides	Nitrates	Salt
Structural Measures			
Irrigation systems	N	M	H
Chemigation back-siphon devices	H	H	N
Animal waste storage	L	M	L
Sub-surface (tile) drainage	N	M	M
Point-of-use treatment	H	H	H
Cropping Systems			
Critical area planting	H	M	N
Cover cropping	H	M	M
Low-input farming	H	M/L	N
Farm Management Practices			
Integrated pest management (IPM)	M	N	N
Animal waste management	N	H	L
Fertilizer management	N	M	L
Pesticide management	H	N	N
Irrigation management	M	H	H
Focusing on sensitive groundwater areas	H	H	H

Source: K. T. Jong, *et al.*, 1996.

Notes: * H = high, M = medium, L = low, and N = none.

STRENGTHENING AGRICULTURE – LIVESTOCK-FORESTRY LINKAGES FOR EVOLVING BETTER ORGANIC CYCLING SYSTEMS

The modern agriculture relying on mass production cuts off the organic cycling relationships and pollutes the environment. Therefore, the reconstruction of an organic cycling system using agriculture, livestock and forestry linkages is important to develop sustainable agriculture. In order to construct the types of cycling system, there will be need to change the concept of development. The priority of agricultural development policy should be placed on the cycling principles of nature rather than on human being itself.

Agriculture and forestry can be linked by compost making from grass, leaves, wood chips, and sawdust. Between livestock and crops, organic fertilizer made of livestock manure can be used to link two sectors, while materials such as feeds, made of sawdust and liquid manure, can link livestock and forestry. To introduce successful organic cycling system, proper policy instruments are necessary. There will need to introduce supporting policy to reduce the managerial instability of farms that may occur in the transferring process of production system.

VALUE OF UPLAND FARMING

- * Flood control function
- * Fostering of underground water
- * Atmosphere cooling effect during the hot summer days
- * Soil loss prevention effect
- * Preservation of social and cultural values.

AGRICULTURAL POLICIES FOR UPLAND AREAS

Compensation Policy for Adopting Low Input Sustainable Farming Practices

Payment of system designed to compensate farmers for using low input farming practices and observing other restrictions are necessary to protect upland environment. The government is already spending ₩5.7 billion for 18,000 farmers for adopting low input farming over 10,572 ha. Compensation payment system reduced quantity of fertilizer and pesticide applications by 48 and 37 percent, respectively as compared to uncontrolled farming practices.

Supporting Program for Model Village

Government spent ₩725 million for developing 16 model villages, which adopted IPM and Integrated Nutrient Management (INM) farming practices since 1999.

Other Programs for Supporting Environment-friendly Farming

- * Subsidies for use of 450,000 mt of slow releasing fertilizers in 1998 and 830,000 mt in 1999
- * Soil testing of 211,000 samples from farmers' fields implemented to advise farmers on exact fertilizer use on their farmlands
- * Supported program for animal manure recycling and purification facilities for 4,686 animals
- * Other soil conservation and recovering programs.

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7. MONGOLIA

Ph. Dr. Jamsran Chuluunbaatar

Head of Horticulture and

Plant Protection Department

Mongolian State University of Agriculture

Ulaanbaatar

Mongolia, with a population of 2.2 million people has a territory of 1,530 thousand km². It is situated in the heart of Central Asia. The country's western, northern and northeastern parts are upland areas. Valleys in between mountains located at a height of 750-1,200 m above sea level are suitable for farming. Mongolia's eastern territories are steppes. The southern part comprising one-third of whole territory of the country is a desert, which is not suitable for cultivation due to lack of water. Forest area covers 10 percent of the country's territory and arable land is 1.7 million ha, i.e., only 1 percent of its total geographic area.

Pasture animal husbandry dominates farming in Mongolia. Here livestock numbers 33 million. Farming tradition is not common, but it has been introduced and made popular for the past 40 years. The country has 1.2 million hectares of cropland. Over 90 percent of this cropland is under wheat. The remaining less than 10 percent is used for growing potatoes and vegetables. Seventy-five percent of total sowing area is in central sowing zone located in central, northern and northwestern parts of the country, which produces 80-83 percent of harvests. In this zone farming is done in between 640 to 750 m above sea level. There are brown and light brown soils with a 20-25 cm humus layer and with 2.5-3.0 percent humus content.

Annual average temperature is 0.5°C, the lowest temperature is in January (-21°C), the highest in July goes up to 18.3°C. The number of annual non-frost days is 80-100. The period of getting the soil warm up to 5°C at the depth of 0-20 cm begins from 20 April. Annual average precipitation is 260-300 mm. Winter crops and potatoes and vegetables (mainly cabbage, turnip, carrot, and onion) are sown early because of short vegetative season. Grain and fodder crops, and potato cultivation do not require irrigation, but for vegetables, fruits and berries irrigation is required.

During 1960-90 the farms engaged in grain, potato and vegetable production activities were state-owned, managed by government and large agricultural joint-stock units. The state-run grain farms and agricultural units had 10-30 thousand ha of farmland.

From the beginning of 1990s the large state farms have been privatized and reorganized into grain farms, each having 1,000-3,000 ha of farmland. There are also smaller farm enterprises owning from 2 to 10 ha. They grow potatoes and vegetables. Farmers engaged in potato and vegetable growing have increased in number for the past few years.

During the course of socioeconomic reforms in Mongolia in 1990s, the agriculture sector was in deep crisis, along with other sectors of economy. Agricultural production dropped sharply because of poor technology, and lack of equipment and machinery supply (Table 1).

Table 1. Annual Harvests of Major Food Crops

Crops	1986-90	1991-95	1996-2000
Wheat	638.0	403.5	194.1
Potato	127.4	67.6	56.4
Vegetables	46.2	20.4	35.3

In 1996 Mongolia harvested 225 thousand mt of grains, 47 thousand mt of potato and 22.6 thousand mt of vegetables. This means that grain harvest dropped by 3.4 times, potato by 2.7 times and vegetables by two times as compared to the annual average harvest volume of 1985-90 period.

Per capita share of potato, vegetables and fruit in Mongolia is 12, 9, and 0.4 kg, correspondingly, i.e., 4.5-12 times less than consumption needs. Therefore, Mongolia has to import potatoes, vegetables and fruits to meet the needs of the population.

In 1996 the number of unemployed people in Mongolia reached 55.4 thousand, i.e., 2.5 percent of total population. About 20-25 percent of the total population lived under absolute poverty. In order to improve the economy the nation-wide movement for development of farming started in 1987. It focused on the improvement of conditions for good crops' farming in Mongolia, up to the year 2000. The aim was to make nation and people food secure, and to increase family incomes by increasing production of potato, vegetable and fruits. This nation-wide program focused on following activities:

- * To grow all kinds of vegetables, fruits, berries, grains, mushrooms, herbs, and tea plants that can be cultivated in Mongolia
- * To extend vegetative season of the plants
- * To increase early and total harvest volumes
- * To develop greenhouse farming
- * To process agricultural products and store them with minimum losses
- * To develop pig breeding, poultry raising, beekeeping and rabbit breeding.

The National Council headed by the Minister of Food and Agriculture defined the basic orientation of this project and its implementation policy. It also managed nation-wide implementation of the project. The capital city and local branches of the Council headed by city and local Deputy Governors were involved in implementing the sub-projects.

PROJECT IMPLEMENTATION AND RESULTS

In Phase I of the project (1998-2000) 30 percent families in cities and settlements were to start growing potato, vegetables, fruits and berries. In the second Phase (2000-05) percentage of people involved in farming is expected to rise up to 50 percent.

More than 100 agro-parks have been set up in the cities, *Aimag* and *Soum* (provincial administrative and territorial units) centers. These parks are used for technology demonstration, training and expert advice. Agro-parks have glasshouses, experimental stations, premises for training, training appliances, manuals, books and reference books, small instruments and equipment. US\$105 thousand were allocated from the state budget for setting up these agro-parks.

Project Financing

During 1998-2000 the government allocated US\$506,000 for the project activities. In addition, 6,638 families and 78 economic units have been granted US\$214,000 worth of soft loans from different sources.

International Assistance and Support

International organizations are giving assistance and support to the project in different ways. Some of them are providing seeds, while others, e.g., World Vision, UN Permanent Representative Offices are undertaking comprehensive measures. Important aspect of outside support also includes organizing special training program to help families in vegetable and fruit production activities.

Main Objectives of the Project

1. *Raising Living Standards and Increasing Incomes of the People*

Over 50 percent potato and vegetable farms grow vegetables on land area of less than 300 m² size. Vegetable harvests from these plots are sufficient to meet family's own needs. Although the size of land plots under crops, types of crops and harvest volumes of families are different, a family owning a 650-m² land plot, on an average, earns about US\$522. Families with farmlands of 1.5 ha can earn up to US\$9,800 from vegetables and fruit farming. It is quite an income in Mongolia. Cost-benefit studies of vegetable farming show that a considerable amount is spent for buying seeds. Cost of cultivation of 1 kg vegetable is about

US\$0.03-0.05. Also, small family farms harvest 1.5-3 times more crops from a plot unit and at a lower cost than large companies and farms.

The basic objective of the farming project is to raise living standards and to increase incomes of the people. Since people themselves are interested in improving their income, there is wide participation in the project. About 77.4 percent families involved in the opinion poll answered that they joined the project so as to find ways to improve their living standards through farming, and 14.8 percent people saw the project as source of income through service.

Forty thousand families, which never grew vegetables and fruits were now interested to do so. They were given plots in 1998, when project implementation started. By 1999, 2,347 farm companies/enterprises and 106,045 families were enrolled by the project countrywide. About 43.7 percent of these families (or 13,247) were poorest of the poor. In 2000, over 30,000 new families were brought under the project umbrella and given land plots. According to the statistics, today, about 30 percent of all families in Mongolia, and 40-56 percent of families in rural settlements are enrolled in the project to become new farming class of Mongolia.

According to the 1998 statistics, annual average income of a family was about US\$846. If annual income of families growing potato, vegetable and fruit on 301-500 m² land plot, and income of family growing food grain on a 501-1,000 m² plot were computed, the values indicate that farming families with 0.5 ha plot were earning about US\$2,046 per annum.

2. *Poverty Alleviation and Unemployment Reduction*

In 1997 the rate of growth of poor population was 54.9 percent, which dropped to 5.7 percent during 1997-99 period. According to the 1998 statistics, 30.3 thousand poor families and 13.2 thousand poorest families were enrolled in the farming project. This accounts for 41 percent of all families involved the program. The assured increase in income levels of these families indicates that the project helped reduce the number of absolute poor in Mongolia to a certain extent.

Possibilities for the Development of Farming

The central and northern parts of Mongolia (one-fourth of country's territory) are the most suitable areas for developing of potato, vegetable, and fruit growing farms because of comparatively favorable natural and climatic conditions and developed infrastructure.

Western and northwestern regions of Mongolia (one-fourth of country's territory) are upland areas located at a height of 1,200-2,000 m above sea level. Vegetative season or growth period of plants is short (60-80 days). These are sparsely populated and there are few settlements. Cropping is not a common tradition in this zone of pure pastoralists. A major part of the local population is engaged in animal husbandry. Road and transport conditions are poor. The areas are not well-connected to markets and urban areas.

Eastern and southern parts of Mongolia have relatively low height (700-1,000 m). Vegetative season of plants is comparatively long (95-130 days). There are few rivers, and precipitation is low. Annual precipitation amount ranges between 60-100 mm. The soil is not suitable for potato, vegetable and fruit growing. It is practically impossible to develop farming in these areas for the reasons that population is sparse, infrastructure is underdeveloped and traditionally local people are not doing farming. Therefore, it is planned to develop farming mainly in the central and northern regions of Mongolia, where there are many rivers, river valleys are vast, mountains are rather low and soil is good. These conditions are very favorable for potato, vegetable and fruit farming with the use of irrigation.

There is over 20 thousand ha of area in river valleys. It has well-developed irrigation system including water-sprinklers. Unfortunately, a considerable part of this farmland remained abandoned for several years. Therefore, there is need to rejuvenate these arable lands. Besides the capital, there are some other big cities in this region. Railway connecting the Russian Federation and the People's Republic of China passes through the capital, and a number of cities having asphalt roads along the railway route are connected to the railway network. The region has centralized power system, population density is high, and the local people traditionally are engaged in land cultivation.

There are many large farm companies in this area, which specialize in grain, potato and vegetable production. They have plenty of available farmland, seeding and other agricultural equipment and machinery. The companies are well-equipped with material and resources, including technical facilities, potato and vegetable storehouses and cellars, etc.

There are scientific and research institutions engaged in potato and vegetable seed production in these regions. But their activities are limited just to production of seeds of few kinds of vegetables such as potato, cabbage, turnip, carrot, onion and garlic, and to producing their new varieties. Seeds of all other vegetables are imported. However, farmers have no experience of controlling potato, vegetable, and fruit diseases and pests. They cannot identify plant diseases and pests, and do not know biological features of the latter. Farmers mainly use few types of imported pesticides. Families growing more potatoes and vegetables than they need for personal consumption face market problems. The opinion polls among farmers highlighted a variety of problems. About 27.2 percent highlighted availability of markets for their produce as a key problem, 20.8 percent faced transport problem to reach markets, 4.8 percent were far away from the markets and 27.2 percent farmers reported marketing competition from imported potatoes and vegetables. Since a potato and vegetable yields per ha are relatively low (Table 2).

Table 2. Annual Average Volume of Potato and Vegetable Harvest

Crops	(Unit: mt/ha)	
	1991-95	1996-2000
Potato	85.5	73.2
Vegetables:	78.5	76.7
Cabbage	194.9	190.5
Turnip	74.1	72.4
Carrot	43.8	42.8
Onion	30.6	29.9
Others	89.0	87.2

Poly-houses are becoming popular for increasing harvest per unit land area. In the past three years, the government has spent US\$28 thousand on the procurement of iron frames for poly-houses and plastic roofing materials. As a result, over 100 poly-houses each covering floor space of 50-100 m² were constructed.

CHALLENGES FACING FARMING PROMOTION PROJECT

Improvement in Food Supply Structures and Consumption Patterns

- * Develop and promote cultivation of new less cultivated vegetables such as leguminous plants, green vegetables, cucumber, tomato, pepper, and increase varieties of vegetables
- * Help public catering establishments acquire expertise and popularize new vegetables
- * Advertise new vegetables and their uses
- * Generate public interest in these new vegetables, processing technologies and recipes
- * The key focus of the project is on conducting effective training programs for new class of farmers.

Provision of Good Quality Seeds to Farmers

- * Primarily grow large amounts of seeds of new varieties of potatoes, vegetables and fruits, selected by scientific and research institutions of Mongolia so as to meet farmers' seed requirement
- * Support technology development and demonstration of seed production of less known/new crops of vegetables such as cucumber, tomato and pepper.

Improvement in Water Supply

- * Conduct surveys of water sources, which can be used for watering vegetables and fruits
- * Restore and improve irrigation systems and water springs, which were in use before
- * Register virgin and long-fallow lands, which can be irrigated and hand over these areas to new farmers and help them settle there
- * Channel government support for development of production and import of ordinary small water pipes, water hoses (plastic, light metal, and synthetic ones), instruments, equipment and water pumps suitable for Mongolia's water supply conditions and working with the help of wind energy and internal combustion engine.

Development of Hothouse Farming

- * Make various designs of hothouses, hotbeds and tunnels
- * Channel government support for import of different kinds of hothouses frameworks and roofing materials.

Reduction in Use of Chemical Pesticides

- * Reduce use of pesticides by developing and promoting IPM and other biological control measures for controlling plant diseases and pests
- * Promote use of organic pesticides
- * Channel government assistance to scientific and research institutions for producing microbiological preparations.

Appropriate Land Policies

- * Take strict measures including the imposition of multiple additional taxes and confiscation of land of those who instead of farming are leasing the farmland to others
- * Grant soft loans and to reduce land and income taxes of those farmers who protect and restore fertility of their farmlands.

Provision of Agricultural Support Services

- * Set up joint product sales cooperatives of farmers
- * Create trade networks for transport, storage and marketing of farm produce.

Provision of Farmers with Storehouses and Cellars

- * Facilitate assistance of professional construction organizations to farmers for helping them in designing and building potato and vegetable storehouses and cellars
- * Channel government support to help farmers in acquiring vegetable processing technologies in domestic conditions for vegetable drying, pickling, souring and canning.

8. PAKISTAN

Dr. Bakht Roidar Khan

*Chief Statistical Officer/
National Coordinator (Oilseeds)*

Oilseed Research Programme

*National Agricultural Research Center (NARC)
Islamabad,*

Muhammad Iqbal

*Extra Assistant Director of Agriculture (Extension)
Peshawar Agriculture Extension Department*

Government of NWFP

Peshawar, and

Zabta K. Shinwari

*National Herbarium, NARC
Islamabad*

UPLANDS OF PAKISTAN

The upland areas in Pakistan constitute 60-65 percent (high uplands, 22-25 percent; and low uplands, 38-40 percent) of the total land area and support about 10 percent of the total population (140 millions) of the country. These areas have always been neglected and marginalized for development activities due to a number of reasons. First, they are not easily accessible because of difficult terrain. In Pakistan, upland area can be divided into three hydrological units, namely; the upper Indus system, the closed basins of Balochistan and the northern coastal drainage region. Upper Indus system comprising Northern area, North-West Frontier Province (NWFP), Northern Punjab and Azad Jammu and Kashmir (AJK), constitute the most important and complex watersheds in Pakistan. The dry arid regions vary in topography, vegetation, rainfall, farming systems and available water resources. The human perception of dryness also varies regionally depending upon people's economic activities and the confidence they have in the technology available to mitigate the negative effects of dryness on their livelihoods (Tennakoon, 1986). Based on land use, two broad categories of people can be recognized.

- * People living in the villages in valley bottoms who are mostly landowners, and most of them possess smallholdings to make a living out of farming
- * People living on hill tops who are often landless, and their livelihoods depend on livestock husbandry.

Many upland areas in Balochistan, NWFP, Northern areas and AJK lie in the shadows of the monsoons and are therefore, classified as dry and cold. They receive variable but more precipitation in winter than in summer. The temperatures are low especially at high elevations, which receive snowfall in winter.

There is great agro-climatic diversity due to altitude (Table 1). From farming viewpoint uplands are divided into two categories: 1) single crop area; and 2) double crop areas.

Women play a key role in farming systems of the hills and uplands of Pakistan. Yet, despite their activities in crop production, animal husbandry, forestry, water management, and postharvest food production, women have been overlooked by those responsible for the formulation and dissemination of technologies, services and policies aimed at assisting rural dwellers in the uplands. Consequently, the development of technologies specifically tailored to women specific tasks and involvement of rural women in the development and transfer of such technologies have received inadequate attention from research, training, and extension departments of government.

Table 1. Productivity Zones of Pakistan

CVP Index Class	Areas Included	Geographical Region	Type of Vegetation	Ideal Site Class (in /ha)
0-25	Indus valley	Indus plain	Desert shrub and grasses, scattered trees near cost, on hill ranges or in sandy tracts	0
25-100	Quetta Division, N. Chitral, Gupis, Gilgit, Skardu, Chilas, Leh, Kargil, Ziarat, Arghun, Harboi Hills of Kalat, Chaman, Qila Abdullah, Pishin, Miransha, Takh-i-Sulaiman, Shahrig, Harnai, Musakhel, Sulaiman Range around Fort Munro	Northwest highlands, northern uplands, northwest arid highlands, northwest uplands	Tropical thorn forests, dry temperate, dry subtropical	0-8
100-200	Pasrur, Gujrat, Fatehjang, Attock, Swabi, Nagarparkar, Malakand, Kalam, Southern Chitral	Northern uplands and coastal strip, northern highlands	Tropical thorn forests, dry temperate and subtropical	1-6
200-300	Southwest corner of Swat and southern Dir	Northern foot hills	Tropical thorn forests, dry subtropical and tropical deciduous	2-1
300-500	Central Swat, Parachinar and Fort Lockhart, Chakdara	Northern foot hills	Dry subtropical chir forests	2-5
500-1,000	Abbottabad, Galis, Kaghan, Murree Hills	Moist hills	Subtropical chir and Himalayan moist temperate	2-8

In view of the fast increasing human population, we need to exploit all sorts of potentials to enhance agricultural productivity. The upland ecosystems and the prevailing farming systems therein need to be studied and improved on sustainable basis for meeting the needs of local people and national interests.

Among the fruit and nut crops, apples, peaches, pears, apricots, plums, cherries, walnuts, peanuts and almonds are cultivated in various degrees as cash crops under wide array of agro-ecological conditions of the uplands. For example, Hindu Kush-Himalayan (HKH) region has monopoly for growing temperate fruits. One may include several types of subtropical and tropical fruits also in the category of hill fruits. These are cultivated in the hills for the comparative advantage of late maturity and off-season marketing benefits. Besides fruits, a variety of temperate off-season vegetables have also become known for their high value farming potential. These include tomato, cauliflower, capsicum, peas, potato, ginger and garlic. Two or three crops of many of these vegetables are grown in a year, using different elevation agro-climatic conditions.

ISSUES AND CONSTRAINTS OF UPLAND FARMING

Like most other countries of the HKH region, Pakistan is facing serious threat of environmental degradation, retrogression in biological diversity, depletion of forests, loss of soils, deterioration of rangelands and highly disturbed habitats for wildlife. Despite highly diversified agro-ecological, socioeconomic

and cultural varieties, the upland areas are treated like irrigated plains for policy formulation, development of plans, provision of support services and infrastructural development as well as for the provision of basic health, education and communication services.

Cash crops farming in the upland areas is full of examples of poor harvest practices, resulting in large-scale loss of produce. Various reports have indicated that an estimated 50 percent of fresh cash crops, fruits and vegetables are lost after harvest by the upland farmers of the HKH region (Teaotia, 1993).

The pressure exerted by economic and demographic processes on the local resource base is a source of serious concern. The two key natural resources – land and water are already being used at maximum capacity.

As a result of deforestation, the ecology of the dry and cold upland areas has changed considerably and degradation has been brought in them. There is scarcity of wood and fodder due to the disappearance of forests. The watersheds are in highly degraded conditions and aridity has increased in the upland areas. The climate of this tract has also changed. The diversity of both flora and fauna has been adversely affected due to human activities. Many species of wild animals, birds, etc. have either become extinct or threatened due to deterioration of their habitat. It is also true for a number of plant species including trees and medicinal plants. These include *Chilgoza* pine in Zhob, juniper in Northern areas and Balochistan and medicinal plants in Chitral, such as *Aconitum chasmanthum*, *Saxifraga ciliata*, *Saussurea lappa*, and *Germanium wallichianum*.

Pakistan is located in the transition zone between two zoogeographical regions, the Palaearctic and the Oriental, due to which it contains rich biodiversity in its upland areas. Status of biodiversity in the country is not fully known, though. However, general trend is that populations of most of the wildlife species have declined over time. A number of wildlife species have declined to endangered status. Systematic surveys and studies have not been conducted to determine their population and habitat status in the country. Major constraints have been the lack of trained technical manpower and resources. One of the major threats to biodiversity at present in these areas is loss and degradation of habitat due to deforestation for agriculture, mineral extraction, settlements, overuse of rangelands by livestock and other development activities. A recent analysis of some areas of the HKH region showed that a number of medicinal plants were endangered due to various factors (Shinwari, *et al.*, 2000). Martin (1995) estimated that about 13,000 people could earn their wages by selling the seeds of *Pinus girardiana* during a good yielding year in Sulaiman range area.

Table 2. Sustainability Issues of Upland Agriculture in Pakistan

Issues	Potential Implications for Pakistan
Population growth	Degradation of natural resource base such that future generations cannot support themselves, increased pollution and degraded quality of life, potential for national and regional conflict over land and resources
Ozone layer depletion	Increasing temperature, increased melting of glaciers and changes in water availability/seasonality
Loss of biodiversity	Lost crop strains, loss of medicinal potential, extinction of plant and animal species
Soil loss	Reduced agricultural productive capacity, reduced operating life of dams for power and irrigation, damage to coastal fisheries
Desertification	Loss of rangelands, changes in way of life of tribal people
Deforestation	Watershed deterioration, loss of wildlife
Destruction of wetlands	Loss of winter grounds for South Asian water fowl

Livestock grazing is one of the important activities of subsistence farming communities of upland areas. Small farmers raise livestock to meet their livelihood needs. The livestock play an important role in regional and national economics. Livestock contributes about 7 percent of national GDP or about 30 percent of agricultural GDP. Uncontrolled heavy grazing is causing impoverishment of palatable grasses and forbs. The socioeconomic benefits of grazing to small farmers cannot be ignored. Moderate and controlled grazing

has positive effects on vegetation. It reduces the chances of accidental fires, helps seed spreading and seed germination. Moreover, the alpine and sub-alpine areas are used by nomadic graziers which otherwise could not have been utilized. In an economic environment, where animal husbandry is integrated to farming and provides livelihood security to the upland farmers, grazing cannot be eliminated all together. Thus, it is important to find solutions to the following livestock-related problems:

- * Poor nutrition and flock management
- * Prevalence of parasitic and other diseases and general animal health problems
- * Poor genetic potential of the animals
- * Lack of infrastructure, including credit, veterinary and marketing facilities
- * Absence of rangeland management and grazing control policies.

FEMALE PARTICIPATION IN UPLAND FARMING

Women, as caretakers of livestock, crops, and forestlands, are in key position to contribute to the building and maintenance of the sustainability of these lands and farm resources. Continual neglect of their important role in upland agro-ecosystem means missing out a great resource of under utilised potential.

Efforts to bring women-friendly improvements in farm technologies are yet unknown in the region. They have been hampered by numerous factors containing women's access to knowledge and adoption of new practices. As in many fields, there exists a wide gap between researchers and users, resulting in little feedback from the field to technology developers and advocates on ways to make technological tools more useful to women. In addition, gender biases cause researchers to overlook the needs of women or what makes a technology appropriate to them.

The extremely low literacy rate of the women in the HKH region coupled with the non-availability of written information in remote hilly areas makes it difficult to extend knowledge through printed materials. In many areas, the introduction of technologies has brought about labor displacement, pushing women into less-skilled jobs with less access to improved technologies and the world of men. It has also been noted that, whenever women focused economically beneficial interventions are made, these are taken up by males, leaving women to their traditional chores. Serious attention to these problems in the upland region has been lacking in the past. Practical efforts focused in this area could result in meaningful changes.

MEASURES FOR SUSTAINABLE FARMING IN UPLAND AREAS

Sustainable Agriculture and Environment

Issues involving the environment are central to sustainable agriculture. Recorded history has many examples of civilizations and nations that suffered or even disappeared because their agriculture was not sustainable. Today, many aquatic and terrestrial ecosystems are showing stress because of agricultural practices that are not in harmony with the environment. Erosion, salinization, desertification, water pollution, and climate change are affecting agricultural productivity in many nations. The agricultural practices identified with environmental degradation include overgrazing, poor irrigation practices, excessive row cropping leading to erosion, overuse or misuse of agricultural chemicals, and bringing land into production that is too fragile to grow crops. Corrective actions leading to sustainable upland agriculture are necessary soon before the growing and more demanding upland population requires food and fiber at levels that cannot be supplied from the current upland agricultural systems. This will require major changes in the food growing patterns and approaches. Needed changes include research to find more appropriate crops and practices and using holistic principles in the development of upland agricultural systems. While free trade promises to raise living standards, benefits must accrue to all the upland population. Otherwise, environmental degradation will continue as the poor gather firewood and water, and use unstable lands for food. To summarize:

- * First, the upland environment is very fragile; it must be used very carefully, otherwise degrading processes become rapidly cumulative.
- * Second, upland areas are highly inaccessible, physical movement and communications are not easy.

- * Third, upland areas are very diverse. The diversity gives it comparative advantages for producing certain products. However, it also is a major limiting factor in benefiting from economics of scale on account of different types of limits.
- * Fourth, in the upland areas, the role of women has not been adequately appreciated and without better integration of women, upland development will never achieve its full potentials.
- * Newer approaches that are more sensitive to physical, social, cultural, and economic environment of upland areas are needed. There are definite instances to show that in addition to refurbishing the upland economy appropriate cash crops farming combinations will also help promote environmental conservation in uplands.
- * To look for new ways of labor division within the household, as presently women do more than 75 percent of work in villages.
- * To implement a sustainable agricultural program, since agriculture is the basis for food production and sufficient food production for life sustenance is a serious problem in the villages, especially those of ethnic minority groups.
- * Pay special attention to improving the economic, social, educational, cultural, health and employment scenario of the village. There is a great potential for fruit orchards in these areas but a balance has to be maintained between cropping system and horticultural practices.
- * Provide primary healthcare, reduce the child mortality rate, and promote animal healthcare since livestock is important for the welfare of farming life.
- * While commercialization is not in itself bad and provides substantial boost in incomes when successfully developed, greater care is needed in managing mono-cropping, overuse of fertilizers and insecticides, loss of farm and non-farm biodiversity and unsustainable rates of natural resources extraction.
- * To stop habitat degradation due to fuel woodcutting, alternate energy sources such as kerosene oil and liquid gas can be provided to local residents on concession rates. This can be accomplished only if oil and gas are more economical than woodcutting. To ensure this, there should be frequent and unannounced checking on these people by the wildlife officials. These steps will help to reduce human impact and human dependence on natural resources of habitat areas.
- * The major objective should be to provide better quality cheap and abundant fodder round the year particularly in winter (fodder scarcity period).
- * Development of an extensive seed multiplication program of improved fodder crop varieties suited to the upland areas.
- * Transfer of improved fodder production technology to the farmers. Modification and adjustments should be made in the improved package, based on research activities and feedback from farmers.
- * Train local agricultural staff and farmers in improved fodder production technology.

CURRENT STATUS OF FARMING SYSTEMS RESEARCH FOR DEVELOPING AND IMPROVING SUSTAINABLE FARMING SYSTEMS

Pakistan has ample knowledge and know-how in developing valuable upland fruit crops, such as apples and citrus fruits. Similarly, institutions in the country are capable to do research on sustainable management of alpine pastures and grazing lands. Pakistan should also be ready to share these experiences with other member countries of the region.

The livestock population in the country is increasing with increase in demand for livestock products because of growth in economy. Livestock population (excluding poultry) was 56.7 million heads in 1972. It increased to 88.5 million by 1988, whereas the present population is about 115.8 million (Economic Survey, 1999-2000).

Farm women are affected by shortages of water, fuel wood, and fodder. With inadequate access to training and education opportunities, women are held back from opportunities to generate additional income during lean periods. Without labor-saving alternatives they are unable to find time to devote to such activities, anyway. The reduction in their work load is a first step in providing women with the breathing space required before taking on additional tasks for income generation, healthcare, or other activities. There is a huge potential of trading medicinal plants from upland areas. For example annual consumption of

medicinal plants from these areas by 10 *dawakhanas* was more than 650,000 kg from 200 species. The scale of trade was Rs.18 million. The estimated production of condiments and spices is given in Table 3.

Table 3. Estimated Annual Production of Spices and Condiments in Pakistan

S.No.	Scientific Name	English Name	Area (000 ha)	Production (000 mt)
1.	<i>Capsicum nuum</i>	Chilies	88.7	136.6
2.	<i>Allium sativum</i>	Garlic	9.2	82.7
3.	<i>Allium cepa</i>	Onion	85.5	1,138.2
4.	<i>Sesamum indicum</i>	Sesame	30.3	14
5.	<i>Curcuma domestica</i>	Turmeric	4.4	41.7
6.	<i>Cuminum cyminum</i>	Cumin seed	1.5	321.94
7.	<i>Trigonella foenum-graceum</i>	Fenugreek	142.1	96
8.	<i>Coriandrum sativum</i>	Coriander	6.7	3.3
9.	<i>Foeniculum vulgare</i>	Fennel	0.6	0.6
10.	<i>Pimpinella anisum</i>	Aniseed	0.3	1.2
11.	<i>Ferula asafoetida</i>	Asafoetida	-	0.039

Source: Watanabe, *et al.*, 1998.

INFRASTRUCTURE DEVELOPMENT AND OVERALL DEVELOPMENT POLICIES FOR UPLAND FARMING SYSTEMS

Reckless exploitation of upland resources has been an important characteristic of rapid commercialization and upland people benefit very little from it. This cannot be seen as a sustainable path for upland areas. In no other part of the world is the need to promote sustainable development of agriculture compatible with the conservation of the environment more acute than in Asian uplands. Indeed the remarkable increase in food production achieved during past 30 years so far was unable to meet demand of large population at the cost of depletion and degradation of resources. The rapid growth of the urban sector in the region has aggravated the food production. The Asian researchers are faced with the daunting task of developing technologies or policies that maximize the use of dwindling land, water, soil and biota resources, but it is still unable to maintain a certain measure of self-sufficiency in major food commodities. To meet this challenge, a few approaches can be considered. One may be improvement in existing technologies, including the selection of cropping systems better harmonized with the natural ecosystems to promote the utilization of complex biological interactions, recycling of the resource base and judicious use of agrochemicals. In another approach, efforts should be made to develop new varieties of crops more resistant to biotic and abiotic constraints through the application of biotechnology as well as new materials. A sustainable approach will be required to focus on the following:

- * Sustainable use of productive soils
- * Sustainable use of water resources
- * Sustainable management and rehabilitation of forests, rangelands and livestock
- * Sustainable use of biodiversity
- * Improving upland farming systems
- * Socioeconomic implications of upland agriculture
- * Combating upland desertification/land degradation
- * Conserving upland biodiversity.

Arid and cold upland areas are spread over vast stretches of Pakistan and other regional countries. These fragile upland areas are experiencing a continuous process of intense land use by increasing population of people and livestock. The disturbance of fragile ecosystem includes a sharp reduction in plant diversity and cover, degradation of soil resources, depletion of grazing lands, acceleration of desertification process, poverty of local farmers, and social and political instability. Sustainable agriculture is an important vehicle

towards government's main objective of alleviating poverty. Moreover, as the primary user of natural resource base, it plays an important role in the conservation and protection of the environment. Although agriculture has generally performed well in the past, there are clear signs of stagnation in productivity growth, mainly due to resource degradation, failure to adopt technical change and lack of incentives. Growth in future will have to be achieved through increased productivity and more efficient use of limited resources. There is a particular need to ensure efficiency and sustainability in the use of most important natural resources, which are water and arable lands. There are still significant yield gaps to be achieved.

But in some instances, given contemporary realities and constraints, there seem to be fewer other alternative opportunities to cash crop farming in the hills/uplands for communities to gain access to improved incomes from farmland. During the past few decades the importance of high value cash crops for improving the economy of the upland populations has been realized in several pockets of the HKH region. Because of the specific agro-climatic conditions and soil requirements of some of the high value cash crops, they provide a unique opportunity of unprocessed, semi processed, and processed products for example, fresh and dry fruits, vegetables, spices, mushrooms, aromatic plants, medicinal plants, and floriculture. Promotion of horticulture with several of these components of cash crop farming has been receiving added attention in the development priorities of many upland areas of HKH countries but not all areas succeeded in cash crop farming.

SOME SUGGESTIONS

For sustained horticulture in dry and cold region, there is need to harness water and other natural resources more effectively. Accessibility to producing areas and means of communications should be improved. Crop losses due to insect pests and diseases must be checked and postharvest losses due to poor handling, storage and transport minimized. Credit facilities and availability of inputs such as fertilizers and pesticides should be made available to small growers.

OFF-FARM EMPLOYMENT OPPORTUNITIES

Off-farm employment implications of cash crops-based activities have shown encouraging trends. Indications are that women have relatively larger participation rate (77 percent) in most of the cash crops-based off-farm activities. The female participation in off-farm activities is encouraged by two factors – female-oriented labor work and lesser mobility required, such as 50 percent of the horticulture activities like transplanting, tending, harvesting, and marketing are carried out by females. From this standpoint, cash cropping has encouraged a greater number of women to benefit from off-farm employment opportunities related to cash crops farming.

Land records of apple growing areas show that most orchards have been established using 70 percent of barren uncultivated land and only 30 percent of agricultural land (Azad, *et al.*, 1988).

Perennial cash crops such as trees and shrubs have the comparative advantage of tolerance to harsh environment conditions like steep rocky upland slopes, frost-prone locations, shallow soil conditions, etc. Drought-resistant tree crops such as almonds, which survive in apparently waterless conditions, are offering scope for cash crop farming under most harsh agro-climatic environments in the uplands. The potential of horticulture crops can never be under estimated for upland agricultural development, focusing on the sustainability aspects of farming, since the tree crops on marginal lands offer the possibility of higher production and income. Generally, food grain production is around 2 mt/ha under Himalayan region conditions but fruit yield of apple trees equals to that of 10 times of the cereal grains from the same area (Azad and Verma, 1994). This establishes the fact that tree crops have the potential of offering sustained high levels of productivity on low fertility marginal and fragile lands, where annual crops can never be grown profitably.

Diverse agro-ecological conditions available in the upland areas form niche for horticulture, floriculture, cultivation of spices and medicinal plants, because of the peculiarity of agro-ecological requirements of these crops. Some with wide and some with narrow range these crops can be grown in the hills and uplands with a comparative advantage over the plains. Since plains have big comparative advantage in growing cereal crops, it is logical that alternative cash crop farming with right niches would give better

benefits to the upland farming communities. In doing so, farmers have two-fold benefits, first agro-ecological, in the sense that the particular cash crops can be grown in particular available climate only, and second the comparative advantage of marketing in the sense that products do not face competition from farming in the plains. Instead it is profitably used as consumptive market for upland products and for easy access to food grains.

There are examples to show that promising genetic materials and local know-how may be available in the upland areas to improve cash crops for local suitability. One, however, finds lack of initiative on the part of research and development (R&D) institutions for exploring and using this local knowledge (Partap, 1993). In Swat valley of Pakistan, through much trial and error, people have gained experience in using incompatible species as rootstock of apple so as to cope with soil borne diseases. They use *Crataegus* as rootstock by first grafting *Sorbus* on it and then later grafting apple on *Sorbus*, which are compatible. These are only indications of a large body of indigenous knowledge, skills and bio-resources available locally, which if fully harnessed, may help find a variety of cash crops and the sustainable ways for their management.

MONOCULTURE AND ENVIRONMENTAL CONCERNS

Efforts on developing local resource-based cash crops will help break monoculture of few introduced crops and save land and environment from degradation. Many of these local biological resources may not require chemical pesticides for plant protection. Harnessing sea-buckthorn and other medicinal plants in the marginal upland areas of China serves as the best example of the future approach (Rongsen, 1992). This would help stop or reverse the process of environmental pollution, land degradation and maintain the regenerative capacity of the farmlands, used for cash cropping. Such option will have to be more responsive to traditional knowledge, practices and local resource base (Partap and Jodha, 1992).

PROSPECTS FOR FUTURE

The positive factor for promoting cash crop farming in upland areas is that small farmers in the uplands have several constraints to enhance their yield and production beyond a particular limit, thus to give them best returns for their small modest-scale produce. Some balancing act has to be made between the cultivation of traditional food crops and cash crops farming, specially in the remote upland areas where food self-sufficiency may be more important than food security. Intercropping, mixed farming, relay cropping or multi-storey cropping – any of these approaches may be tested for different situations.

At present inadequate support services, i.e., credit availability, inputs, storage facilities, marketing and transportation infrastructure, and information dissemination render it a haphazard and ineffective process of transformation. There is a pressing urgency for greater coordination between agricultural research institutions, extension services and the local farming communities so as to identify needs and evaluate the impacts. This can be achieved by actively involving the research institutes and extension agencies in understanding the types of constraints and needs, facing the farmers. Nevertheless, successful and failed experiences of cash crops farming have shown that building strong infrastructure, R&D and institutional support is necessary for enhancing pool of cash crops suited to specific niches, for better and sustainable crop management, post harvest operations and marketing with advantage.

SCOPE FOR ALTERNATE AND SUSTAINABLE ENERGY SUPPLY

There is hardly any industry in the upland regions of Pakistan. The existing means of communication are primitive and energy requirement is much larger than in the plains because of cold climate. Per capita domestic energy consumption is estimated to be 15.07 million KJ for hill population as against 2.93 million KJ for the plains. Traditionally, wood has been the major source of domestic energy for cooking and heating. The other sources are agricultural waste, biomass and animal dung, which however, have limited availability in the upland areas for a number of reasons.

The study showed that per capita fuel wood and wood waste consumption is about 0.07 m³. Per capita energy consumption in rural areas was 68 percent higher than in urban areas. Thus, the total fuel wood

energy consumption for 0.8 million population in Northern areas is 560,000 m³ per annum, which is well within the productive potential of existing forests. All forests are not accessible; therefore, forests would continue to be heavily burdened with cutting of trees.

The results of study in Ziarat have shown that almost all households use fuel wood in variable quantities to meet their needs for domestic cooking and heating (Table 4). About 83 percent of the surveyed households were using fuel wood and kerosene; 7 percent, only fuel wood; 5 percent, fuel wood and LPG; 4 percent, fuel wood, kerosene and LPG; and 1 percent, LPG only. The average fuel wood consumption per household was 1.75 kg/day.

Table 4. Timber Obtained from Various Forests

Region	Volume (long form)
Hazara	10.807
Malakand	9.065
AJK	6.389
Northern Areas	4.170
Muree Hills	0.687
Tribal Areas	7.000
Total	38.118

RECOMMENDATIONS

The cultivated land has increased manifold. The area under orchards, vegetables and fodder crops has also been increased. For biodiversity conservation, a two-phase approach should be adopted. Collection of seeds or plants be made for *ex situ* conservation in national bank. Similarly, efforts also be made for *in situ* conservation, which can lead to biodiversity utilization of native flora. There is a need for establishing more control over the use of natural resources in each ecological zone. Sporadic efforts are being made for genetic resource collection and preservation of native flora by different departments, which need to be properly coordinated and documented. To effectively check the advancing land degradation and biodiversity losses, bold structural changes in the socioeconomic and political systems are required. If the situation has to be saved there is need for bold initiatives, otherwise uplands will face possibilities of mass migration.

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9. PHILIPPINES

Dr. Evelyn Aro-Esquejo
*Training Center Superintendent and
Regional Technical Director for Training
Agricultural Training Institute
National Training Center
Benguet*

PHILIPPINES UPLANDS AND ISSUES

Prompted by the uncontrolled upland migration and its impact on the environment and the sustainable use of its natural resources, the Philippines launched various programs to arrest the degradation process. In 1998 alone, country's uplands lost 52,681 ha due to unabated slash-and-burn and shifting agriculture. In Philippines, 60 percent of the 30 million ha of land area comprises uplands. Here agriculture and forestry are practiced on slopes ranging from 18 percent upwards. Incidentally, it is here where the majority of the poor live. Likewise uplands are today home to most rebel groups. As is known, the basic cause of insurgency in the country is poverty. The poor Filipino falls easy prey to the group's promises of quick response to his basic needs for education, source of income and livelihood, health, and other services. In most cases, these needs are inadequately addressed by government (Tacio, 2000).

The situation is aggravated by the fast conversion of forestland to agricultural areas and later, agricultural areas to settlement communities. It also starts the process of unequal distribution and access to land among people of the area. With 75.3 million Filipinos living on 30 million ha of land, the limits to demands people impose on land and the technology used, become critical. The search for viable alternatives to control degradation, restore productivity in the uplands and ensure poverty alleviation is thus a tall order – an unending desire. It has become a major concern for both government and the private sector, which is described through various experiences in this paper.

PERFORMANCE OF SUSTAINABLE FARMING SYSTEMS

All kinds of sensible solutions to upland problems – ranging from agricultural systems to agroforestry schemes have been developed by government and also through private sector initiatives since the 1970s. A few major successful interventions are described here to give insights to efforts made for evolving sustainable farming in the uplands.

Private Sector Initiatives

The Mindanao Baptist Rural Life Center, a private volunteer organization in southern Philippines, has introduced a package of technologies for soil conservation and food production integrating several soil conservation and crop production measures in just one setting. The initiative, called Sloping Agricultural Land Technology or SALT, is already in its third phase. The technology involves 3-5 m bands between double contoured rows of nitrogen fixing shrubs and trees to minimize soil erosion and maintain fertility. The traditional farm erosion rate of 1,163.4 mt/ha/year was remarkably reduced to 20.2 mt/ha/year through application of SALT. The rate of soil loss under SALT is estimated at 3-4 mt/ha/year, very much tolerable compared to those in other countries at 10-12 mt/ha/year.

SALT-1 applies agroforestry approach using agricultural and forestry crops at a percentage ratio of 75:25. Putting up SALT-1 involves locating and developing the contour lines, planting contour lines with leguminous shrubs and trees, cultivating and planting the strips alternately, planting long-term crops on every third strip and land borders, planting short-term crops on every first and second strip, rotating food and cash crops and maintaining the farm.

SALT-2 is an agro-livestock-based approach incorporating goat-based agroforestry with a land use scheme of 40 percent agriculture, 20 percent forestry and 40 percent livestock. The technology involves locating and developing the contour lines, establishing hedgerows, planting food and cash crops, developing forage garden, locating the goat barn, procuring the stocks, feeding and breeding the goats, marketing the products and maintaining the farm.

SALT-3 focuses on sustainable agroforestry land technology approach. It is, in fact small-scale reforestation integrated with food production. The farm is devoted to about 40 percent agriculture and 60 percent forestry. Here, it is necessary to set up an agroforestry nursery to care and manage the seedlings, establish food crops on the lower half of the farm, prepare the site for wood crops, compartmentalize and space wood crops, out-plant the trees, intercrop the tree crops, do tree stand improvement and harvest agroforestry products regularly.

Another international institution “International Institute of Rural Reconstruction” (IIRR) based in Silang, Cavite has also developed several technologies for upland farming. Farming systems models of IIRR showcase soil and water conservation technologies and agroforestry systems such as contour canals, contour bunds, bench terraces, contour hedgerows, check dams and soil trap. Bio-intensive gardening with agroforestry and basket composting are also demonstrated.

The Geofarm Philippines in Bayambang, Pangasinan has started a family project that has become a lifestyle now. It is being sought after by organic-conscious families and public and private sector enterprises. It espouses integrated appropriate technologies, which are ecologically sound, simple, low-cost, culturally appropriate, sustainable and adaptable. Three kinds of waste (human, animal and vegetable) flow into a biogas digester’s mixing tank to produce methane for cooking, heating and refrigeration as well as solid and liquid fertilizer. Water overflows to a water-cleansing basin where impurities and pollutants are absorbed by aquatic plants and where the crystal clear water rich with nutrients supplies the water and fertilizes the polyculture ponds need as feeds for the fish. The rice and vegetable gardens around the fishpond are irrigated through capillary action. Excess water goes back to the underground water table. The water cycle is completed when the wind pump sucks the water for home use. All agricultural products are organically produced.

The Food and Agriculture Organization of the United Nations (FAO), in partnership with the Royal Government of the Netherlands (donor country) and the Government of the Republic of the Philippines (host country) started a project on the Sustainable Agrarian Reform Communities – Technical Support to Agrarian Reform and Rural Development (SARC-TSARRD). Using the farming systems approach, it has provided technical assistance to the Philippines’ Department of Agrarian Reforms (DAR) to address the major constraints confronting agrarian reform beneficiaries in 1,000 pilot communities called Agrarian Reform Communities (ARCs). The approach is sought to ensure that interventions administered will be consistent with the identified needs and the development priorities of the ARCs. The Farming Systems Development (FSD) is a holistic and highly participatory approach to the development of people and community on a sustainable basis. The process starts from planning the people’s needs toward the improvement of their lives, then accessing resources from all available sources to implement their plan, and along the way, regularly monitor and assess whatever progress they make in their living conditions. Six phases of the project constitute:

- Phase I *Barangay* Workshop Consultations (BWCs) and Orientation/Pre-training Conference
- Phase II Secondary Data Collection and ARC Profiling
- Phase III Training: Concepts Discussion and Planning Skills Development
- Phase IV Fieldwork: Household Survey, Focused Dialogues and Farming Systems Profiling
- Phase V Training: Firming Up of ARC Development Plan
- Phase VI Fieldwork: Plan Implementation Government Sector Initiatives.

Government Sector Initiatives

The Department of Environment and Natural Resources (DENR) through its Ecosystems Research and Development Bureau (ERDB) and the DAR have forged an agreement to provide livelihood opportunities to upland farmers but at the same time restoring the environment. A farmer-centered agroforestry program called Comprehensive Agrarian Reforms Program-Integrated Social Forestry Program (CARP-ISF) has been

evolved. The intervention features different livelihood entry points, namely, agroforestry, agri-livestock, and agro-silvi-pastoral with varied strategies of implementation. The community organizing process is a common step to all, but the level by which people's participation is elicited varies. The types of interventions introduced range from institutional development to trainings and cross-visits, research (adaptability trials, comparative studies, market flow analysis and cropping combinations), infrastructure development and others.

A typical project funded by DAR is CARP-ISF program implemented by DENR-ERDB. It is the 1:4 Agroforestry Technology. Introduced in Silang, Cavite this project is a system of multi-storey cropping, enabling farmers to harvest four times more produce and earn 4-5 times more than in mono-cropping. Crops planted include pineapple, papaya and peanut integrated in the coconut farm during the first cycle and coffee, *guyabano* and black pepper during the second cycle. The Alion Agroforestry Livelihood Project in Mariveles, Bataan, likewise a CARP-ISF project, implements SALT-1 with *kakawate* hedgerows, peanut, bush beans, sweet corn, eggplant, squash, ginger, tomato and okra, alley cropping, i.e., fruit trees with bush beans and corn and multi-storey scheme with black pepper and *ube* under *kakawate* and fruit trees. Supplemental income is derived from cooperative operations and charcoal trading.

The Department of Agriculture (DA) through its various instrumentalities has contributed its own initiatives. The DA-CECAP (Central Cordillera Agricultural Program), a European Union-funded undertaking in the central part of the Cordillera region introduced its Highland Integrated Farming Systems Project. The project envisages cropping system intensification involving rice-vegetable-dry bed condition, integration of ducklings in newly transplanted rice, pasturing ducks after rice, fish culture with rice and tilapia raising after rice and rice yield intensification, i.e., early transplanting, green manuring with azolla and sunflower and zinc sulphate application. Other component of the project is farm mechanization using micro-tiller.

The DA's Kasakalikasan Program is an inter-agency undertaking on the Philippine National Integrated Pest Management (IPM) Program. It sponsors a series of season-long Training of Trainers on Integrated Pest Management (TOT-IPM) for rice, corn and vegetables, including upland vegetables. Each of these trainings involves the conduct of farmers' field schools, which serve as the laboratory for the agricultural technicians attending the TOT. The component activities of the training feature appropriate farming systems technologies including resistant seed varieties, applicable biological pest/disease control measures and cultural practices, organic fertilization, etc. The methodologies include technology demonstration farm trials, experiential and discovery-based learning methodologies, participatory action research and others. The IPM involves the use of a combination of compatible farm management practices to control pest population to a non-destructive level without relying solely on chemicals.

The Farming Systems and Soil Research Institute (FSSRI), an institute based in the College of Agriculture, University of the Philippines at Los Baños (UPLB) provides leadership in developing strategies for technology dissemination. It replicates SALT through its Landscape Approach to Sustainable Agricultural and Rural Development (LSARD) in Mount Banahaw areas in Central Luzon. Looking at the upland as a system where household, agricultural production and water resources are interrelated, the following integrated technologies were introduced; SALT, contour bunds, terraces, contour rock walls, mulching, contour canals, intercropping, nutrient cycling through green manuring and farm gully stabilization. The crops raised were squash, tomatoes, *camote*, rejuvenated coffee, gladiola, corn, peanuts, bananas and *sitao*.

Issues and Constraints

Many issues and constraints beset the implementation of farming systems development in the uplands. These are, however, replete with lessons learned and are therefore, surfaced as basis for evolving better content and methodologies in the administration of future undertakings. The issues and constraints are classified into three categories: 1) those that relate to substance or content of technology; 2) those that are of procedural/methodological nature; and 3) issues of general nature.

Substantive/Technology Issues and Constraints: Giant earthworms of two species (*Polypheretima elongata* and *Pheretima* or *Metaphire*), which measure from 7 to 50 cm long, are destroying the Banaue Rice Terraces, a protected world cultural heritage. They make holes on the terrace walls resulting in the loss of water and the collapse of bunds in rice paddies. Researchers are still studying the possible control measures. Another issue concerns the existing extension manpower's commodity orientation. It is felt that they need

to assume a farming system-orientation and be adept at sound resource management. Recent focus of the *Agrikulturang MakaMASA* Program of the national government on rice, corn and fisheries to ensure food sufficiency continues to make extension workers commodity specialists. Gender concerns should likewise be included considering the contribution women make to farm activities especially among the indigenous upland communities.

Procedural/Methodological Issues and Constraints: Many adaptable technologies are not reaching the intended beneficiaries. If available, they are not necessarily appropriate to the specific circumstances of farmers. This poor access of new and emerging technologies indicates poor linkage between research and extension, thus isolating extension staff from researchers. This may be attributed to inadequate packaging of technologies. This is worsened by the devolved extension workers' low wages and their assignment to jobs not related to agriculture, which have led to their low morale. There is also poor adoption of improved agricultural technologies due to the aversion of farmers to risks. Lack of access to formal credit due to insufficient information dissemination and unacceptability of untitled land as collateral has affected upland farmers. Some credit institutions encounter innate risk of lending to farmers because of their usual dole out mentality.

There is a need to involve the community at the initial planning stages of projects till the implementation stages. Their participation enables co-owning the projects. Also, there is a need for a continuous monitoring of FSD projects so as to boost the determination of the farmer co-operators to improve the accomplishments.

General Issues/Constraints

There are other issues and constraints, which cut across the substance and process of development undertakings. For instance, there are pockets of upland areas where unstable peace and order have critically affected the implementation of FSD projects. This may be due to insurgency. There is also a very obvious low public investment in research and development (R&D). Then, even with the limited funds, allocation of funds among R&D agencies has given minimal concern to farming systems development. Transport problems, poor farm to market roads, bridges and foot trails also have become barriers to free flow of upland agricultural products to the nearest market. Irrigation facilities and common postharvest facilities like multipurpose drying pavements, warehouse, cold storage and packing centers are minimal in upland areas. Fluctuating prices, market glut of vegetable products, and stormy weathers are beyond anyone's control but they also have become detrimental to an efficient production system. Finally, the uplands continue to be threatened by tourism and land developments. In Banaue, Ifugao, the centuries-old terraces are beginning to be neglected because the new generation of farmers' offspring who are educated are beginning to migrate to urban centers after their graduation in search of job opportunities.

MEASURES FOR SUSTAINABLE FARMING IN UPLAND AREAS

Novel Farming Practices

There are a few indigenous practices in the uplands to sustain livelihoods on upland farming. To reduce the use of chemicals in their pest management systems, four practices are documented:

- 1) Madre de cacao (*Gliricidia sepium*) brew – used as a bio-spray for rice at 4 gallons of water for every liter of juice extract. Crushed leaves can also be used as fertilizer and repellent.
- 2) Tobacco water brew – One part tobacco stems and leaves diluted in four parts water can control corn and vegetable pests.
- 3) Manzanilla (*Chrysanthemum indicum* L.) flowers are dried and powdered. Seven parts are added to 2.5 gallons of soapy water and 3 tbsp. wood ash or clay loam can control corn pests. Tobacco powder added to the concoction gives good results.
- 4) Garlic mixture – 3 oz. finely chopped garlic bulbs soaked in 2 tsp. Of mineral oil for 24 hours added to a soap solution from 1/4 oz. soft soap to 1 pint water can be sprayed over infested vegetables.

Where irrigation facilities are rare, bamboos are being used as improvised water hoses, tapping and channeling spring water to the gardens. Then, in the upland vegetable farms of Atok, Buguias and Bakun,

all in the Cordillera region, calla lilies (*Zandeschia althiopica* L.) of the gabi family were compactly planted and used for erosion control and for its economic value as a cut flower. In the IIRR experience, the soil and water conservation systems have used varied types of grasses as hedges to bind soil for terraced structures. The grasses are also used as fodder (napier/elephant grass), roofing and mulch (vetiver grass) and essential oil (lemon grass).

In Siquijor's contour farming experience, movable livestock shadehouse are set up – one for cattle and another for goats. Made of light materials, the shadehouse is constructed in the middle of the farm. The animal waste collected every two months is spread over the field for soil amelioration. After two years, the shadehouse is moved to a new site. Incorporating the waste increases the water holding capacity and waste retention thus preserving soil moisture at a much longer time. *Ube* (*Dioscorea alata*), *camote* (*Ipomoea batatas* Panthor) and *kadios* (*Cajanus cajan*) are common cover crops. They are also utilized as food and sold for added income. In Mountain Province and Ifugao, the indigenous camote plots called *palaling* or *lisang* are aesthetically designed following a spiral, rake or parallel style. There maybe no documented scientific explanation for this, but the practical purpose is to ensure efficient soil and water management. After one cropping, what used to be gullies become the new spiral, rake and parallel plots. Rice straw and wild sunflower leaves serve as fertilizers, hence, are integrated during the land preparation.

In Benguet Province, upland farmers have indigenized their vegetable transport problem by setting up a vegetable tramline. To operate this, an elongated steel tube is attached to the car axle. The machine is put on and the vegetable load from below the hill is lifted up.

Support Mechanisms

At the UPLB, a degree course in agronomy with major in farming systems has been introduced. It still is an ongoing course with short-term courses offered occasionally by its FSSRI. One problem encountered, however, is the minimum interest it attracts among students especially because job opportunities are not too many for graduates. Trainings on entrepreneurship enable upland farmers to make their farming activities a business enterprise. Not all farmers can become entrepreneurs, but given favorable environment, more of them can become enterprising. Their entrepreneurial values and attitude are thus developed through agri-based enterprises development, offered by the DA's Agricultural Training Institute and other government entities. This is seen as an important follow-up through mechanism after productive endeavors introduced in upland development. These are complemented with on-site as well as off-site trainings and cross farm visits to successfully manage upland development projects for these have proven effective in ensuring the sustainability of FSD efforts.

Organizing community has taken precedence in the introduction of FSD projects. Involving the people, the local government units and key/influential leaders are undeniably key factors in the success of sustainable farming development approach in the uplands.

STATE OF FARMING SYSTEMS RESEARCH

In the Philippines, the International Rice Research Institute (IRRI), the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and the UPLB spearheaded R&D in farming systems. Farming systems research has involved many other organizations also, for which it can be fairly concluded that it is adequately institutionalized in several organizations. The FSSRI set up in 1982 as part of the College of Agriculture at the UPLB, is an institutional leader in the development and promotion of systems-oriented methodologies, strategies and technologies to improve the productivity and sustainability of different agro-ecosystems. As such, it engages in research, extension, human resource development and technical assistance. One of the entities that it has worked with continuously for some time is the DA through its Bureau of Agricultural Research. Together they have set up the National Technology Verification Network with fund support from the World Bank. Through the project, a Regional Integrated Agricultural Research System (RIARS) has been set up in every region, to undertake R&D work focused on crops, animals, soils and socioeconomic systems using the farming system orientation. After establishment of the development of the Department of Science and Technology (DOST), it has also become yet another source of funds. It is spending ₱34 million to finance 345 studies and the training of RIARS staff and members of Provincial Technology Verification Teams (PTVTs). Being the central body of the government

tasked with coordinating all R&D efforts in agriculture, the environment and natural resources and considering the growing concern of the government for food security, PCARRD is the key institution. It has institutionalized a farming systems research commodity team to work out optimum productivity of farm resources and maximum profitability among farmers. What facilitated success in its intervention is its vast network of state colleges and universities, government institutions and NGOs engaged in R&D.

Also at UPLB, an Upland Agroforestry Program (UAP) has been set up to initiate basic and applied research studies on agroforestry. Its main thrusts are to:

- * document and evaluate existing or indigenous agroforestry systems (cropping pattern/crop combination)
- * investigate fundamental and underlying biological and physical processes of agroforestry technologies and practices
- * develop, evaluate and validate sustainable, profitable and acceptable agroforestry technologies through on-station and on-farm studies/experiences
- * develop a methodology for the effective promotion of agroforestry technologies.

Accordingly, it engages in the documentation/assessment of agroforestry systems, nutrient cycling, biomass production, herbage decomposability of various hedgerows species, and the continuous search for appropriate technology and extension methodologies.

The DENR through its ERDB is another government entity, which is a major supplier of research in agroforestry. The DA, in itself has several projects utilizing farming systems research (FSR) as a basic strategy. Most of its foreign-assisted projects are anchored on the farming systems perspective. The efforts of one of these projects – the DA-CECAP have been highlighted earlier in this report. The Bureau of Agricultural Research, acting as the central coordinating body for R&D at the DA, now has four ongoing action research projects with the FSSRI on farming systems development. One is focused on improving the integration of animal production in the upland farming systems in selected communities of Mt. Banahaw. Soon collaborative projects initiated by the above organizations spread out to involve state colleges and universities until they themselves have institutionalized FSD as an integral part of their research and extension responsibilities.

Incidentally in spite of the richness of Philippine experiences accumulated on FSD, there are still some areas requiring improvements. Some of these have been observed earlier by Dr. William Dar during a National Experts Workshop on Farming Systems, but they persistently affect upland development until this day.

Real Farmer Participation

Based on the Kasakalikahan experience, farmers are willing partners in technology demonstration projects. Their curiosity once tapped can truly convert them and create a continuing urge to become true scientists. Then, there can be no stopping them from knowing more. More opportunities should therefore be given to them to participate in research. This is the essence of people empowerment in the field of sustainable agriculture.

Operationalization of the Research-Extension Linkage

Too many discussions have been held on this issue. Yet, many good research outputs continue to have difficulty reaching their end-users, especially after the devolution of extension workers to the local government units. The Agriculture and Fisheries Modernization Act (AFMA) ensures a stronger research and extension linkage but since it is passing in 1997, the extension component has not been able to adequately complement the efforts already initiated on the research side. To make it worse, in the DA itself, extension is a responsibility separated from research. More specifically, the new organizational structure of the DA assigns the two functions under two different undersecretaries down to the regional level. From the national level down to the field level, research is a responsibility (assigned to the Bureau of Agricultural Research) independent of the extension component (a responsibility of the DA's Agricultural Training Institute). There really has to be serious structural adjustment particularly on the government side to link up

the two. Also, the AFMA calls for a stronger partnership between the DA and the state colleges and universities, the latter being tapped for their expertise in research and extension.

On-station/On-farm Research Linkages

There must exist a free flow of information between on-station research and on-farm research. An output of one must necessarily be an input to the other.

Research in Upland and Hilly Land-based Farming Systems

It continues to be accorded second priority to other research areas despite the fact that majority of the poor live in these areas. More importantly, government should pour more funds on R&D. The present share of R&D in the national budget is barely 2 percent. This should at least be increased to 10 percent.

Knowledge Gaps and Research Areas

There is a need for continuing search for better alternatives to unending concerns such as:

- * conservation of resources such as soil, water, indigenous crops and livestock
- * agronomic, socio-cultural, economic and political viability of indigenous knowledge in agriculture/ agroforestry especially in marginal areas – cropping systems, animal husbandry, non-conventional feed sources, farm tools and implements and pest management systems
- * suitability of native/indigenous species of trees and other crops
- * multi-location experiments to test the applicability of agroforestry systems to various site conditions
- * enhancement of herbage decomposition
- * agricultural/agroforestry technology impact assessment.

INFRASTRUCTURE DEVELOPMENT FOR SUSTAINABLE FARMING SYSTEMS

Infrastructure is a good entry point for development. Many of the FSD projects have considerably shown that these tangible investments of government have become a motivating factor among upland dwellers. The construction of foot trails, tire paths, hanging bridges facilitate the mobility of people and upland products. Water impounding projects provide greater access to water for irrigation purposes. The construction of animal sheds ensure proper management of dispersed animals. Multipurpose drying pavements double as basketball courts and *barangay* socialization activities such as the usual fiestas (feast days). Vegetable tramlines provide convenience to farmers in transporting their upland products. The overall economic impact has added profitability. The so-called '*bayanihan*' or voluntary work among intended beneficiaries have even facilitated the construction of these infrastructures of facilities. Materials and equipment are subsidized while free labor is the counterpart of the recipients.

Integrating Infrastructure Development in Development Policies

The AFMA of 1997 invokes the formulation and implementation of a medium- and long-term comprehensive Agriculture and Fisheries Modernization Plan (AFMP). The said plan, formulated and based on the aggregation of local, regional and subsectoral AFMPs, shall focus on five major concerns: food security; poverty alleviation and social equity; income enhancement and profitability especially for farmers and fisherfolk; global competitiveness; and sustainability. As such, the DA is mandated to formulate the AFMP considering infrastructure and market support requirements to make agriculture and fisheries production input, information and technology readily available to farmers, fisherfolk, cooperatives and entrepreneurs.

Moreover, it is the policy of the state to use its natural resources rationally and equitably. Hence, it prevents the further destruction of watersheds, rehabilitates existing irrigation systems and promotes the development of irrigation systems. Other agriculture and fisheries infrastructure support services such as farm to market roads, rural energy, communications infrastructure, water supply system, research and technology infrastructure, postharvest facilities, public market and abattoirs, as well as agricultural machinery are all guaranteed provided they are all indicated in an agriculture and fishery infrastructure plan.

It is just unfortunate however, that the AFMA now entering its third year is yet to see substantive evidences of these facilities. The required agriculture and fishery infrastructure plan is intact: the partner organizations are ready to work with the government: the beneficiaries are waiting incessantly; but the funds supposed to make these plans a reality are not available up to this date. The government still has to source out funds from added revenues, greater collection effort, donations and perhaps loans.

It can, therefore, be said that mere integration in the national policy framework of the infrastructure requirements of the sector is not enough. There has to be complementarity of actions. Policy should be administered seriously with adequate fund support and the political will may make it happen. The later rests much in leadership.

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10. SRI LANKA

Muthbandara Dissanayake
Deputy Director (Agriculture)
Sabaragamuwa Province
Department of Agriculture
Kegalle

INTRODUCTION

Sri Lanka is a tropical island. A wide array of rainfall, temperature, soil conditions and vegetation prevails in the country. The mean annual rainfall ranges from 600 mm in the dry zone to 6,000 mm in highly wet central parts of the country (at 1,800 m). The highest altitude is 2,575 m above the mean sea level. The average temperature ranges from 27°C in hot areas to 8-10°C in central hills. The country is administered through nine provinces viz. Central, Eastern, Northern, North Central, North Western, Sabaragamuwa, Southern, Western, and Uva. There are 25 districts and 256 sub-districts (Divisional Secretariats), which are administrative units at lower levels.

AGRO-ECOLOGICAL ZONES OF SRI LANKA

Using rainfall and elevation as two parameters Sri Lanka is divided into seven key agro-ecological zones. Further adding distribution of annual rainfall, soil type and land forms, each of these major agro-ecological zones is further sub-divided into 24 agro-ecological zones (Panabokke, 1996).

Rainfall Pattern

Because of the unique geographical location Sri Lanka experiences a wide range of rainfall pattern. Rainfall pattern over most part of the island follows a bi-modal pattern with two peaks in June and November. Based on this rainfall pattern two major cropping seasons are recognized:

- * *Yala* Season: March to September – dry season (southwest monsoon)
- * *Maha* Season: October to February – wet season (northeast monsoon).

However, the country has a unique history for developing irrigation systems to cultivate major staple food crop, rice in lowland. It is presently estimated 750,000 ha available with irrigation for paddy cultivation.

Land Use

The country has a population of 1.9 million who live in a land area of 65,610 km². Out of this land area 2,905 km² are occupied by inland water. The land man ratio is 0.11 ha per person. The population density is 300 people/km². Out of total land area, 2 million ha is arable land, out of which 750,000 ha are used to cultivate rice. Rest of the cropland is in the uplands.

AN OVERVIEW OF UPLANDS FARMING SYSTEMS IN SRI LANKA

Recognized cropping patterns in the uplands are broadly divided into following categories:

- * Farming systems with perennial crops
- * Farming systems with annual crops
- * Farming systems in mixed gardens/homesteads/home gardens
- * Shifting cultivation's/shifting farming systems
- * Integrated farming systems.

Table 1. Land Use in Sri Lanka

Crop	Land Area (ha)	Crop	Land Area (ha)
Tea	190,473	Green gram	17,510
Rubber	158,140	Cowpea	14,830
Coconut	443,952	Ground nut	10,110
Cinnamon	24,510	Manioc	30,070
Coffee	16,260	Sweet potatoes	8,650
Cocoa	5,760	Potatoes	2,330
Pepper	28,050	Chilies (green)	21,640
Cardamom	4,350	Mustard	330
Paddy	848,264	Red onions	5,660
Kurakkan	6,040	Big onions	1,420
Maize	29,790	Ginger (raw)	1,550
Meneri	220	Turmeric (raw)	1,240
Sorghum	110		

Source: Department of Census and Statistics, 1999.

Perennial Farming Systems

These are based on perennial tree crops, which take more than a year to mature. Most important perennial crops are the tea, rubber and coconut.

1. *Tea Production*

Tea is the most important crop after paddy in Sri Lanka. Table 2 shows the significance of the smallholding sector in tea.

Table 2. Tea Production in Sri Lanka

Item	Smallholders	Estates
Cultivation (ha)	88,000	104,602
Land (percent)	40	60
Share of production (percent)	61	40
Share of income (percent)	73	27
Productivity per annum	2,192	926
Ownership	206,000	22
Share to GNP (percent)	12	4

Source: Tea Small Holding Authority.

Table 2 shows that the smallholders are playing important role in the tea sector. Tea has a year-round groundcover which helps to prevent erosion.

2. *Rubber*

Rubber is grown in low wet zone of the country. Non-availability of tapers, frequent rains limiting the number of days of tapping, and heavy competition with imported latex are the major problems. Total rubber production is 110 million kg of manufactured rubber in the country. Average yield is around 1,000 kg/ha.

3. *Coconut*

Coconut is grown in low country and mid country areas. Average yield is around 10,000 nuts per ha per annum. Low yields and poor price make farmers to divert their farms to non-agricultural projects or to intercropping with other crops.

Annual Cropping Systems

All vegetables and coarse grains are cultivated in annual systems. Sri Lanka is self-sufficient in vegetable requirements. They are mainly grown on uplands. It was found that in hill areas farmers are overusing fertilizer and pesticides. There is evidence to prove that vegetables are harvested before the pre-harvesting periods and residual insecticides are found in stored products (ARTI). Considerable amount of vegetables are grown under agro-wells. There is evidence to prove that soil and groundwater is contaminated with nitrogen fertilizer.

Shifting Cultivation

Although limited to dry zone of Sri Lanka shifting cultivation was practiced in some areas in the country. However, due to limitation of available land and restrictions imposed by authorities this practice is on the decline. Some coarse grains, pulses and local vegetables are grown under this system. Very small extent of upland rice farming is also practiced. Reduction of fallow period limits the regenerating capacity affecting the sustainability of this system.

Home Gardens

These are the home plots, which are less than half an acre. Almost all fruits except banana are grown in home gardens. Some vegetables and root and tubers are cultivated in homesteads. As a farming system this system is stable but economically not viable due to poor yields.

Integrated Farming Systems

Integrated farming is a tradition with the Sri Lankan farmers since long. The integration of crop with livestock has proved as sustainable system. Currently government is promoting this system through agricultural loans.

ISSUES AND CONSTRAINTS OF FARMING SYSTEMS IN UPLAND AREAS

Low productivity and poor quality of product is the biggest problem faced by farmers in Sri Lanka. The high labor cost in agricultural produce make them less competitive in open market. Soil erosion is a severe problem in hill country. Smallholdings cultivated as mixed home gardens do not provide food security and adequate livelihood. Therefore, farmers look for off-farm employment opportunities. There is over-usage of fertilizer in vegetable cultivation leading to emergence of several related problems. It has now drawn the attention of planners and policymakers. Low level of mechanization and low farm income generation have created circumstances for youth to drift away from agriculture. Poor coordination among the institute involved in sustainable farming has made farmers face problems in marketing their products. Because of influx of imported agricultural products and effect of globalization on local agriculture, farmers are diverting their agricultural lands to other non-agricultural activities. In Sri Lanka, there is high incidence of postharvest losses especially in fruits and vegetables, which exceed 40 percent of total agricultural produce.

RECOMMENDED SUSTAINABLE UPLAND FARMING PRACTICES

Organic Manure

Organic manure content of the soil plays an important role in conservation of the soil moisture. It also helps increase the fertilizer efficiency and nematode control in the soils. *In situ* production of organic manure in all cropping systems is needed. Considerable efforts have been made in Sri Lanka to popularize this practice.

“More Crop for a Drop”

Water is becoming a scarce resource for upland farmers of Sri Lanka. Therefore, focusing on developing efficient irrigation systems will help grow more crops with limited water. Rainwater harvesting, drip irrigation and fertilizer application techniques are important. Motto in uplands is “More Crop for a Drop”.

Integrated Pest Management for Highlands

Pest-resistant crop varieties, locally available repellents and biological pest control methods are important for upland farming. In most cases, pests are developing resistance to pesticides and also new pests are emerging.

Integrated Fertility Management

It is very important to protect and improve the soil fertility through an integrated approach. For this, indigenous fertilizer resources, organic manure, and use of crop residues are recommended. Green manuring is yet another appropriate method for *in situ* fertility improvement.

Local Organizations

Local people's organizations and women organizations have proved useful tools to sustain farming systems. Women involvement in savings and credit management has been the focus of development programs in farm households and farming systems.

Institutionalization

Institutionalization of sustainable upland farming is important. This has been highlighted in all development efforts of the nation in recent decades.

CURRENT LEVEL OF FARMING SYSTEM RESEARCH

Conservation farming system research is being carried out by National Agricultural Research Institutes. The priority areas of research include:

- * development of crop varieties, which are resistant to pest and diseases and with a wide range of adaptability
- * use of naturally existing pesticides
- * biological control methods for pests
- * low cost soil conservation methods
- * preparation and incorporation of organic manure *in situ* and green manure production systems
- * use of multipurpose tree species in farming systems
- * productivity improvement techniques for crops.

ISSUES NEEDING ATTENTION OF RESEARCHERS

Salinization in upland areas is a major problem in agro-well farming systems. A large number of wells have been dug in dry zone. It has been reported that a trend of salinity is developing in these areas. It is compounded further by depletion of water table during the dry season. There is a need to find out ways and means of reducing cost of production of farm products and mechanization of upland. There is a need to find out low cost packing materials to prevent postharvest losses in farm products. Low cost and energy saving methods of fertilizer application are also a priority, as the water is scarce.

POLICIES AND INFRASTRUCTURE DEVELOPMENT FOR SUSTAINABLE FARMING

Overall development policies are directed to greater participation of private sector as the engine of growth. Privatization of government managed commercial ventures is underway in the country. The country gives priority for developing agriculture, industry, trade and tourism, human settlement development and economic infrastructure development. These criteria are in many ways compatible with the requirements of promoting sustainable farming. Export promotion of agricultural produce through contract is helping farmers. The open economic policies encourage farmers to increase the quantity and improve quality of their produce. In the poverty alleviation programs sustainable farming has been given a high priority, thus encouraging farmers to follow eco-friendly farming practices. Environmental conservation and environmental impact assessment are called from all development programs aiming at sustainability. Productivity improvement in all sectors is encouraged by the government policies. Under human resource development programs health and education are the priority areas. They encompass sustainable agriculture as well.

MEASURES FOR PROMOTING INTEGRATION IN DEVELOPMENT POLICIES

Since there are a large number of institutions involved in sustainable agriculture research and development (R&D), their programs need integration. Following are some of the measures, which could encourage such integration:

Forward Contracts

It is necessary to integrate small producers with large-scale entrepreneurs through forward contracts. That encourages the private sector participation in economic development of the country as well as it will benefit farmers.

Productivity Improvement in Agriculture

Productivity and quality improvements of farm produce are today necessary for upland farmers. For this, farmers will need to be organized to seek better price and lobby for antidumping laws so that influx of imported agricultural produce could be restricted. Also, farmers should be encouraged to use organic matter.

Credit through Village-level Institutions

Nearly all upland farmers live in rural areas. The credit requirement for them is to be met at village level by farmers' banks such as Gramman Banks, Janasakthi banks and Samrudhi banks. That will reduced the cost of credit and also save farmers' time.

Crop Insurance to Sustain the Farming Systems

In Sri Lanka, currently both farmers and crops could be insured with agricultural insurance board. Policy provision needs to be made for ensuring the whole cropping system.

Inclusion of Stakeholders in Research

A large number of research projects are carried out to develop sustainable agricultural systems. It is important to include farmers as partners of research to harness their indigenous knowledge in agriculture. That will also facilitate speedy dissemination of information.

Land Amalgamation

The country has a large number of fragmented small farms. They become non-viable. So it is necessary to amalgamate these small farming units to make viable farms. It will also be necessary for the nation to restrict diverting the agricultural land to non-agricultural purposes.

Informal Links

Apart from integration of smallholders with large companies informal link with farmer groups could be encouraged. Informal farmer group formation and their group activities should be encouraged by agricultural extension system. The development programs with them should be planned on catchment basis.

Integrated Planning

Agricultural development plans should be integrated at all administrative levels. A mechanism should be developed to institutionalize this.

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11. THAILAND (1)

Dr. Paiboon Suthasupa
Associate Professor
Department of Agricultural Extension
Faculty of Agriculture
Chiang Mai University
Chiang Mai

INTRODUCTION

Since the last 30 years, when the Thai Government began to implement its first National Social and Economic Development Plan, several visible negative changes have emerged. These are depletion of forest resource, declining rice yields (upland rice), rice insufficiency and soil degradation. Water availability in traditional irrigation system is lower. Time spent for firewood gathering is longer. Illegal hill tribe migrants from neighboring countries are uncontrollable. Land resource has become more limited and land use conflicts between lowland, highland communities and forest authority are frequently observed. Expansion of mono-vegetable crop production with high inputs has led to disputes over water quality and distribution. While use of chemical fertilizers, pesticides and herbicides on vegetable crops is increasing, diversity of highland agriculture is also reducing.

Through the introduction of the Royal Project, many social and economic development projects aimed at improving the welfare of highland hill tribes, either by government, non-government or bilateral aid programs, have been independently implemented. Land use practices and modern agricultural techniques have been introduced to various villages mainly to substitute traditional farming systems. New farming systems technique includes high value sub-temperate cash crops, namely; flowers, vegetables and fruit trees. The approach is to maximize income over limited land area expecting that the high return would provide incentives for hill tribe farmers to cease growing opium. This new farming technology has increased the highland agriculture's dependence on external inputs and market. Few development projects have considered the basic problem of rice insufficiency. It is noticed that the initiation of mono-cropping of cash crops regardless of highland fragility may not prove sustainable (Senthong, 1989).

The current years also have witnessed a growing demand of mountain areas for resorts by land speculators and investors, resulting in the trading of land use right between poor farmers and rich outsiders. The promotion of tourism has brought in the widespread use of drugs and AIDS problems, which have now become the most serious social problems in the highlands.

AN OVERVIEW OF THE UPLANDS IN NORTHERN THAILAND

Upland region occupies about 52 percent of total area of Northern Thailand. In addition to lowland northern Thai, there are a number of different ethnic hill tribes dwelling in the mountainous areas.

Through many years, landlessness and unemployment have driven hundreds of thousands of poor families in the lowlands to upland and highland areas where they have become "squatters" by operation of law. In many cases these have resulted in the destruction of remaining forest resource in the area. The land has become marginally productive as the topsoil continues to be lost through soil erosion leading to improper agricultural performance.

Although there is a growing dependence on upland and highland resources, highland agro-ecosystems development has received marginal concern from government agencies. As a consequence, the recent times have witnessed a significant environmental degradation in highlands of Northern Thailand.

Inaccessibility dimension, e.g., isolation, distance and poor communication, socio-cultural and economic constraints dampen the willingness and commitment to work in the highlands. Besides, the ambiguity of policies on conservation and economic growth make it difficult to extend resource management measures to highland areas. Almost all the research and development programs were concentrated in the

lowlands leaving highland people and environment outside the mainstream efforts for sustainable development. Only when the Royal Project for highland development was initiated in early 1970s, many national government agencies joined and implemented development programs to alleviate poverty and worked for environmental protection in the highlands.

However, there is still skepticism about inhabitants of highlands. Since watershed degradation is blamed on those hill tribe resettlement schemes which have been drawn and implemented as pilot project in selected sites (Phrek, 1993).

FORMS AND PATTERNS OF SOME EXISTING UPLAND FARMING SYSTEMS SHIFTING CULTIVATION

Shifting cultivation, an age-old method of resource use, is still commonly practiced on the steep slopes, where rotation of fields is observed. Land clearing is by means of slash-and-burn technique. Regeneration of nutrients is achieved by length of fallow period which is now restricted to 2-3 year cycles. Yield estimation of upland rice grown on seven-year fallow plot at Mae Chan watershed, Chiang Mai, did not show any evidence of sustaining yield. It is rather difficult to overcome soil fertility management in the highlands. There is very weak research support to develop economically managed fallow systems. Soil improving legumes (*Stylosanthes* species) sown together with upland rice seemed promising. It is reported that species with its perennial growth habit could be used as one component to improve the fallow system. The rice-forage legume mixture could provide opportunity for livestock grazing as well.

Forest Tea (*Miang*) System

This system is thought to be ecologically sustainable in the highlands of over 800 m. The tea (*Camellia sinensis*), which grows naturally in extensive mountain areas, is now planted by local Thai people in the forests. There are two products derived from tea: “Chinese tea” and “fermented tea” called *miang*.

The forest tea production system does not produce good income due to less demand for *miang* consumption. The *miang* production also requires large amount of firewood for processing.

To make forest tea production system economically sustainable, farmers at Mae Taeng district have incorporated *Zanthoxylum limonella*, a local forest species as part of this system. It provides thin canopy, enabling it to fit well with under-storied tea plantation. In addition, the fast growing multipurpose tree species are established to overcome firewood shortage (Phrek, 1993).

Integrated Farming with Fruit Trees

Integrated farming practices have been promoted by various development agencies as protective measures against risk and uncertainty in the highlands. The emphasis is primarily on food security and efficient use of farm resources. Cash income would be obtained from fruit trees. It is observed that banana is now becoming important component crop after forestland is first encroached.

The highland environment offers comparative advantage for specific products. Examples are sub-temperate fruit trees such as litchi, plum, pear, persimmon, etc. and off-season vegetable crops and flowers.

Integration of fruit tree species into the land use system is the most preferable agroforestry practice adopted by upland farmers, aiming at permanent land use. This is also the main approach being adopted for rehabilitating the degraded highlands.

Conservation Farming

The introduction of different soil conservation practices into farming systems in the highlands is a response to overcome soil erosion on the steep slopes. The most common practice is planting *leucaena* hedgerows along the slope contour intercropped with annuals or fruit trees. *Leucaena leucocephala* is the dominant species used by the Land Development Department and NGOs for extending conservation farming practice into the highlands. Other species used are *Gliricidia sepium* and *Cajanus cajan*. Their main functions are soil erosion control and windbreak.

Alternative Agriculture

This approach is a response to overcome the failure of commercialized, high input farming systems that cause indebtedness of farmers. It is advocated mainly by the NGOs who are against the mainstream

agriculture. Its function is to provide food security as high priority, and it also emphasizes less dependence on external inputs. Local wisdom and management and use of biodiversity are essential factors that poor farmers are able to stand on their own and able to cope with changing requirement.

In practice, alternative agriculture comprises of many forms, e.g., low external input agriculture, integrated farming, natural farming and agroforestry, etc.

As the environment impact receives more public concerns, the “pesticide-free” food production, e.g., rice and vegetables is being promoted as environmentally friendly agricultural products. To encourage such practice, consumers are urged to take part in the promotion campaign by supporting the farmer producers in all aspects.

IMPROVING RESEARCH AND EXTENSION

At the Faculty of Agriculture, Chiang Mai University, a system approach was introduced in early 1980s to review the overall research and extension activities. A set of criteria was used to assess the performance of alternative cropping technology. These criteria “helped research and extension workers” to modify the extension approach towards farmer-focused participatory approaches. With experiences in rural extension and highland development in Northern Thailand, the Faculty of Agriculture has developed programs for the region, especially the mountain areas of the mainland Southeast Asia. This program is expected to introduce a participatory approach for the development of sustainable land use and community forest management as the key to rehabilitating degraded hill areas (Pongsak, 1999).

SUSTAINABLE UPLAND FARMING AND INSTITUTIONAL INFRASTRUCTURE

The administrative framework for hill tribes’ development have been implemented through various line departments such as Community Development, Education, Agricultural Extension, Cooperatives Development, Livestock Development and Health. The resource-oriented policies are implemented through the Royal Forest Department, which retains residual land rights over most of the upper mountain zones. The Land Development Department retains residual land rights over most of the upper mountain zones. This Department is responsible for land capability and existing land use surveys. The narcotic policies of the Royal Thai Government are implemented through the Office of Narcotic Control Board (ONCB), which is attached to the Prime Minister’s office. The Hill-tribes Division of the Public Welfare Department within the Ministry of Interior is responsible for the people-oriented policies concerned with hill tribes’ development. The policies of these government agencies are coordinated through the National Committee on Hill-tribes. The Thai military is represented on all the hill tribe committees for national security issues.

The recent years have witnessed the changing patterns of land use in response to environmental concerns. Farmers are trying several alternative agricultural practices. Although agroforestry practice holds promise to provide secure food supply and stable income, yet the pace of development is rather slow as it required research and extension for agroforestry systems.

To make agroforestry succeed cash cropping should be carefully designed to capture harnessing of niche, i.e., comparative advantage.

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12. THAILAND (2)

Methee Manaphong

Subject Matter Specialist

Highland Agricultural Extension Sub-Division

Horticultural Crop Promotion Division

Department of Agricultural Extension

Ministry of Agriculture and Cooperatives

Bangkok

INTRODUCTION

Northern Thailand is geographically mountainous, with high mountains ranging from north to south connecting with those in Yunnan, China. These highlands are major upper basins with sloping hills and high mountains. There are nine provinces with highlands in the Upper North, namely; Chiang Mai, Chiang Rai, Lampang, Lamphun, Phayao, Phrae, Nan, Tak and Mae Hongson. Total area of these upland provinces is 105,000 km². The highlands are more than 600 m above sea level, of which 50 percent are about 250-600 m; 39 percent between 600-1,200 m; and 11 percent with an elevation more than 1,200 m. The highest peak Doi Intanon is 2,595 m high.

Highland temperatures are lower than the valley plains and have more rainfall. The wet season is from May to October under the influence of the southwest monsoon from the Indian Ocean, together with the monsoon from the Gulf of Thailand. The months with the highest rainfall are August and September, with a total average rainfall of 1,462 mm per year. After October, the weather gets cooler until early February. In winter, the temperature is lower than other parts of the country, with an average temperature of 21.1°C.

Northern Main Watershed Areas

The principal watershed area in the Upper North is the upper basin of the Chao Phraya River. It consists of the Ping, Wang, Yom and Nan river basins, with a total area of 10.6 million ha, or 20 percent of the whole catchment area of Thailand. Those river basins in the north are classified as first class upper basins. The government has recognized 2.86 million ha of this watershed area as the upper basin because of its characteristics, which might have impacts upon the environment with changing land use. From satellite pictures taken in 1995 it was found that the first class watershed area in the Ping, Wang, Yom and Nan river basins had been already encroached to the extent of 210,000 ha or 47 percent of the total area. The main causes of encroachment were agriculture and housing.

People who live in the highlands or sloping lands are mainly hill tribes. Most of them have been living there for a long time. Some might have migrated from neighboring countries 100-200 years ago. There are nine main hill tribe groups: Karen, Hmong, Yao, Muser, Lisu, Akha, Lahu, Thin and Kamu. Mountain dwellers prefer living on highlands above 600 m. Hmong and Lisu tribes are settled in villages at altitudes of 1,150-1,500 m. Karens live in valleys or in foothills at elevations of 600-1,200 m above the sea.

Agriculture has always been the main occupation and income source of highland residents. The Hmong, Akha, Lisu and Muser groups were engaged in temporary cropping by occupying the forest to grow maize and opium. When the soil was no longer fertile, they moved out. The Karen, Lahu and Tin would cut the secondary forest for rotating cropping for 3-10 years for rice. Moreover, the Karen also earn their living from livestock such as cattle. Employment, handicraft and hunting were other sources of income. At present, instead of opium, the hill tribes grow temperate zone crops, which are researched and promoted by the Royal Project.

ISSUES IN UPLANDS

The social foundation of hill tribe villages before the Royal Project existed was primarily agriculture and closed communities. Communication with the outside world was rare. They made a living from

temporary cropping and opium. They worshiped spirits and ancestors. There was no education system, medical services, nor public health services from the state. There was also very little awareness about impact of their farming culture on natural resources.

Beginning 1969, when the Royal Project began implementation, mountain residents received education and were trained in agriculture and settled habitation. Communities were settled and rapidly increased, and also were more open to outsiders. The communication infrastructure has also been facilitated. Several aspects of highland residents' lives have been improved.

Forest areas have been degraded for several reasons, such as forest occupation by hill tribe farmers for cropping; by lowland dwellers for earning a living; and other land-based activities; as well as natural disasters such as fire in the dry season. Reforestation and forest conservation by the government cannot be undertaken over the whole area. Nor can it replace or compensate for the rapid rate of forest destruction. Moreover, people who live in the forest, as well as government agencies, do not know the exact boundaries of forestlands. Therefore, problems about forest occupation and land tenure will continue to be important issues in the future.

HIGHLAND AGRICULTURAL DEVELOPMENT

Highland agricultural development in Thailand has been going on for many years and many agencies are engaged in such efforts. However, the development is slow because of so many problems. Then King Bhumibhol Adulyadej the Great, established the Royal Project. It aimed at supporting hill tribes' development. At that time, the United Nations recognized the value of hill tribes as human resources. Thus, the UN set up a fund, which was contributed by member countries. The objective was to develop the economic situation of the hill tribes by using cash crops to replace opium cultivation.

Highland Agricultural Policy

Implementation of highland agricultural policy has been shared by several concerned agencies, namely; security, narcotics, forestry, hill tribe welfare, and agriculture. The Ministry of Agriculture and Cooperatives has adopted a Highland Agricultural Policy for inclusion in the Eighth National Economic and Social Development Plan, with the following elements:

Strategies for Highlands Development

- * Promotion of agricultural activities that support and facilitate sustainable environmental management and solve problems related to natural resources destruction, including addressing disputes concerning regulations that limit enhancement of development.
- * Implementing a Biodiversity Plan of Action to sustainably manage conservation and utilization of biodiversity, as well as recognising the importance of biotechnology and local wisdom.
- * Modifying planning and budgeting practices in response to more sustainable natural resources management particularly watershed development and location-specific development.

The Royal Thai Government also emphasized highland agricultural development, drew up a national master plan of highland community development and highland narcotic crops control. Then involved agencies were assigned to join the program. Department of Agricultural Extension (DOAE), Ministry of Agriculture and Cooperatives, which is responsible for transferring appropriate technologies from research institutions to farmers, set up policies concerning highland agricultural development:

- * Promote sufficient food crop production for family local consumption
- * Promote cash crop production to enable farmers to replace income derived from opium cultivation
- * Promote establishment of farmers' institutions, which will encourage the farmers to work together
- * Promote the efficient use and conservation of natural resources in agriculture
- * Promote close cooperation among Thai and other agencies to realize above objectives.

However, highland agricultural development is a special work different from the general lowland agricultural development because there are three unusual factors involved in it:

- 1) The operational area is mountainous and forested, which is different from the major cultivated areas of the country. The altitude, slope, temperature, and fertility of the soil are important things for development workers to study carefully.
- 2) Most of the opium-substitute crops are new and strange temperate crops introduced from abroad. Extension workers rarely have had experience with these new crops.
- 3) The target persons are hill tribe farmers, who are minority groups. There are six main tribes with different ways of living. The strategy of extension to achieve goals is “individual contact” which is quite different for each tribe.

The responsibilities of DOAE in highland agricultural extension include:

- * formulating policy and making a work plan for the development and promotion of livelihood occupations for hill tribes in the responsible areas, according to the National Social and Economic Development Plan.
- * to monitor and supervise the implementation of the project in order to achieve the goals on time.
- * to cooperate and work together with other agencies involved in highland agricultural development such as the Royal Project, research institutions, foreign agencies, etc.

LIST OF PROJECTS

The Highland Agricultural Extension Center Project

This project was set up in 1979. There were 20 centers (up to 1992), 10 in Chiang Mai, five in Chiang Rai, one in Lam Poon, one in Loei, one in Kanchanaburi, one in Mae Hong Son, and one in Tak. The project establishes plant propagation centers and transfers appropriate technology to hill tribe farmers in the satellite villages.

The Volunteer Hill Tribe Farmer Project

This project was first implemented in 1977. The farmers who are selected to join the project are trained in various agricultural technologies. These volunteers support the work of the extension workers in order to achieve goals rapidly and efficiently.

Special Projects

Projects, which receive support or contributions from foreign countries or projects, which have specific characteristics. At present, there are two such projects.

1. The Thai-German Highland Development Program

This integrated project concentrates on the preservation and development of natural resources. This project started in 1982 at Tambol Wawi Amphoe Mae Suay, Chiang Rai and Amphoe Pang Ma Pa and Huay Poo Ling, Amphoe Muang, Mae Hong Son. An agricultural development plan was made in cooperation with other agencies involved. The Office of Narcotics Control Board (ONCB) was the coordinating agency of the project.

2. Doi Tung Development Project

This is an integrated rural development project. There are many agencies working together on this project in Amphoe, Mae Fha Luang, Mae Sai and Mae Jun, Chiang Rai. The project was started in 1988. It has established a plant propagation center and transfers appropriate technology to target farmers.

CONCLUSION

The situation in the highlands of Thailand is not very different from that in the highlands of other developing countries, particularly the highlands of the Mekong river basin. These areas have similar geography, environment, traditions and cultures, as well as similar limitations. Furthermore, a situation in one country may have implications for neighboring countries. However, each country has had different experiences in managing and addressing problems in the highlands. Therefore, technical cooperation and

exchange, as well as a close working relationship among policymakers in each country, related to regional highland development issues are important for the future. The Ministry of Agriculture and Cooperatives is willing to support all efforts for cooperation in order to bring sustainable management and protection of natural resources, and to conserve the well-being of hill tribe groups living on highlands.

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1. LIST OF PARTICIPANTS, RESOURCE SPEAKERS AND SECRETARIAT

A. PARTICIPANTS

<i>Country</i>	<i>Name/Official Address</i>
Republic of China	Dr. Tzong-Shyan Lin Professor, Department of Horticulture National Taiwan University 1, Section 4, Roosevelt Road Taipei 10617
Fiji	Mr. Taito Tabaleka Nakalevu Senior Research Officer Department of Land Resource Planning and Development Ministry of Agriculture, Fisheries and Forests P. O. Box 5442 Raiwaqa
India	Mr. K. R. Dhandapani Deputy Commissioner (Watershed Monitoring) Department of Agriculture and Cooperation Ministry of Agriculture Government of India Room 385 B, Krishi Bhawan New Delhi Mr. Dinesh Nigam Assistant Soil Conservation Officer Rainfed Division Department of Agriculture and Cooperation Ministry of Agriculture Government of India 116 B Wing Shastri Bhawan New Delhi 110 001 Mr. Bisweswar Rath Assistant Commissioner Department of Agriculture and Cooperation Ministry of Agriculture Government of India 116 B Wing Shastri Bhawan New Delhi 110 001

Indonesia	Mr. Haryanto Head of Agricultural Macro Policy Planning Sub Division Bureau of Planning and Foreign Cooperation Ministry of Agriculture Building A, Room 334, Jl. Harsono RM No. 3 Ragunan, Pasar minggu Jakarta 12550
Islamic Republic of Iran	Mr. Valiollah Habibi Bastami Director Project for Border Rivers Development in Iran Planning and Economic Research Institute No. 28 Shaghaiegh St., Shahid Daemi St. Keshavarz Bulvd, Tehran
Republic of Korea	Dr. Jin-Chae Yoo Professor Department of Agricultural Economics Chungbuk National University 48 Gaesin-dong, Cheongju Chungbuk 361-763
Mongolia	Ph. Dr. Jamsran Chuluunbaatar Head of Horticulture and Plant Protection Department Mongolian State University of Agriculture Zaisan 210153, Ulaanbaatar
Pakistan	Dr. Bakht Roidar Khan Chief Statistical Officer/National Coordinator (Oilseeds) Oilseed Research Programme National Agricultural Research Council (NARC) Islamabad 45500 Mr. Muhammad Iqbal Extra Assistant Director of Agriculture (Extension) Peshawar Agriculture Extension Department Government of NWFP Jamrud Road, P/o University of Peshawar Peshawar
Philippines	Dr. Evelyn Aro-Esquejo Training Center Superintendent and Regional Technical Director for Training Agricultural Training Institute National Training Center BSU Compd., La Trinidad Benguet 2601
Sri Lanka	Mr. Muthbandara Dissanayake Deputy Director (Agriculture) Sabaragamuwa Province Department of Agriculture Kegalle

Thailand

Dr. Paiboon Suthasupa
Associate Professor
Department of Agricultural Extension
Faculty of Agriculture
Chiang Mai University
Suthep Road, Amphoe Muang
Chiang Mai 50200

Mr. Methee Manaphong
Subject Matter Specialist
Highland Agricultural Extension Sub-Division
Horticultural Crop Promotion Division
Department of Agricultural Extension
Ministry of Agriculture and Cooperatives
2143/1 Phaholyothin Road
Chatuchak, Bangkok 10900

B. RESOURCE SPEAKERS (alphabetical)

Dr. A. S. Dogra
Principal Chief Conservator of Forests and
Director, Kandi Area
Government of Punjab
Sco 26-27, Sector 24A
Chandigarh
India

Dr. Anthony S. R. Juo
Professor of Agronomy
Department of Soil and Crop Sciences
Texas A&M University
College Station
Texas 77843-2474
U.S.A.

Dr. Tej Partap
Head, Mountain Farming Systems Division
International Centre for Integrated Mountain Development
(ICIMOD)
P. O. Box 3226, Kathmandu
Nepal

(Present)
Vice Chancellor
CSK Himachal Pradesh Agriculture University
Palampur - 176 062
Himachal Pradesh
India
(Asia Pacific Representative
Mountain Forum Board of Directors)

Dr. Rita Sharma
Joint Secretary and Land Resources Commissioner
Ministry of Agriculture
Government of India
Krishi Bhawan, New Delhi 110 001
India

C. SECRETARIAT

NPC

Mr. J. Aggrawal
Chief Programme Co-ordinator
Director (Agriculture & PA)

Mr. K. V. R. Raju
Deputy Director (International Services)

Mr. Ashok Kumar
Section Officer
(International Services and Cooperation)

National Productivity Council
Institutional Area
Lodi Road, New Delhi - 110 003
India

Tel: (91)11-24690331/3
Fax: (91)11-24615002/24626986/24698878
e-mail: npc@ren02.nic.in
URL: www.npcindia.org

APO

Mr. Teruo Miyake
Director
Agriculture Department

Dr. Muhammad Saeed
Program Officer (Agriculture)
Agriculture Department

Asian Productivity Organization
Hirakawa-cho Dai-ichi Seimei Building 2F
1-2-10, Hirakawacho
Chiyodaku, Tokyo 102-0093, Japan

Tel: (81-3)5226-3920
Fax: (81-3)5226-3950
e-mail: apo@apo-tokyo.org
URL: www.apo-tokyo.org

2. PROGRAM OF ACTIVITIES

(15-19 January 2001)

Date/Time	Activity
<i>Mon., 15 Jan.</i>	
Forenoon	Opening Ceremony Presentation and Discussion on Topic I: <i>People's Participation in Watershed Development: Experience of India</i> by Dr. Rita Sharma Presentation of Country Reports by Participants
Afternoon	Presentation and Discussion on Topic II: <i>Farming on Sloping Uplands of Asia: Sustainability Perspectives and Issues</i> by Dr. Tej Partap Presentation of Country Reports by Participants
<i>Tues., 16 Jan.</i>	
Forenoon	Presentation and Discussion on Topic III: <i>Technologies for Sustainable Management of Steep Lands in Asia: Harmonizing Economic and Ecological Sustainability</i> by Dr. Anthony S. R. Juo Presentation and Discussion on Topic IV: <i>Agroforestry-based Land Management Systems in Indian Himalayas</i> by Dr. A. S. Dogra
Afternoon	Presentation of Country Reports by Participants
<i>Wed., 17 Jan.</i>	
Forenoon	Presentation of Country Reports by Participants
Afternoon	Leave for Field Visit
<i>Thurs., 18 Jan.</i>	Field Visits to Integrated Watershed Development Program (IWDP) Dehradun
<i>Fri., 19 Jan.</i>	
Forenoon	Summing-up, Evaluation and Discussion Session
Afternoon	Valedictory Session