CGPRT NO. 36

Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture

Integrated Report and Proceedings of a Workshop Held in Seoul, Korea May 20-22, 1998

Edited by Min-Jae Kim
D.R. Stoltz

The CGPRT Centre

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The Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific (CGPRT Centre) was established in 1981 as a subsidiary body of UN/ESCAP.

Objectives

In co-operation with ESCAP member countries, the Centre will initiate and promote research, training and dissemination of information on socio-economic and related aspects of CGPRT crops in Asia and the Pacific. In its activities, the Centre aims to serve the needs of institutions concerned with planning, research, extension and development in relation to CGPRT crop production, marketing and use.

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In pursuit of its objectives, the Centre has two interlinked programmes to be carried out in the spirit of technical cooperation among developing countries:

1. Research and development which entails the preparation and implementation of projects and studies covering production, utilization and trade of CGPRT crops in the countries of Asia and the South Pacific.
2. Human resource development and collection, processing and dissemination of relevant information for use by researchers, policy makers and extension workers.

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Humid Tropics of Asia and the Pacific

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Foreword

Recognizing the importance of sustainable development in upland agriculture, the CGPRT Centre implemented sustainability-related projects since 1993. The Centre completed a project “Sustainable Upland Agriculture in Southeast Asia - A Study of Constraints and Prospects for its Development (SUASA-1)” in 1995, and a follow-up project “Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture (SUASA-2)” in 1996.

The SUASA-2 project was implemented in collaboration with partner organizations in China and India, the two biggest countries in Asia, where a considerable number of farmers are cultivating marginal uplands. Two case studies were conducted in each country to identify constraints to and prospects for sustainable resource management in marginal upland areas, with emphasis on economic effects of the applicable technologies. The case studies also aimed to characterize the transfer or adoption mechanism of resource management techniques and to suggest directions of sustainable resource management.

I am pleased to publish **Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture: Integrated Report and Proceedings of a Workshop Held in Seoul, Korea, May 20-22, 1998**. I believe that readers of the report can understand the importance of resource management for future development of sustainable agriculture in marginal upland areas.

I thank all the national experts for their enthusiastic participation in the project and their organizations for allowing them to work with us and providing continuous support. My special thanks go to the Korea Rural Economic Institute (KREI) for cosponsoring the workshop, and to all the participants for their active discussions at the workshop. I would also like to express appreciation to the Government of the Republic of Korea for funding the project.

November 1998

Haruo Inagaki
Director
CGPRT Centre

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We would also like to thank many other people who have provided invaluable assistance in publishing this report. Firstly, we are very grateful to Dr Haruo Inagaki, Director of the CGPRT Centre, and Dr Kedi Suradisastra, former Programme Leader (Research & Development) of the Centre, for their full support and guidance in the implementation of the project. Secondly, we would like to extend special thanks to Dr Sangwoo Park, President of the Korea Rural Economic Institute (KREI) and his staff for their staff for his assistance in arranging the workshop. Sincere thanks also go to all the participants of the seminar for their valuable presentations, and active discussions and comments. Finally, we are very thankful to the Centre's staff, Ms Babay P. Putra and Ms Agustina Mardyanti for their typing and editing of the manuscript of this report.

Bogor, Indonesia
December 1998

Min-Jae Kim
D.R. Stoltz
CGPRT Centre

Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture

Min-Jae Kim[*]

Introduction

Sustainable agriculture and resource management

Issues of sustainability have come to the fore in discussions among policy-makers and researchers all over the world during the last decade or so. In particular, "sustainable development of agriculture" has drawn increasing attention from people working in the area of agriculture because it has widely been recognized that agriculture, which depends on a limited natural resource base, should be developed in a more sustainable manner to meet food requirement as well as to protect the environment for present and future generations.

As a matter of fact, non-sustainable agriculture is widespread in the world and is a serious threat to the environment or natural resource base on which agriculture depends. It is well-known that, particularly in upland areas in many countries of the ESCAP region, the majority of farmers are cultivating marginal lands and forested areas that are unsuitable for agriculture and, in some areas of higher income, the farmers are using excessive chemical fertilizers and pesticides to try to get maximum production on a limited area of land. These activities result in various types of land degradation and other environmental damage such as soil erosion and water contamination, which in turn affect the sustainability not only of agriculture but of the other industrial sectors as well.

The causes of the non-sustainability in agriculture are many and the linkages among them seem to be very complicated. However, one of the most important underlying factors affecting natural resource degradation in upland areas of the region seems to be the population pressure, which most of the countries in the region have experienced in the last decade (Table 1).

As food production fails to keep up with population growth and the land resource in the lower lands becomes scarce, farmers have no alternative but to use their existing land more intensively by applying more fertilizers and pesticides, or to cultivate the marginal upland with poor soil in hilly and mountainous areas which are usually vulnerable to floods, droughts and other natural disasters. The intensification of farming on the existing land or the move to marginal upland will contribute to a certain extent to the increase of the total food production in the country. However, the growth in the production cannot continue because of various biological and physical limits. The yield will even decline eventually if there are no efforts to improve the quality of soil or the productivity of crops. It is true, in many of the upland areas in the region, that farmers are forced to practice shifting cultivation through deforestation because of poor soil or natural hazards. Moreover, as population increases in the area, they have to cultivate steeper slopes and poorer soils. This exacerbates the problems of soil and water conservation resulting in lower yields and in turn lower incomes.

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In view of this situation facing the upland areas in the region, technically feasible and economically viable agricultural resource management is indeed of great importance to ensure sustainable development which the World Commission on Environment and Development of the United Nations (WCED) defined in its landmark 1987 report, Our Common Future (the Brundtland Report), as ”development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

Table 1 Population and agricultural production in the major countries in Asia.

Country	Indicators	1980	1985	1990	1995
China	Midyear population (millions)	996.13	1,070.20	1,155.30	1,221.46
	Population density (persons/km^2)	104	112	120	126
	Agricultural production index(1989-1991=100)	63.2	80.3	101.2	141.9
India	Midyear population (millions)	675.00	750.91	834.70	915.97
	Population density (persons/km^2)	205	228	251	285
	Agricultural production index (1989-1991=100)	67.3	84.1	99.8	115.1
Indonesia	Midyear population (millions)	146.63	164.63	179.25	195.28
	Population density (persons/km^2)	77	85	93	101
	Agricultural production index (1989-1991=100)	67.2	82.9	101.2	113.2
Philippines	Midyear population (millions)	48.32	54.67	61.48	68.42
	Population density(persons/km^2)	161	182	205	228
	Agricultural Production Index(1989-1991=100)	88.4	87.3	103.8	113.9
Thailand	Midyear population (millions)	46.72	51.58	55.84	59.40
	Population density (persons/km^2)	91	101	109	116
	Agricultural production index (1989-1991=100)	81.7	95.5	94.8	114.1

Source: Statistical Indicators for Asia and the Pacific, United Nations (1997).

Background of SUASA-2

While there have been a number of definitions of sustainability besides the definition by the WCED and numerous general views on the causes and effects of non-sustainability, it does not seem to be easy to find any good solution to improve sustainability in a specific sector in a specific area, since sustainability is not just an environmental issue, but it is also closely linked to so many other area-specific socio-economic matters, and the relationships among them are quite complex.

Aiming to promote socio-economic research and development of CGPRT crops, the CGPRT Centre identified “sustainable agriculture and resource management” as one of the major themes of research and development activities in its “Strategic Plan for the Centre in the 90's and Beyond”. The Centre conducted a research project “Sustainable Upland Agriculture in Southeast Asia - a Study of Constraints and Prospects (SUASA-1)” which was funded by the Government of Japan during the period of 1994-1995. The main objective of the project was to find the constraints and prospects of sustainable agriculture in some upland areas in the participating countries of the project, i.e., Indonesia, Thailand and the Philippines.

The second phase of the project (SUASA-2), funded by the Government of the Republic of Korea, was an extension of SUASA-1. The main objective of the project was to identify the constraints and prospects of sustainable resource management in marginal upland areas with emphasis on economic aspects of resource management, to characterize the transfer/adoption mechanism of resource management techniques and to suggest directions for sustainable resource management based on the results and findings of the previous project, SUASA-1.

China and India, the two biggest countries in Asia, were chosen as the participating countries of SUASA-2 since, in both countries, upland agriculture occupies a considerable part of agriculture which often faces issues relating to resource management and sustainability of production. The project provided policy makers and researchers in the region with some examples of solutions to improve the sustainability of agriculture in marginal upland areas through technically feasible and economically viable resource management. The project was also consistent with the Agenda 21, adopted by the UN Conference on Environment and Development (UNCED) held in 1992 at Rio de Janeiro, especially its chapters 14 and 34.

Implementation of SUASA-2

The overall approach of the project followed that of the preceding project SUASA-1. The project was also implemented as a collaborative project with partner institutes of the participating countries. The Centre played a role in coordination, method development and dissemination of findings to other countries in the region. Case studies and empirical analysis of data obtained in farm and field surveys were conducted. The top priority was put on quantitative assessment of the economic effect of available resource management techniques and practices to meet the objectives. The project activities included three stages, i.e., preparation, data collection and analysis and reporting and dissemination.

Preparation

This was the stage for gathering preliminary information on the general situation of resource management and the relevant institutions in the participating countries from various sources. This was also the stage for selection of appropriate collaborating agencies, case study sites and national experts. A planning meeting involving the selected national experts of the project was held at the Centre.

The activities of this stage were conducted mostly during1996. In the early part of the year, preliminary information was gathered. Then in August, selection of the collaborating agencies, prospective case study areas and national experts was made through consultation with relevant personnel of the participating countries. Four collaborating agencies, national experts and case study areas were selected, i.e., two in each participating country in order to cover as many different but representative agricultural sites as possible in the participating countries (Table 2).

A planning meeting was scheduled to be held in November 1996 at the Centre inviting the selected four national experts from the organizations mentioned above. It was cancelled, however, due to difficulties of the national experts of China to participate in the meeting. Instead, missions were made to the participating countries, India and China, by the Centre’s staff in November 1996 and in January 1997, respectively, to examine the case study areas and to discuss the work plans for the case studies with the national experts.

Data collection and analysis

This was the stage for the national experts to collect information on various resource management techniques, agro-ecological conditions and farming systems in the study sites from relevant national agencies and international research institutes, and to develop analytical methods to facilitate the economic assessment of resource management techniques in conjunction with specification of the type of upland farming and resource conditions.

In this stage, an interim meeting was held at the Centre from 18 to 19 March 1997 with the participation of all of the national experts to monitor the progress of the case studies, to discuss the detailed work plans specific for the case study sites and to discuss common approaches to be applied in the case studies of each participating country. In the meeting, the characteristics of the selected case study sites in each of the selected areas and the major constraints on sustainability or resource management involved in the areas were identified.

Table 2 Collaborating agencies, national experts and case study areas of the project.

Country	Collaborating Agency	National Expert	Case Study Area
China	Commission for Integrated Survey of Natural Resources, Chinese Academy of Sciences, Beijing	Dr Gu Suzhong, Senior Economist	Guizhou Province, southwestern part of the country
	Department of International Cooperation, Ministry of Agriculture, Beijing	Mr Ni Hongxing, Senior Policy Officer	Qinghai Province, northwestern part of the country
India	Project Directorate of Cropping System Research, Indian Council of Agricultural Research (ICAR), Modipuram, Meerut, Uttar Pradesh	Dr Mahander Singh, Senior Researcher	Uttar Pradesh state, central northern part of the country
	ICAR Complex for Northeastern Hills (N.E.H.) Region, Barapani, Meghalaya	Dr Gour Chandra Munda, Senior Scientist	Meghalaya state, northeastern part of the country

Reporting and dissemination

This was the stage for the national experts to write country reports of the case studies and for the Centre to disseminate the results and findings of the project.

Although the national experts were requested to submit their draft country reports of the case studies by the end of June 1997, the submission was delayed because of the tough case studies and some communication problems. The first draft country reports were submitted to the Centre in August and September 1997, and it was again a long process for the Centre to revise the drafts through discussions with the national experts.

A mission was made to China in September 1997 by the Centre’s staff to discuss the draft reports with the national experts. A meeting was held at the Centre from 10 to 11 February 1998 with participation of all of the national experts of the project, a resource person, and the Centre’s staff to finalize the country reports. A mission was made again to India in March 1998 by the Centre's staff for more discussions with the national experts on problems found in their draft reports.

The Centre held a regional seminar on “Resource Management and Sustainable Agriculture in Marginal Upland Areas” at the Korea Rural Economic Institute (KREI) in Seoul, Korea, from 20 to 22 May 1998 with cosponsorship by the KREI. All of the national experts of the project, commentators for the reports, resource persons and guests from China, India, Thailand, Indonesia and Korea participated in the seminar. It was a good opportunity to discuss more broadly agricultural resource management in relation to various sustainability issues to conclude the project.

Outlines of the case studies

The national experts of the project intensively analyzed the economic impacts of some resource management techniques adopted by the farmers in the case study areas. The following sections are outlines of the case studies conducted by the national experts in each of the study sites.

Pingba county near Guiyang, the capital city of Guizhou province, China

Guizhou province is located in the sub-tropical Yunnan-Guizhou Plateau, Southwest China. The province consists of three main topographies: mountains (87%), hills and hilly areas (10%) and basins (3%). Also, Karst area constitutes 73% of the total area, covered with stones and gravel. Most of the land in Pingba county has an altitude of 1,200-1,500m. Major crops grown are rice, wheat, maize, cotton and potato. Population of the province in 1996 was 35.55 million. In 1995, the per capita GNP was US$ 250 and the farmers' per capita annual income was US$ 118. The province is one of the most underdeveloped, grain-deficient and poverty-stricken regions in China.

Resource management problems in the site include the following:

- Severe shortage of arable land (0.27 ha/farm household).
- Most (53%) of the fields are located on mountain slopes with greater than 15% slope.
- Thin layer of topsoil mixed with gravel (soil depth: 20-30cm).
- Low productivity of the farmland: grain yield is 83% of the national average.
- Small-scale fragmented plots of farmland ("palm field" or "hat field").
- Frequent drought disasters (uneven temporal distribution of rainfall).
- Poor capacity for utilizing rainfall and groundwater.
- Others: shortage of agricultural investment, poor education, poor capacity for technological application and acceptation of farmers, etc.

The major concern of the study was the economic assessment of the terracing project, which the local government conducted from1991 to1995 to improve the farming situation on mountain slopes. It was one of the model sites of the research project "China's Sustainable Agriculture and Rural Development Research (SARD)" conducted by the Ministry of Agriculture of China.

The total area terraced in the country during the period was 807 ha and the average cost of the terracing was US$ 710/ha. The cost consisted of material cost (29%) and labour cost (71%). There were four main types of terracing: transforming sloping dry fields into terraced dry fields (74%), sloping dry fields into terraced paddy fields (5%), sloping wasteland into terraced dry field (8%) and sloping wasteland into terraced paddy fields (1.3%). When selecting the sites for terracing, the local government gave priority to existing cultivated land with slopes of 15-25% in poverty-stricken areas.

The benefits that terracing brought to the area were various: arable land was expanded by 8%, average plot scale was expanded from 0.03 to 0.9 ha, the topsoil layer was thickened from 15-30 to 40-60 cm, floods and droughts were greatly alleviated, grain yield was increased by an average annual growth rate of 16% during 1992-1997 and the farmers were provided with more working opportunities resulting in average growth of their annual income by 7.5%. The terraced farmland began to produce net benefits (accumulated benefits minus accumulated costs) from 1977, two years after completion of the project.

Several recommendations emerged from this case study:

- Specific-purpose terracing investment should be increased. The local leaders should try to attract foreign investors' attention, including every kind of monetary organization.
- The selection procedure for terracing project areas should be greatly improved from provincial government officials downward to village heads.
- The recommended procedure is: organize a special provincial technical group including officials and technicians, prioritize counties according to their actual need for terracing; select key terracing project areas by county terracing headquarters.
- The terracing standard should be improved.
- More attention should be given to fund diversion in terracing. Fund supervising and auditing should be strengthened and improved further.

Huangyuan county located in the east of Qinghai province, China

Qinghai province is located in the northeast of the Tibetan Plateau bordering Tibet and Xingjiang to the west and Gansu and Sichuan to the east. Most of the province is 3,000m above sea level on average and characterized by a very rugged and panoramic terrain, mountain ranges, steep valleys and gorges. The province is a semi-arid or arid climatic zone with long and cold winters and low levels of rainfall (annual precipitation: 310-450mm). The province is one of China's main pastoral areas, feeding some 23 million head of livestock. Major crops cultivated are wheat, barley, pea, broad bean, potato, rapeseed, oats, fruit and vegetables. Population in 1995 was 4.812 million. In 1995, the per capita GNP was US$ 413 and the per capita annual farm income was US$ 115.

Resource management problems in the site include the following:

- Climatic constraints: long and cold winter and insufficient rainfall limit crop production to one crop per year; spatial and temporal distribution of rainfall is uneven.
- The capacity for utilizing water resources is poor (annual use of the total quantity of water resources: 4.5%).
- The altitude determines the length of the crop growing period.
- Soil erosion on the mountain slopes and poor quality of soil: low organic carbon and low cohesiveness.
- Poor extension system and no research activities.
- Lack of credit facilities for farmers.

Despite these constraints, the province still has considerable untapped potential for increasing production; about 500 thousand ha is available for expansion of farmland (86% of the present cultivated land) and precipitation over the highland is sufficient.

This case study also focused on economic assessment of the effect of terracing which was regarded by the local government as one of the most important techniques for improving productivity and managing agricultural resources in the province. The terracing project has been conducted there on a large-scale combined with watershed management since 1982. Due to the limitation of time and the availability of data, the study analyzed only the effect of the terracing projects completed in 1995 in Huangyuan County, which was one of the 150 model experimentation and demonstration counties for ecological agriculture in China.

The total area under terrace construction in the county in 1995 was 1,283 ha, of which 207 ha were transformed into 171 ha of dry terraced field and 1,076 ha were transformed into 891 ha of irrigated terraced field. The activities in relation to the terraces were: reforestation, and construction of earth checks and dams, stone checks and dams and ditches. The total investment (US$ 509,000) needed for terracing and its related activities came from government at various levels (56%), collectives (28%) and the farmers (16%). Priority was given to the land with slope over 25%. The major cost of terracing consisted of the interest (7%) of the total fund invested, the opportunity cost of the land which had disappeared due to the terrace construction and the maintenance cost for the terraced land.

The direct economic benefit of terracing was the yield increase of wheat. According to studies conducted in the province in the past, the wheat yield increase in the terraced dry field was about 5% for the first year, 13% for the second year and 25% for the third and later years. The yield increase in the terraced irrigated field was 15% for the first, 32% for the second and 52% for the third and later years. Other benefits of terracing were: increase of the water-holding capacity of the soil, reduction of soil erosion and the production of fuel wood from the reforested area. Based on estimation of benefits and costs for the years 1996-2010, the case study indicated that the B/C ratio for the terraced dry field was 1.00587 and that for the terraced irrigated field was 1.34, indicating that terrace construction combined with irrigation facilities and reforestation was economically feasible.

Several recommendations emerged from this case study:

- The environmental effects of terracing such as water conservation should be advertised greatly, particularly for transforming sloping land into terraced dryland.
- Terracing should be more and more combined with improving irrigation systems so as to maximize its benefit.
- Sloping land with convenient irrigation conditions should be selected first for terracing.
- The practice of terracing combined with reforestation should be maintained so as to improve the natural resource base.

Karanpur village, Mathura district in the southwestern part of Uttar Pradesh state, India

The state of Uttar Pradesh, bounded on the north by Tibet and Nepal, represents the semi-arid subtropical tract of India. The case study site, Karanpur village, is located in Mathura district and falls under the southwestern semi-arid agro-climatic zone of the state. The annual precipitation is 500-700mm. The maximum (65%) rainfall is received in July and August. Most (92%) of the cultivated area is irrigated mainly with underground water through tube-wells. Major crops are pearl millet, wheat, barley and mustard. The population density of the village is 257 persons per km^2. The majority of farm families have an annual income less than Rs 11,000.

Resource management problems in the site include the following:

- Poor quality of underground water for irrigation purposes due to i) excessive salt content, ii) high sodium adsorption ratio (SAR), iii) high residual sodium carbonate (RSC), and iv) high content of other toxic elements.
- Other constraints to technology adoption: low and erratic rainfall, drought, high cost of technology, non-availability of inputs, poor extension services, incompatible loan procedures, agricultural labour shortage, small and fragmented land holdings, low education level, etc.

The case study aimed to analyze the impact of some important agro-techniques that had been developed since 1993 by the Central Soil Salinity Research Institute of the Indian Council of Agricultural Research (ICAR). The institute tried to manage the poor quality irrigation water by land leveling, bunding, gypsum application and the sprinkler irrigation method in pearl millet-wheat and peal millet-mustard cropping systems with saline/alkaline water in the semi-arid region.

In the village where the fields had 0.5-3.0% slopes, land leveling was essential to increase water retention in the soil, which was useful for leaching of harmful accumulated salt from the soil. Bunding around (1m) and within (50cm) the fields was also useful for retention of irrigation water. When water stagnates in a field, salts are dissolved and moved with water to deeper soil layers, so the root zone becomes free from harmful salts. On average, 3,000 kg/ha of gypsum ($CaSO_4$) was applied just before the start of the monsoon rain to minimize the alkalinity of the soil. Sprinkler irrigation was used to uniformly distribute the available poor quality water to minimize the quantity of such water applied. The operational cost for each technology was incurred by the farmers who adopted the particular technology. The costs included those for land preparation, seed, seed sowing, fertilizers, weed control, irrigation, harvesting, etc.

The study found that all of the technologies applied were useful in bringing down the salt load of the field through leaching, and, because of this effect, the farmers who adopted these technologies obtained 27-170% higher yields than those farmers who practiced conventional farming in the two cropping systems. The highest yield was from gypsum application, followed by land leveling. With the adoption of these technologies, the cropping intensity was also increased (117%). The benefits in alkaline water conditions were higher than in saline water conditions. B/C ratios were calculated to compare gross returns to operational costs. The highest B/C ratio (Rs 33,900/Rs 12,263 = 2.76) was on the pearl millet-wheat system in alkaline water conditions with gypsum application.

Several recommendations emerged from this case study:

- The government should improve credit infrastructure, supply inputs in a timely manner, manage subsidies efficiently, consolidate land holdings, strengthen the extension infrastructure, develop small irrigation and drainage grid systems and support farmers' education and participation in planning and implementation of programs.
- Farmers should develop their banking aptitudes and habits to take full advantage of credit facilities extended by the banks and develop confidence to break social barriers and the government-launched programs should be taken in good stride and should be treated as important as their own programs.
- Research is needed to develop low cost technologies to bring down the cost of sprinkler and drip irrigation systems, bullock-drawn land levelers and bund-makers and other farm machinery. The non-availability of gypsum in the area is one of the constraints for its use; therefore, locally available alternatives to gypsum should be developed. There is a need to develop location specific salt tolerant crop varieties. Research on development of appropriate and profitable alternative farming systems like agro-forestry systems and silvi-pastoral systems is needed.

Mawlasnai village near Shillong, the capital city of Meghalaya state, India

The case study site is located in the North Eastern (N.E.) region of India, which is mostly hilly and mountainous. Agriculture is the main occupation of the people. Crop production activities are carried out under varying slopes (0-100%) and altitudes (50-3,000m). Agro-climatic conditions vary from mild tropical in the low altitude areas to temperate in the high altitude area. The area under cultivation is concentrated mainly in valleys, plateaus, foothills and hill slopes. Rainfed crops such as rice, maize, millets, potato and ginger are grown at subsistence levels. The area has remained deficient in food grain production.

Resource management problems in the site include the following:

- Prevalence of the slash and burn method of shifting cultivation (jhuming) and the raised bed method of cultivation (bun) on steep hill slopes associated with deforestation resulting in soil erosion and other land degradation.
- High rainfall and high humidity during the wet season.
- Apathy of the farmers towards the use of chemical fertilizers and pesticides, non-adoption of HYV crops.
- Lack of knowledge and skill in farm operations.
- Poor returns from piggeries and other subsidiary sources of income.
- Lack of banking and cooperative facilities.
- Poor infrastructure facilities for storage, transport and marketing, etc.

The case study characterized some traditional farming practices on the sloping land in the study site and discussed the benefits and costs of the three most important resource management techniques: jhuming, bun and broom grass cultivation in relation to agricultural sustainability. Some improved and alternative land use practices were presented and the issues surrounding their expansion were also discussed.

For jhuming on hill slopes, the trees and shrubs slashed during December-January are left to dry and burned to make the land ready for planting rice, maize, ginger, etc. The crops are grown under rain-fed and natural fertility conditions without tilling. No care is taken until harvest beginning in September. After 2-3 years, a new site is selected for another jhuming. In the bun method, raised beds are made along the hill slopes. Grasses and leaves are placed on the beds and covered with soil, and then burned under the soil cover. Crops are planted on the bun. As in jhuming, no care is taken and there is loss of topsoil. Farmers shift to a new site for the next few years. The abandoned land regenerates its vegetation and becomes ready for a few years of farming again. Broom grass planted on hill slopes is harvested from the third year for 10-12 years. Then the land is kept fallow for 3-4 years after which bun is practiced again. Labour input and planting materials are the major costs of the cultivation in the three resource management techniques.

While the three farming practices are related to livelihood of the farmers in the area, they are neither profitable nor sustainable; the B/C ratios of jhuming and bun for rice in the first year were only 1.03 and 1.07, respectively. Jhuming in the second year onwards and bun beyond the fourth year were not profitable. Broom grass, cultivated on a limited scale, was the most profitable (the B/C ratio for years 3 -10 was 2.65). The study stressed that, although jhuming and bun are not likely to disappear in the near future, they have to be replaced or improved. Introduction of contour bunding or trenching and toposequential cropping, use of HYV crops and fertilizers would be useful to improve the productivity of jhuming or bun. Terracing may be a good replacement.

Several recommendations emerged from this case study:

- Immediate priority should be given to the improvement approach to gradually improve jhuming or bun methods with appropriate farming systems.
- In the long run, the replacement approach should be adopted as an alternative to jhuming or bun systems. Preference should be given to mixed land use (forestry in the higher ridges, horticulture plantation with half-moon terraces in the middle portion, agricultural and horticultural crops at the lower terraces).
- Hills with steep slopes (100%) should be utilized for forestry land use to produce fuel and timber.
- Foothills should be used for field crops as well as vegetable crops.

- Production of rice under wetland conditions should be intensified by using HYV during the monsoon season with proper drainage and growing of a second crop of boro rice during winter/summer months with assured irrigation.
- On-farm research and demonstration of improved packages of practices for crop production and soil conservation measures should be undertaken by a core team of scientists.

Workshop Proceedings

Message of the Executive Secretary, United Nations Economic and Social Commission for Asia and the Pacific

*Mr Adrianus Mooy**

It is a great pleasure for me to greet you on behalf of the United nations Economic and Social Commission for Asia and the Pacific to this workshop organized jointly by the ESCAP CGPRT Centre and the Korea Rural Economic Institute (KREI). We have attached great importance to this event as it illustrates our growing commitment towards the improvement of marginal land which is associated with the rural poor. The presence of senior government officials and experts in the meeting has further demonstrated the commitments of the national governments in this area.

As you may already know, the main purpose of the workshop is to conclude the activities of the project on **Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture (SUASA-2)**, generously funded by the Republic of Korea since 1995. The objective of the project is to understand more thoroughly the mechanism of sustainable land and soil management in marginal upland areas. The CGPRT Centre had invited two heavily populated countries of the region, China and India, to participate in the project activities. Both the countries have great agricultural potential due to their size, population and expertise.

The case studies conducted during the last two years have given us more knowledge on sustainable land management in marginal upland areas. This workshop will facilitate dissemination of the results and findings of those studies. It will hopefully contribute to increased public awareness and understanding of the importance of resource management in sustainable development of upland agriculture. We also hope that the workshop will discuss the constraints to sustainable resource management and deliberate on various remedial options for policy planners to improve economic and social conditions of upland farmers.

Following the economic crisis in Asian countries, there has been a renewed faith in the agricultural sector as a key to national development. The outcome of the project will provide support towards this end. It could also contribute to alleviation of rural poverty. This workshop is timely and can provide critical inputs to the countries of the region.

Before I conclude I would like to express once more our appreciation to the Government of the Republic of Korea for providing financial assistance and a non-reimbursable expert to undertake the project.

I wish you every success in your deliberations.

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* Read by Mr Kiran Pyakuryal, Chief, Rural Development Section, RUDD, ESCAP Headquarters, Bangkok, Thailand.

Opening Statement

*Sangwoo Park**

In the ten years since the Brundtland Commission published Our Common Future, the concept of sustainable development or sustainability has emerged as an important principle in national and international policy-making and evaluation. At the 1992 United Nations Earth Summit in Rio de Janeiro, one hundred fifty participating nations affirmed sustainable development and endorsed Agenda 21 as part of their policy agenda. Since then, this criterion has been rapidly extended and explored in various policy projects and their assessments.

In producing essential primary goods and conserving natural resources, agriculture faces with a new challenge to "meet the needs of the present without compromising the ability of future generations to meet their own needs". Sustainable agriculture therefore should encompass environmental needs while maintaining the ultimate objective of food for all.

To enhance geographical, temporal, and institutional equity and efficiency in agriculture, sound resource management practices and techniques are of great importance. They embrace proper soil and water management, land conservation, ecological stability and resilience, sustainable pest control, and stable climate and market conditions. The achievement of sustainable agriculture requires a few additional degrees of freedom depending on the levels of individual farms, regions, and nations.

More than ever, national and international communities are deliberately pursuing this issue in the dimensions of research and policy. Sustainable resource management in marginal upland agriculture in Asia and the Pacific is particularly an emerging theme since CGPRT crops (coarse grains, pulses, roots and tuber crops) have dominance over the areas and the farming is practiced in fragile resource conditions.

For this reason, I believe it is a timely and relevant workshop that can provide discerning research results. I am glad and feel honored that KREI has the privilege of hosting the workshop in Seoul, Korea, with the ESCAP CGPRT Centre.

The case studies to be presented here will potentially be valuable lessons in agricultural policy aspects. They will also be important sources of country- or region-specific information in Asia and the Pacific. Discussions and debates on the issues will help to expand our knowledge and enhance our understanding regarding sustainable agriculture and resource management.

I hope this seminar will further motivate international collaboration in agricultural R&D by which we are capable of meeting the challenge ahead and contributing to agricultural development in this area. Developing stronger research coordination between the ESCAP/CGPRT Centre and KREI is regarded as highly desirable at this time.

Here, I would like to recognize the commitment and efforts of the staff and researchers in the ESCAP/CGPRT Centre as well as the leadership of Dr. Haruo Inagaki, Director of the Centre since 1995. They have successfully implemented various research and development projects on the socio-economic aspects at CGPRT crops, education, and upland agricultural. Their support and preparation made it possible to hold this seminar in Seoul, Korea. The generous support by ESCAP and its staff is greatly appreciated as well.

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* President, Korea Rural Economic Institute, Seoul, Korea.

Finally, I welcome all participants in this workshop, particularly from abroad. I can say with confidence that our discussions in this workshop will greatly improve research and agricultural development in Asia and the Pacific. I sincerely hope you have a good time during the session and pleasant stay in Seoul, Korea. Again, welcome to the seminar.

Opening Statement

*Haruo Inagaki**

It is my great pleasure to be able to hold the workshop on **Resource Management and Sustainable Agriculture in Marginal Upland Areas** today here in Seoul, co-sponsored by the Korea Rural Economic Institute.

It is my great honor to have the attendance of Dr. Park Sang-Woo, President of the Korea Rural Economic Institute, and Mr. Suh Kyuyong, Director-General of the Agricultural and Horticultural Production Bureau, Ministry of Agriculture. I thank Mr. Kiran Pyakuryal, Chief of Rural and Urban Development Division, Economic and Social Commission for Asia and the Pacific (ESCAP) for his presence to represent ESCAP, to which the CGPRT Centre belongs as a subsidiary body.

This workshop was planned in principle to discuss and disseminate the findings of a research project **Economic Assessment of Selected Resource Management Techniques in Marginal Upland Areas (SUASA-2)**.

The project was first formulated and proposed by Mr. Lee Nam-Bok, the former Programme Officer of the CGPRT Centre and the current Director of the Pusan Branch Office, National Plant Quarantine Service, and it was funded in 1995 by the Government of the Republic of Korea. The project focused on the effectiveness of specific land and soil management measures in the region. China and India were invited to participate in the project mainly because their rational and effective management of land and soil is extremely important for stabilizing crop production in the marginal upland areas in these countries.

The outline of the project will be introduced later by Mr. Min-Jae Kim, the present Programme Officer of the Centre provided by the Korean government. In this context, firstly, I would like to express my sincere appreciation to the Government of the Republic of Korea for its generous and continued support to the project as well as to the CGPRT Centre in providing the funds and project experts.

Secondly, I would like to thank those national experts of China and India for their devoted efforts to tackle such a tough subject at those study sites located precisely in the marginal areas. At the same time, my thanks should go to their institutes who supported their studies all the way through.

I am also very grateful to all of you for your participation in this seminar. In particular, I thank those distinguished speakers who will present keynote addresses, special discussions and comments to the seminar, which will surely strengthen our discussions in many aspects.

The CGPRT Centre, in its co-ordination function, will publish the reports of the project and the proceedings of this workshop. Together with the discussions in the seminar today, if these publications contribute to you in your future studies and policy planning in related fields of agriculture, it would be our utmost pleasure.

Lastly, I would like to thank all of those who cooperated with the CGPRT Centre in arranging and preparing this workshop.

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* Director, CGPRT Centre, Bogor, Indonesia.

Opening Statement

Kyuyong Suh[*]

On behalf of the Ministry of Agriculture and Forestry, the Government of the Republic of Korea, I am very pleased to address the opening of this regional seminar on **Resource Management and Sustainable Agriculture in Marginal Upland Areas**.

I believe today's workshop, during which we will discuss global issues such as developing measures of resource management and sustainable agriculture, will greatly contribute to raising the practical use of marginal land and food self-sufficiency, not only in Korea but also in the other countries in the Asia-Pacific region.

Food self-sufficiency to ensure food security is a very important task for Korea especially under the circumstances of the national division into South and North. Moreover, Korea is one of the major importers of agriculture products in the world, and food security in this country is exposed to intimidation by a few food-exporting countries.

I believe food self-sufficiency is also an important task for many countries in the Asia-Pacific region. In order to accomplish food self-sufficiency, one of the most important measures will be development of marginal land. This development should be carried out in a more environment-friendly manner.

I would like to point out that agriculture has positive effects on the environment by ensuring food security, preserving ecosystems, and providing recreation areas. On the other hand, its adverse effects on the environment are pollution caused by using input materials such as pesticides, chemical fertilizers and animal wastes. Taking these aspects into account, the development of sustainable agriculture could be approached in an environment-friendly way to maximize its positive effects on environment and to minimize its adverse effects.

The Korean government has initiated policies to promote sustainable agriculture from 1996, which can be grouped into three major parts. They are to mitigate pollution from using input materials, to maintain and improve agricultural conditions of farmland, water resources, etc, and to support environment-friendly farming techniques.

I sincerely hope that discussions on these issues today will lead to accomplishment of our common goal of developing sustainable agriculture in the entire Asia-Pacific region. I would like to take this opportunity to express my sincere appreciation and gratitude to Dr. Park Sangwoo, President of the KREI, and Dr. Haruo Inagaki, Director of the CGPRT Centre for organizing the workshop to be held here today. I am confident that this seminar will serve as a good opportunity to enhance the cooperative relationship between the ESCAP CGPRT Centre and the Korean government.

Lastly, I would also like to thank the distinguished participants especially from abroad for taking time out of their busy schedules to attend the seminar, and I hope that your remaining stay in Seoul will be a pleasurable and memorable one.

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[*] Director-General, Agricultural and Horticultural Production Bureau, Ministry of Agriculture and Forestry, Korea.

Current Status and Future Tasks in Marginal Upland Agriculture

Sang-Woo Park[*]

Introduction

At the outset, I would like to point out that land resources and human populations are not evenly distributed over the earth. As a result of this uneven distribution, patterns in the use of land vary considerably between countries.

Arable land is scarce in many densely populated regions. Marginal uplands or sloping land in these regions tend to be cleared of the original forest cover and used for agronomic and/or livestock production. Also the intensifying pressure to utilize sloping land increases soil erosion and flooding hazards in addition to posing serious challenges to sustainable production throughout the watershed.

Agricultural activities on marginal uplands have become a major concern throughout the world, particularly in regions with high population density. A critical problem confronting both developing and industrial nations is the rapid deterioration of soil and water resources as a result of non-sustainable agricultural practices. Although some marginal lands have been used and managed successfully for tree and annual crop production, large areas of such land are currently in danger of irreversible degradation, because of intensive use and lack of conservation measures.

The people cultivating marginal uplands often have no alternative for producing food. Many poor peasants depend on marginal upland for their subsistence, and many countries heavily rely on marginal uplands to meet the food security needs of their urban populations.

Typically, one of the critical problems in marginal upland areas is soil erosion. Other off-site effects include eutrophication of waterways, loss of reservoir storage, disruption of stream ecology, flooding, and increased water treatment costs.

Many problems are caused by converting sloping land from forests into cropland. As population grows, the poorer segments of the farming community increasingly develop marginal sites, such as steep and less fertile lands.

Today, I would like to address the current situation and the future tasks of marginal upland agriculture along with the many problems Korea currently faces. I believe the issue holds an important place in the future food production and environmental protection as well, and hopefully, this will help other Asian countries that face similar problems.

Before discussing the current situation, let us start with the projected world population and food production capacity. According to the world population projection by the United Nations, the 5.3 billion population on earth in 1990 is estimated to reach 8.5 billion in the year 2025. More than half of the world population increase will be in Asia (Table 1).

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[*] Korea Rural Economic Institute, Seoul, Korea.

Apparently, the current size of the farmland of the world is about 1.44 billion hectares, which occupy 11% of the total land on earth. Farmland expansion over the last ten years (1981-1991) has been a mere 1.6%. It is estimated that there is a possibility for the world's farmland to be expanded by 70-120 % in the future from the area in 1991, while the farmland area in Asia are expected to expand only by 5-37 % in the future from the current farmland area of Asia in 1991. This illustrates that capacity for expansion of croplands in Asia is very limited (Table 2).

Moreover, newly expanded cropland has some problems. These lands characteristically have less suitable conditions such as unfavorable soil, weather, gradient and water resources. Furthermore, forests occupy most of those lands, so land clearing causes great and direct impact on the environment.

Per capita cropland, which presently stands at 0.27 ha/person for the world and 0.14 ha/person for Asia has been decreasing (Table 2). The reasons for this decreasing trend are: (i) suitable lands for farming are decreasing, while expanding new farmland is difficult due to restrictions of forest clearing, and (ii) desertification of the existing farmlands, soil erosion, land conversion and so on. Per capita cropland in Asia is expected to decrease further in the future. A similar estimate for water resources in Asia also predicts very little margin for securing new water resources needed for irrigation.

Table 1 World population: trend and projection.

	Population ('00 million)			
	1970	1990	2000	2025
World	37.0	52.9	62.6	85.0
Nations				
Developed	10.5	12.1 (23%)	12.6	13.5 (16%)
Developing	26.5	40.9 (77%)	50.0	71.5 (84%)
Asia	21.0	31.1	37.1	49.1
India	5.5	8.5	10.4	14.4
China	8.3	11.4	13.0	15.1
Europe	4.6	5.0	5.1	5.2
Oceania	0.2	0.3	0.3	0.4

Source: UN The World Population Trend1991.

Table 2 Land utilization in the world (million ha).

Area	Land Area	Grassland		Forestry		Farmland			Possible Future Farmland Area	
	1991	1991	1991/81 (index)	1991	1991/81 (index)	1991	Per farmland capita (ha)	1991/81 (index)	USA	Nishikawa
World	13,042 (100.0)*	3,358 (25.7)	102.1	3,861 (29.6)	92.0	1,442 (11.1)	0.27	101.6	3,178	2,442
Asia	2,679 (100.0)	759 (28.3)	108.4	530 (19.8)	95.5	458 (17.1)	0.14	101.2	627	482
Europe	473 (100.0)	83 (17.5)	96.2	158 (33.4)	101.0	138 (29.2)	0.27	98.0	174	170
Oceania	845 (100.0)	430 (50.9)	94.6	157 (18.6)	100.2	48 (5.7)	1.79	108.3	154	120

Source: FAO, Production Yearbook, 1992.
* Figures in parentheses are percent.

While cropland has expanded little over the last 10 years, development of high yielding varieties and other modern technologies has made a great contribution to the world food supply. The development and spread of improved rice breeds, the so-called Green Revolution mainly in Asia since the 1970s, has contributed greatly to the increased crop yield. However, its spread seems to have seen its end these days. The development of higher quality varieties and better crops by biotechnology is now under study, yet the results are still uncertain.

The crop yield increase can largely be attributed to a wide use of agricultural chemicals such as fertilizers and pesticides. However, the use of these chemicals is now often strictly limited in consideration of environment and health safety.

In addition, the construction and expansion of irrigation systems have also greatly contributed to the increase of crops. At present, 17% of the whole farming area in the world is irrigated, and 34% of the farming area in Asia, where there are many paddy fields, is irrigated (Table 3).

On the other hand, as household and industry water demands are expected to rise in the future, securing new water supplies for agriculture will become more and more difficult. Water problems may be more serious in Asia where water resources are already fully utilized for paddy farming and other uses.

Table 3 Farmland area, irrigated farmland area and state of irrigated land (million ha).

	Farmland Area			Irrigated Farmland Area			Rate of Irrigated Land (%)		
	1971	1981	1991	1971	1981	1991	1971	1981	1991
World	1,376	1,419	1,442	172.2	213.9	241.6	12.5	15.1	16.8
Africa	164	173	182	9.0	10.1	11.4	5.5	5.8	6.3
Asia	441	452	458	112.0	134.1	154.5	25.4	29.7	33.7
South America	84	102	115	5.6	7.3	8.8	6.7	7.2	7.7
Developed nation	667	671	666	45.5	60.2	63.9	6.8	9.0	9.6
Developing nation	663	705	775	126.7	153.8	177.6	18.0	20.6	22.9

Source: FAO, AGROSTAT.

Due to the limited possibility of expanding farmland and water resources along with increasing population, securing the food supply in Asia is the most sensitive issue for the future.

Problems and measures of marginal upland agriculture in Korea

Current status of marginal upland agriculture

Marginal upland agriculture in Korea, where most of the marginal upland is situated on sloping land, faces difficulties, in particular, due to the less favorable natural environment and social conditions.

As the nation’s economy grew and the peoples’ tastes changed, the rate of food self-sufficiency has gradually declined mainly in grain production except for rice. It is now at the lowest level of 27% (including fodder supply, 1996 in Table 4). Hence, improving food self-sufficiency is the most critical task for the nation’s agricultural policy at present.

Of course, the size of arable land in Korea is very limited. Only 20% of the total land is arable. About two-thirds of the arable land is paddy field and one-third is upland. The average farm size is 1.3 ha.

In marginal upland areas often located hilly and mountainous regions, the population of younger persons in the labor force engaged in farming is low as a result of depopulation. Moreover, in these areas, the proportion of abandoned farmland is higher than in other areas.

Abandoning of cultivated land began in the 1980s mainly in marginal land areas. Statistics show that abandoned farmlands reached 65 thousand hectares in 1995, which is 3.3% of the nation’s total farmland (Table 4). This ratio in the hilly intermediate and mountainous regions is particularly high. As for the marginal land in steep slope areas, the ratio goes up to 16% (Table 5).

Table 4 Major economic indicators in Korean agriculture.

Indicator	1970	1980	1990	1996	1970-1996 Annual Growth Rate (%)
• Total population ('000 persons)	31,430 (100)	38,120 (100)	42,870 (100)	45,545 (100)	1.44
- Farm household population	14,420 (44.7)	10,827 (28.4)	6,661 (15.5)	4,692 (10.3)	-4.23
• Farm households ('000)	2,483	2,155	1,767	1,480	-1,97
• Economic growth (1990 constant billion won)					
- GNP	27,128 (100)	52,261 (100)	178,262 (100)	272,324 (100)	9.28
- Agri. GNP	7,153 (26.4)	7,657 (14.7)	15,592 (8.7)	17,583 (6.6)	3.52
• Land use ('000 ha)					
- Total land	9,848 (100)	9,899 (100)	9,927 (100)	9,931 (100)	0.03
- Forest	6,611 (67.1)	6,658 (66.3)	6,657 (66.1)	6,455 (65.0)	-0.09
- Arable land	2,298 (23.3)	2,196 (22,2)	2,148 (21.6)	1,946 (19.6)	-0.64
- Abandoned farmland	na	na	40.4	64.6	9.84
• Food self-sufficiency rate excluding fodder (%)	80.5 (86.2)	56.0 (69.6)	43.1 (70.3)	26.7 (52.4)	-

* Figures in parentheses are percentages.

This is compounded by stagnation of infrastructure improvement in less favorable areas, which apparently prohibits the introduction of machinery into these farmlands, and, thereby, results in the reduction of agricultural productivity as compared to the plain areas (Table 6).

These less favorable conditions in marginal upland agriculture have resulted in socio-economic factors as well as natural and technical impacts. Socio-economic factors are as follows: (i) decline in the number of farmers and increase in their age, (ii) concerns over the future prospects of farming in the world of liberalized agricultural trade, (iii) job opportunities other than farming in particular regions, and (iv) delay or neglect in social capital infrastructure and comprehensive regional planning. In turn, the natural and technical impacts are listed as: (i) each farming lot in marginal uplands is rather small, which makes mechanization difficult, (ii) the intricate topography and small-scale fields are causes of inefficient farming, (iii) the lack of farm roads makes access of machinery and farm activities in the fields difficult, (iv) soil erosion in the upland fields is high due to slope and non-conservative farming practices, and (v) the costs for land grading, irrigation and drainage facilities tend to be much higher.

The rise in abandoned farmlands and also their deteriorating conditions are expected to cause many threatening problems to regional environment and the national land conservation effort as well as food supply. A collective move to give up cultivation in a large pool of marginal upland fields may cause a collapse of those farmlands, which will lead to the loss of the natural functions they perform such as a flood control and aquifer recharge for the region.

Table 5 Comparison between marginal area and other rural areas.

	Marginal	Other
Arable land (%)	13.9	39.5
Abandoned cultivation (%)	16.1	1.5
Consolidated land (%)	27.8	57.5
Irrigated paddy (%)	50.8	68.3
Farm household (%)	70.5	52.2
Farm labor force over 60 years old (%)	42.6	38.5
Cultivation rate of greenhouse (%)	0.1	2.1
Annual population increment (%)	-6.2	-1.8
Population density (person/km^2)	38.6	276.3
Local tax amount per capita (won)	54,480	152,474
Number of medical doctors per ’0,000 persons	0.8	3.9

Source: Korea Rural Economic Institute (KREI) 1997.

Table 6 Comparison of productivity between marginal areas and other areas, 1993-95.

	Yield (kg/ha)			Value Added (’000 won/ha)		
	Kangwon (A)	Chungnam (B)	A/B	Kangwon (C)	Chungnam (D)	C/D
Rice	365	462	0.79	473	571	0.83
Soybean	164	185	0.89	272	305	0.89
Chinese cabbage	7,071	8,731	0.81	728	704	1.03
Cucumber	6,424	8,234	0.78	3,249	5,193	0.63
Tobacco leaf	268	292	0.92	1,256	1,185	1.06
Sweet corn	3,699	5,015	0.74	538	719	0.75

Note: Kangwondo is the most mountainous and hilly area in Korea, whereas Chungnam-do is a typical farm area in Korea.

Source: Rural Development Administration, Standard Income of Agricultural and Livestock Products in the Republic of Korea, 1993-1995.

Policy measures for marginal agriculture areas

Up until the 1980s, agricultural and rural development policy in Korea focused on the achievement of rice self-sufficiency. Currently, the development program of upland and slope land is based on the Isolated Area Development Law (1988), the Farm Land Law (1994), and the Rural Improvement Law (1994).

By way of further detail, the 1988 Isolated Area Development Law was the first measure which paid attention to upland and slope land areas. Under the law, less developed and low income rural areas including 403 townships are in the process of integrated development which aims to boost income and welfare of those areas during 1990-1999.

According to the 1994 Farm Land Law, about 43% of the arable land has been designated as ”agriculture promotion area”. The areas designated as the agriculture promotion area, most of which is in good production condition, cannot be converted into other land use so as to secure food supply. Conversely, arable land outside the agriculture promotion areas may be converted for non-agricultural use. Since most of the sloping land and marginal upland is located outside the agriculture promotion area may be altered, conversion of marginal upland to non-agricultural use may be accelerated.

In recent years, agricultural policy and investment have placed their first priority on the agriculture promotion area, which has resulted in discouraging farmers in less favored areas such as mountainous and slope land areas. Furthermore, since the UR agreement, the open economy has impacted on Korean farmers in marginal land making them much less competitive.

As for the 1994 Rural Improvement Law, it contains three programs which are the Rural Living Environment Improvement Program, the Rural Resort Area Development Program, and the Marginal Land Improvement Program. The first program is for urbanized rural areas, while the latter two programs are for hilly and mountainous areas with tourist potential. It is my intention to discuss the latter two programs in further detail.

First, the Rural Resort Area Development Program includes several venues such as tourist farm, lodging township, resort area, etc., which basically target increased non-farm income through nature and landscape preservation. This program is progressing smoothly because it coincides with the increasing human demands for enjoyment of the natural landscape and closeness to nature.

On the other hand, the Marginal Land Improvement Program has two venues. One is to utilize marginal land as productive arable land, and the other is to utilize it for non-agricultural use or for multiple use such as rural resort area, livestock breeding area, orchard area, housing area, industrial area, etc.

However, the Marginal Land Improvement Program is not really running for several reasons. One of the reasons is the lack of investment in the marginal land areas. Another reason is that the program to utilize marginal land for multiple uses has the risks of trial and error.

Presently the Korean government plans to introduce a direct payment scheme to farmers who cultivate arable land in the less favored areas such as mountainous and hilly areas, insular areas, isolated areas, and so on. This scheme has the objectives of increasing food supply and protecting nature and the landscape.

Characteristics of marginal upland agriculture

When we look at marginal upland areas only from an economic perspective such as agricultural productivity, we cannot help but regard it as less favorable land. However, from a different perspective, marginal upland agriculture can have many values and possibilities not seen in flat lowland agriculture.

Many marginal uplands are less suitable for agriculture since they are often characterized by low nutrient availability, low levels of organic matter and shallow topsoil. These characteristics, combined with high intensity monsoon rains, make them very susceptible to erosion when cultivated.

Evidently soil erosion is the most significant ecological constraint to sustainable agriculture on marginal uplands. The rates of soil loss in many cultivated slope land areas are estimated between 100-200 tons/ha/yr. Such slope land erosion rates are influenced by land use and management practices, precipitation patterns, inherent soil properties, and topography. Erosion is, however, unlikely to occur under the natural ecosystem where the soil surface is normally covered with natural vegetation.

There are several liabilities to marginal upland agriculture. Firstly, as marginal upland areas are generally located in hilly and mountainous regions, the population density is sparse and transportation systems are far from convenient. Therefore, opportunities to enjoy urban facilities and conveniences are limited, which causes acceleration of depopulation and aging of residents in those areas. Also, because of topographical restrictions, the farming scale is too small to receive the benefits of large-scale farming. These unfavorable conditions make the introduction of farming machinery more difficult.

Moreover, the upland fields are susceptible to soil erosion. To cope with this problem, some agricultural measures, such as agricultural engineering and cultivation systems are necessary to protect them. Lastly, land consolidation is likely to be delayed because costs for such work on marginal uplands are higher.

There are some merits of marginal upland agriculture as well. Taking advantage of differing temperatures in the same region due to the topography and altitude would open ways for a unique farming of high quality crops such as greenhouse crops (vegetables, flowers) and fruit trees.

While large-scale farming is difficult in these regions, a unique small-scale farming with diverse products can be realized by implementing land readjustment and building more farm roads and irrigation systems.

These regions are quite often the habitats for diverse wild flora and fauna besides the beautiful landscape. These factors can provide excellent opportunities for eco-tourism and field study for urbanites to revitalize the localities.

In addition marginal upland agriculture contributes greatly to national land conservation and regional environmental protection. Sustainable agriculture in those regions is valuable not only for food production but also for environmental protection.

General measures and future tasks for marginal upland agriculture

Implementation of conservation projects

Land use activities in the upland areas impact on lowland areas. If the upland portion is being misused and degraded, that action may disrupt the stability and productivity of the lowland portion as well. Thus, it is critical to “harmonize” the upland and lowland use systems.

To insure long-term viability of lowland agricultural development, it is necessary to invest in vegetation and structural measures that can prevent degradation in upland agricultural systems. Therefore, the planning and the designing of agricultural conservation projects will require multi-disciplinary efforts.

The management of marginal upland for farming essentially involves implementing conservation practices designed to retain topsoil. Conservation technologies preserve water holding capacity and soil fertility. These technologies enable sustainable crop production by substantially decreasing soil and nutrient loss. In many instances, the use of conservation technologies may increase crop yields by 50%.

Soil conservation practices fall into the following three general categories. Firstly, in sloping land farming, construction of physical structures, such as rock barriers, contour bunds, waterways, terraces, and stabilization structures (dams) are often necessary. The second category is the vegetation measures. An effective way to control erosion is to maintain year-round vegetation cover, which dissipates the erosive energy of rain. Mixed measures fall into the third category. It is often useful to combine vegetation conservation measures with physical structures, such as planting useful trees along the downslope side of rock barriers, which enhances the stability of contour rock terraces.

Land-use policy

Farmland can be separated into two groups, farmland with high productivity and that with low productivity. The high productivity farmland should be further improved in a production capacity by land consolidation and other methods. As for the low productivity farmlands, land consolidation is an indispensable measure for preserving and upgrading of marginal upland agriculture. However, as the costs for the advanced agriculture infrastructure in marginal upland tend to be higher, an increase in government subsidies and also technical development involving less expensive agricultural engineering will be necessary.

Development of agricultural management skills

In hilly, mountainous areas it is important to explore and introduce new crops, fruits, vegetables, flowers and other specialty products that are most suitable in particular soil, topography or weather for marginal upland agriculture. For this purpose, further research in high technology will be essential.

The development of farm machinery and establishment of farm work-paths is important for both safety and saving labor for the farmers in marginal upland.

Many farmers in marginal upland have no choice but to produce many different crops in a rather small scale. Therefore, it is vital to study how to organize these farmers and teach them more about combined farming systems to handle multiple crops including livestock.

In addition, in order to increase the value added for upland farm products, it is important to develop food processing techniques and the distribution system.

Regional development with agriculture

A comprehensive policy for regional development can be drawn up which centers on agriculture and entails its rich natural environment. A positive attitude toward the introduction of eco-tourism, field studies and recreational activities often contributes to a revitalization of those areas.

Many of the marginal upland agricultural districts still maintain rare wilderness and the traditional settings of mountain farming villages. These settings and the natural environment have intrinsic value, and it is necessary to revitalize those regions by enhancing and discovering their environmental values.

In sum, the future needs for agricultural lands will be met only by marginal upland or less favorable slope lands. The locational disadvantages of marginal upland areas should be overcome and comprehensive policies should be set up. Suitable technologies should be developed and extended to enhance the rich natural environment of marginal upland agriculture.

Long-term commitments from land users and local communities, technical and financial support from government agencies is also critical to successful management of marginal upland agriculture.

On the other hand, the productivity of existing cultivated fields in marginal upland should be improved more than ever by creating sustainable agriculture.

Thus, a great number of difficulties are anticipated in securing the food supply and a safe environment. In order to solve these difficulties, countries with similar problems are encouraged to actively exchange their experiences, information, and achievements. It is desirable to work together toward the common goal of developing new technologies best adaptable for marginal upland agriculture.

Economic Assessment of Selected Management Practices for Efficient Use of Saline-Sodic Water in Arid and Semiarid Subtropical India

Mahander Singh[*]

Introduction

Land is the most precious of nature's gifts to mankind and the physical basis of biomass production and other supporting systems. Its availability, which was already limited, is further shrinking owing to burgeoning population pressure of human beings and animals alike**,** resulting in escalation in food, feed and fuel needs and diversion of agriculturally productive land to non-agricultural uses due to rapid industrialization and urbanization. The per capita net sown area in India, which was 0.38 ha in 1950, has shrunk to 0.20 ha in 1980 and is further estimated to decline to 0.15 ha by the advent of the new millennium (Table 1). If this trend is any indication, it becomes imperative that we will be required to produce more and more food/feed/fuel/fodder from less and less land in coming years.

Table 1 Per capita availability of net sown area.

Year	Area (ha)
1950	0.38
1980	0.20
2000	0.15

When the land resource is limited, water becomes of utmost importance for increasing crop productivity. Not only that, water is an effective resource for sustaining life and the environment. In view of its limited availability and competing demands it is imperative to utilize water with utmost efficiency. Water resource development and efficient use are necessary to meet the basic needs of biotic populations and to maintain a congenial environment. However, India has only 35% net irrigated area. Out this irrigated area about 51% is irrigated by groundwater sources (Table 2).

Table 2 Source-wise net irrigated area.

Source of Irrigation	Area ('000 ha)	Total Area (%)
Canal	17,290	35.4
Tank	3,348	6.9
Tube-well/ Well	25,012	51.3
Others	3,150	6.4

[*] Project Directorate for Cropping Systems Research, India.

A survey of groundwater quality shows that 32-84% of aquifers have poor quality water. The use of this poor quality water for irrigation purposes affects soil health and crop growth adversely. There is thus a need to manage this water properly.

Objectives

The case study was undertaken to analyze the impact of land leveling, bunding, gypsum application and the sprinkler system of irrigation on the performance of pearl millet- wheat and pearl millet-mustard cropping systems under irrigation with saline and alkaline waters. The specific objectives of the study were:

- To analyze impact of the above mentioned techniques on crop production in farmers' fields under semi-arid environments of the Indian sub-continent when saline or alkaline water is used for irrigation.
- To study economic aspects of these techniques for sustainable crop production.
- To study the impact of selected techniques on sustainability of natural resources.
- To identify constraints in adoption of these techniques.

Methodology

Site selection

Keeping in view the specific objectives of the study, the village of Karanpur in the district of Mathura on Farah-Achnera road was selected. The most important point which was considered in favour of Karanpur was that the village had an acute problem of saline and alkaline water for irrigation purposes. Moreover, an organization of Indian Council of Agricultural Research, i.e., Central Soil Salinity Research Institute, Karnal had initiated an Operational Research Project (ORP) in the village since 1993. The purpose of the ORP is to demonstrate the usefulness of suggested technologies for use of saline-alkaline waters for irrigation purposes on farmers' fields.

Data collection and analysis

The data on land use pattern, soil type and topography, water quality, rainfall pattern and climate, fertilizer use, irrigation, human population, literacy percentage, etc. were collected from the State Department of Agriculture (Government of Uttar Pradesh), Department of Economics and Statistics, Ministry of Agriculture (Government of India), R.B.S. College Bichpuri (Agra), Central Soil Salinity Research Institute, Karnal, Central Soil and Water Conservation Research and Training Institute, Dehradun and Board of Revenue, Mathura.

Two types of underground irrigation water exist in the village where the study was conducted. These are saline and alkaline waters. To achieve the objectives of the study, observations were conducted in the village. During the observations four different technologies applied on farmers' field were recorded. The technologies observed are: (a) leveling technology, (b) bunding technology, (e) gypsum application and (d) sprinkler usage. These improved technologies were compared to farmers' conventional technology in the study site.

Information on crop yields, cost of cultivation and other related variables from each type of farming practice was recorded. For economic analysis prevailing market prices of crops produced were taken into account. The operational cost for each technology was considered as expenditure incurred by farmers on that particular technology. Operational cost includes cost of land preparation (including bunding leveling, gypsum application and sprinkler irrigation as needed), seed, seed sowing, fertilizer and manure, weed control, irrigation, and crop harvest and threshing. While calculating the economics of the technology, the fixed costs, which include rental value of land, interest on capital, depreciation cost, etc., were not taken into account.

The data were tabulated separately for pearl millet-wheat and pearl millet-mustard rotations. Comparison was made based on yield improvement on account of technology adoption over farmers' conventional practices. Benefit-cost ratios were calculated as gross returns divided by total operational cost. Here, gross returns means quantity of produce (including by-product also) multiplied by per unit market price of the produce.

Overview of the study site

The State of Uttar Pradesh lies between 23° 50' to 31° 28' N latitude and 77° 4' to 84° 38' E longitude, bounded on the north by Tibet and Nepal, on the north-west by Himachal Pradesh, on the west by Punjab, Delhi and Haryana, on the south-west by Rajasthan, on the east by Bihar and on the south by Madhya Pradesh. Uttar Pradesh shares 8.91% of the total area of the country.

The study site, i.e., Karanpur village, is located in Mathura district and falls under the south-western semi-arid agroclimatic zone of Uttar Pradesh which represents the semi-arid sub-tropical tract of the country. This zone covers six revenue districts, namely: Agra, Mathura, Aligarh, Etah, Firozabad and Mainpuri spread over an area of 22.41 thousand km^2 which is 13% of the total geographical area of Uttar Pradesh.

Biophysical characterization

The annual precipitation of the village ranges between 500 and 700 mm with an average of 620 mm which is much lower than the state average (Table 3). The maximum (65%) rainfall is received in the months of July and August. Precipitation exceeds evaporation during this period. September and October also experience a few erratic showers. The maximum mean relative humidity (80-85%) is recorded during August, while May is the driest month with a mean relative humidity of 30-35%. May and June are the hottest months when the maximum temperature shoots up as high as 43°C, while during January, the coldest month of the year, the minimum temperature dips below 0°C.

Table 3 Comparative annual rainfall of study site.

Location	Rainfall (mm)
India	1,388
Uttar Pradesh	987
Karanpur Village	620

The soils are of alluvium origin, light in texture, sandy loam at the surface to sandy clay loam at subsurface. They are moderately drained and slightly to moderately alkaline in reaction. Soils are generally low in available N and medium in P and K status.

Farm practices

The major *kharif* crop of the study site is pearl millet (*Pennisetum glaucum*). Fodder sorghum (*Sorghum bicolor*) is also grown by a few farmers. However, some farmers also practice green manuring with *Sesbania aculeata.* During rabi season wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and mustard (*Brassica juncea*) crops are grown. The average cropping intensity of the selected village site is 117%.

Ninety-two percent of the cultivated area in the village is irrigated. The main source of irrigation is tube-wells. The water table depth fluctuates between 7 and 8 meters. Water quality parameters are given in Table 4. It is evident that the quality of the tube-well water is saline - alkaline. Many tube-wells (68%) have high SAR saline waters and remaining have alkaline waters. Saline water with high SAR is found in the eastern part of the village and alkali waters in the western part.

Table 4 Water quality at the study site.

Category	% of Tube-wells	EC_{IW} (dS/m)	RSC(me/l)	SAR_{IW}(minole/l)^{½}
High SAR saline waters	68	5.9-14.4	-	11.5-36.7
Alkali waters (high RSC waters)	32	2.5-3.0	4.8-12.8	9.8-17.9

A number of crop rotations are practiced in the village. However, pearl millet-wheat and fallow-mustard occupy the largest area. The following rotations are common:

- pearl millet-wheat
- pearl millet-barley
- green manure-wheat
- fallow-wheat/mustard/barley
- sorghum (F)-mustard/wheat
- pearl millet-mustard

The status of the two major fertilizer nutrients (N & P) use in the village is given in Table 5. The use of other nutrients is either nil or negligible. The use of herbicides, pesticides etc. is also not very common.

Table 5 Fertilizer use (kg/ha).

Crop	Nutrient Use (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Pearl millet	31	0	0
Wheat	110	54	0
Mustard	63	37	0
Barley	60	37	0

Socio-economic characterization

The total population of the village under study is 665 with a density of 257 persons per km^2 , which is much lower than the state average of 470 persons per km^2 (Table 6). The literacy rate of the case study village is 49%, which is greater than the average for India (43%) as well as Uttar Pradesh (34%). It was further noted that among the literate the ratio of males to females was 74:26.

Table 6 Area, population density and literacy rate.

Location	Area	Total Population	Density (persons/km^2)	Literacy (%)
India	328.7 m ha	844 million	260	43
Uttar Pradesh	29.4 m ha	139 million	470	34
Case study site	258.6 ha	665	257	49

With respect to land holding size, the majority of farmers are classified as marginal (40%) followed by small (20%), sub-medium (20%), medium (15%) and large (5%).

The average income of families from different sources was observed to be quite low (Table 7). Only 13% of families had an annual income higher than Rs 11.00 thousand.

Table 7 Family income of farmers in case study site.

Income Group (Rs per annum)	Percent of Families
< 4,000	8
4,001-6,000	43
6,001-8,500	23
8,501-11,000	13
> 11,000	13

Effect of agro-techniques on yield, monetary returns and sustainability of natural resources

Yield and monetary returns

The four techniques improved the yield and farmers' income (Tables 8-12). The increase in yield due to these techniques over the fields where these techniques were not applied ranged from 27 to 122%, the highest being with gypsum. The benefit-cost ratios reveal that on average farmers may get a gross benefit of Rs 2.32 to 2.52 for each rupee invested in crop production due to adoption of improved techniques.

Table 8 Effect of leveling on grain and straw yields (kg/ha) of pearl millet-wheat and pear millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmer's practice	981 (2,453)*	2318 (2,898)	3299 (5,351)	1009 (2,523)	909 (455)	1918 (2,978)
Improved with leveling in saline water	1,475 (3,688)	3,530 (4,413)	5,005 (8,101)	1,310 (3,275)	1,320 (660)	2,630 (3,935)
Improved with leveling in alkaline water	1,390 (3,475)	3,590 (4,488)	4,980 (7,963)	1,280 (3,200)	1,308 (654)	2,588 (3,854)

* Figures within parentheses are straw yield.

Table 9 Effect of bunding on grain and straw yield (kg/ha) of pearl millet-wheat and pearl millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmer's practice	803 (2,008)*	2,616 (3,270)	3,419 (5,278)	850 (2,125)	809 (405)	1,659 (2,530)
Improved with leveling in saline water	1,160 (2,900)	3,180 (3,975)	4,340 (6,875)	1,260 (3,150)	1,180 (590)	2,440 (3,740)
Improved with leveling in alkaline water	1,204 (3,010)	3,205 (4,006)	4,409 (7,016)	1,204 (3,010)	1,275 (638)	2,479 (3,648)

* Figures within parentheses are straw yield.

Table 10 Effect of gypsum application on grain and straw yield (kg/ha) of pearl millet-wheat and pearl millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmers' practice	1,050	2,587	3,637	780	603	1,383
	(2,625)*	(3,234)	(5,859)	(1,950)	(302)	(2,252)
Improved with leveling in saline water	1,730	3,790	5,520	1,520	1,205	2,725
	(4,325)	(4,738)	(9,063)	(3,800)	(603)	(4,403)
Improved with leveling in alkaline water	1,809	4,009	5,818	1,710	1,360	3,070
	(4,523)	(5,011)	(9,534)	(4,275)	(680)	(4,955)

* Figures within parentheses are straw yield.

Table 11 Effect of sprinkler irrigation on grain and straw yield (kg/ha) of pearl millet-wheat and pearl millet-mustard systems.

Technology Adoption	Cropping System					
	Pearl millet	Wheat	Total	Pearl millet	Mustard	Total
Conventional farmers' practice	714	2,410	3,124	920	820	1,740
	(1,785)*	(3,013)	(4,798)	(2,300)	(410)	(2,710)
Improved with leveling in saline water	980	3,435	4,415	872	1,420	2,292
	(2,450)	(4,294)	(6,744)	(2,180)	(710)	(2,890)
Improved with leveling in alkaline water	1,008	3,360	4,368	955	1,328	2,283
	(2,520)	(4,200)	(6,720)	(2,388)	(664)	(3,052)

* Figures within parentheses are straw yields.

Table 12 Effect of selected techniques on monetary returns of two cropping systems.

Technology	Benefit: Cost Ratio		
	Conventional Practice	Improved Practice in Saline Water	Improved Practice in Alkaline Water
	pearl millet-wheat system		
Leveling	2.01	2.58	2.58
Bunding	2.12	2.57	2.30
Gypsum*	2.23	2.62	2.70
Sprinkler**	1.94	1.84	1.89
	pearl millet-mustard system		
Leveling	2.73	2.62	2.58
Bunding	2.39	2.41	2.51
Gypsum*	1.90	2.32	2.62
Sprinkler**	2.47	1.96	2.36

Note: For calculating cost of gypsum application per year, it was assumed that gypsum is applied once in 3 years, thus the total cost of the gypsum was equally distributed over 3 years. The life of a sprinkler set was considered 10 years, thus the total cost of the sprinkler set was equally distributed over10 years. Land rent and depreciation are not included. The cost of leveling is calculated on a nine-hour basis.

Sustainability of natural resources

Effects of land leveling, field bunding, use of gypsum, sprinkler irrigation, salt tolerant variety, green manuring, organic manure and fertilizer were demonstrated on the fields of 19 farmers. Data on soil pH in the beginning of ORP and after harvest of wheat in 1996 are presented in Table 13. Out of 19 farmers, soil pH decreased in the field of 14 farmers within two years of application of improved techniques. Decreasing pH indicates that soils are becoming more neutral in reaction, thus there is a decrease in the soil degradation process. The data also reveal that continuous use of improved techniques may lead to long-term sustainability of soil health and crop productivity.

Table 13 Effect of improved management practices for use of saline or alkaline water on pH of soil (0-15 cm) on farmers' fields.

Farmer	Year	
	1994	1996
Gonadhan Singh	8.5	8.0
Satya Den	8.9	7.9
Beni Ram	8.2	8.5
Santosh Kumar	8.4	7.9
Chhotelal	8.3	8.5
Biri Singh	8.2	8.1
Ram Singh	8.0	7.7
Chandari Singh	8.2	7.7
Daram Das	8.0	7.8
Omprakash	8.6	8.5
Ram Barose	7.6	7.6
Ram Swaroop	6.8	7.6
Bhajani Ram	8.8	8.5
Keshau Den	8.1	8.7
Sunerilal	8.4	8.4
Ram Swaroop	8.8	8.0
Hani Prasad	9.0	8.5
Mahesh Uppadhaya	8.3	7.9
Deni Prasad	7.9	7.6

Source: Tomar 1996; EC = ds/m, pH 1:2.

Further, improved irrigation systems such as sprinklers, because of their high irrigation efficiency compared to flood irrigation systems, need less water pumping which results in less addition of salts to soil and thus a delay in process of soil deterioration.

Irrigation with saline or alkaline water makes the soil less permeable to water. Because of this, a major part of rainwater flows away as runoff from the fields and causes flood-like situations in adjoining areas. Also, there is little recharging of natural aquifers due to impeded downward movement of water. Adoption of suggested technologies can cause improved permeability of soil, which will result in increased water storage capacity of soil, less wastage of rainwater as runoff, more intake of water into the soil and increased recharge of aquifers.

Constraints to technology adoption

In spite of the higher benefits from the improved technologies, these technologies have not found favour of farmers due to the following constraints:

- Economic constraints: resource poor farmers, high cost of technology, small land holding.
- Social constraints: fragmented land holdings, low education, lack of community approach, agricultural labour shortage.
- Institution and infra-structural constraints: non-availability of inputs, poor extension services, incompatible-loan procedures.
- Technological constraints: lack of suitable implements.

Recommendations

Based on the findings of this study, the following suggestions can be made for consideration of government, farmers and researchers to make the use of saline/alkaline waters in crop production more efficient and to ensure the sustainability of crop yields, farmers' income and the environment.

Government

- Improved credit infrastructure is essential. As inferred from the status of land holding size and family income, the majority of farmers are marginal and small and fall into low-income groups. Because of this their purchasing power is poor and they are unable to purchase inputs and implements for adoption of unproved technologies. Therefore, specific efforts of government are needed for further strengthening of the banking infrastructure to extend adequate credit facilities to the farmers of problem soil/water regions of the country considering the importance of agriculture in the national economy.
  - Chargeable interest rates may be further brought down through suitable financial and banking reforms.
  - Repayment terms may be further liberalized for poorer sections of the society, as agriculture is highly risk prone in these areas. However, the recovery schedule should be adhered to, to smoothen the flow of credit in both directions.
  - Considering the basic fact that most of our farmers are either illiterate or not conversant with complicated banking procedures, loan procedures need to be highly simplified to make them farmer-friendly.
  - More functional autonomy with less political interference is needed for better functioning of Cooperative Credit Societies.
  - Introduction of credit cards to farmers needs to be encouraged to reduce malpractice.
- Timely supply of inputs includes planting materials, agro-chemicals, etc.
- Efficient management of subsidies will prevent mortgages and maximize benefits.
- Land consolidation will facilitate adoption of improved technologies.
- Strengthening of the extension infrastructure will improve adoption of government programmes.
- Development of small irrigation and drainage grid systems will support water management.
- Education of farm families will assist adoption of improved technologies.
- Farmers' participation in planning and implementation of programmes would ensure greater acceptance and adoption of these programmes.

Farmers

- Farmers should develop banking aptitudes and habits to take full advantage of credit facilities extended by the banks.
- Farmers have many superstitions or social barriers about new things. Farmers should develop confidence to break these barriers.
- Government launched programmes should be taken in good stride and should be considered as important as their own programmes.

Researchers

- Research is needed to develop low cost technologies to bring down the cost of sprinkler and drip irrigation systems, bullock drawn land levelers and bund makers and other farm machinery.
- The non-availability of gypsum in the area is one of the constraints to its use. Therefore, locally available alternatives to gypsum are required.
- Animal dung, presently used for making dung cakes to meet household fuel requirements, can be saved for agricultural purposes by popularization of gobar gas plants and encouraging social forestry. However, there are certain flaws in the currently available designs of gobar gas plants which need to be eliminated.
- There is a need to develop location specific salt tolerant crop varieties.
- Research on development of appropriate and profitable alternative farming systems like agro-forestry systems and silvi-pastoral systems is needed.

Irrigated Ecosystem in India - Sustainability Issues

R.L. Yadav[*]

In retrospect we find that all ancient civilizations developed and flourished along natural watercourses, as one can not think of life without water. Agriculture also thrived only in those regions where adequate water was available in the form of precipitation or irrigation sources developed by humans.

Most of the land area of the Indian sub-continent broadly falls under a sub-humid climate where evaporation generally exceeds precipitation during much of the year. Under these situations irrigation becomes of paramount importance. If we analyze agricultural growth during the past four decades, we find that the development of a dependable irrigation infrastructure has been instrumental in achieving the targets and in fact provided an impetus to large-scale adoption of high yielding improved varieties and fertilizer use, which have been major factors contributing to achievement of the green revolution in India. The reported irrigation potential developed so far in the country is about 90 million hectares and the ultimate potential is estimated to be 114 m ha, which is very difficult to achieve in the near future.

The projected foodgrain demand of more than 300 million tons by 2025 to feed 1.4 billion Indians, in the absence of any national population policy, implies an increase of about 100 million tons in the next 25 years. The problem is further compounded on two accounts. Firstly, per capita availability of net cultivated land will further decline to 0.10 ha by the year 2025 from the estimated 0.14 ha during 2000 and secondly, water available for agriculture will decrease by 10-20% in view of more competitive demands for drinking, industries and other life support systems. It is, therefore, very clear that sustainable growth in irrigated agriculture will be very essential in years to come because the lion's share of the future food needs will have to come from increased crop yields on currently cultivated land. This will require an increase in the average yield per hectare by at least 65% through accelerated, more efficient and intensive use of modern farming technologies.

Contribution of irrigated ecosystems to foodgrain production

Depending upon the natural water resources, efforts have been made at all levels throughout the country to develop irrigation potential and each state has a certain area under irrigated agriculture. But, broadly considering the states having 40% or a larger area under irrigation, two distinct irrigated ecosystems emerge. One is the Indo-Gangetic plain region comprising the states of Punjab, Haryana, plains of Uttar Pradesh, Bihar, and plains of Jammu and Kashmir. The other ecosystem may be carved out of coastal areas of Andhra Pradesh and Tamilnadu.

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At present a 51.2 million hectare net cropped area is irrigated by different sources, which constitutes about 36.03% of the net cultivated area. Estimates indicate that more than 56% of total foodgrain production comes from irrigated ecosystems while progress has been very sluggish in rainfed agriculture, which still accounts for 92.8 m ha or 65% of net area sown and contributes only 44% to national foodgrain production. Further estimates show that at present 72.3% of cereals and 20.5% of pulses are produced under irrigated ecosystems. It is worth noting that of the total 14.3 m tons of fertilizer nutrients (NPK) consumed in agriculture during 1996-97 in the country 8.07 m tons were used in irrigated ecosystems. If past trends are any indication it may be visualized that in the future also the major gain in production, at least 80% of the incremental food needs required by 2025, has to come from irrigated ecosystems where new genotypes and intensive fertilizer use will continue to play a dominant role in enhancing crop productivity.

Crops and cropping systems of irrigated ecosystems

The principal crops with sizeable percentage of area under irrigation in the country are wheat (84.3%), sugarcane (87.9%), barley (60.8%), rapeseed and mustard (57.5%), rice (46.8%), tobacco (41.2%), cotton (33.2%), chickpea (21.9%), maize (21.8%) and groundnut (19.2%). Among the states Punjab ranks first with 94.6% of cropped area under irrigation, followed by Haryana (76.4%) and Uttar Pradesh (62.3%).

Cropping systems (defined as an arrangement of crops in temporal and spatial dimensions on a given piece of land) are governed by a complex of agro-climatic, socio-economic and trade related factors and vary from region to region at the macro-level. However, approximations are possible to identify the major cropping systems in a region or zone through available area estimates. These estimates suggest that large diversity for cropping systems exists under rainfed and dryland areas due to greater risks involved. However, under assured irrigation situations, the following cropping systems may be short-listed, as they have considerable coverage across the region contributing significantly to national foodgrain production:

- rice-wheat,
- rice-rice,
- rice-groundnut/mustard,
- cotton-wheat,
- sugarcane-wheat,
- maize-wheat,
- maize-potato-wheat,
- pigeonpea/groundnut-wheat.

Issues in irrigated ecosystems

The major issues emerging in irrigated ecosystems are briefly discussed in the section.

Resource characterization

Adequate information is lacking on characterization of land and water resources and climatic parameters at the micro level, which is very essential for efficient land use planning and resource deployment.

Farmers' participation in research

A critical lacuna in our past approaches has been inadequate effort or lack of mechanisms to build up research programmes that take into account the experience and knowledge base that exists within the farming community. In our efforts to develop and improve upon existing technologies, involvement of people in conceptualization and extension of technologies appears to be very important. The farm family has never been the focal point of our investigations. This top down approach of our scientists has given them a poor perception of the problems that they tried to solve. In fact farmer participation should be considered an integral component of cropping/farming systems research, particularly applied aspects of it.

Cropping systems oriented production technology

In the past our approach for agricultural research and development was component based. Only in recent years, have we realized that the field problems we attempt to define and find solutions for are in fact an integral part of a larger and continuous environment, and what we attempt to solve may indeed have a series of repercussions that we rarely take into account. It is indeed due to this piece-meal approach that we have encountered increasingly acute problems in managing and protecting our resources and the environment. We hardly realized that field problems to which we seek solutions are rarely amenable to solutions through a single component/discipline oriented research. System oriented production research needs to be strengthened as it is essential for maximizing land productivity by harnessing synergies generated through various interactions in soil-crop-crop systems. The cropping system approach to resource management has been showing immense potential in enhancing resource use efficiency and pest management.

Low water use efficiency

Despite the fact that water is a precious and scarce resource, its application and use efficiencies have been quite low. Low water use efficiency is apparently attributable to:

- excessive irrigation due to improper leveling of fields, coupled with improper application methods such as check basins even in agriculturally advanced areas, and a faulty pricing policy for electricity and canal water.
- non-adoption of appropriate cropping systems, for example extensive cultivation of rice in sandy soils of Punjab, and advancement of rice transplanting to April/May in Punjab and Haryana.

Land degradation problem

Soil salinity hazards due to groundwater rise and impeded natural drainage in certain canal command areas are well known.

Indiscriminate exploitation of groundwater

The excessive pumping of ground water for irrigation purposes in intensively cultivated areas of Punjab, Haryana and western U.P. has caused lowering of the groundwater table in certain pockets. During the past decade, water tables dropped at a rate of 0.5-0.8 m per year in the state of Haryana and at a rate of 0.2-1.0 m per year in Punjab. Declining water tables not only increase production costs by pumping water from greater depths but such rapid rates of decline raise serious questions about the long-term sustainability of the rice-wheat system itself in these areas. Contrary to this, the vast potential of groundwater in eastern U.P., Bihar and adjoining areas remains untapped.

Inefficient land use

Diversion of highly productive irrigated land to non-agricultural uses: such as industry, housing etc., especially in areas of rural-urban interface needs to be viewed seriously.

Decline in factor productivity

Due to imbalance in fertilizer use, widespread deficiencies of secondary and micro-nutrients are emerging and reduced organic matter content of cultivated lands is becoming a problem. A declining trend for responses to nutrients, especially to nitrogen, in major cropping systems is being observed on farmers' fields. Thus, to sustain earlier yield levels farmers need to apply higher fertilizer doses.

Imbalance in fertilizer use

The problem of imbalance in fertilizer use has been accentuated on three accounts:

- With intensive cropping, nutrient removal by crops from soil has far exceeded replenishment through fertilizers and manure. This is causing a negative balance of nutrients in soil, and if this trend continues, a serious threat will be posed for sustainability of the major cropping systems of irrigated areas,
- Due to continuous cereal-cereal cropping in most of the irrigated fertile lands during the post green revolution period, multiple nutrient deficiencies have emerged. Long term experiments have clearly shown a decline in organic carbon, nitrogen and P in cereal-cereal intensive cropping,
- Farmers tend to use higher doses of nitrogenous fertilizers maybe because N is cheaper than P and K. This has resulted in widening ratios of N : P and N : K to undesirable levels.

Build up of diseases/pests

With crop intensification under high input use, a serious threat of occurrence and build up of some obnoxious pests and diseases has crept in. This factor again hinders vertical growth and questions are raised about the sustainability of the environment under intensive input use, which is badly needed for maximizing crop yields. Heavy infestation of *Phalaris minor* in the continuous rice-wheat cropping system in the northwestern plains is a glaring example.

Inadequate considerations for environmental quality

With the pressing need for producing more and more from an ever decreasing land resource, environmental quality is seriously threatened. A potential danger may be envisioned in the form of pollution of natural water bodies and underground aquifers due to nitrate leaching and phosphates causing irreparable harm to natural ecosystems under high fertilizer use without improving their use efficiencies.

Issues of major cropping systems

Rice-wheat cropping system

The rice-wheat cropping system is the largest cropping system of India, practiced in about 123 districts covering 9.8 m ha in Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and it contributes about 25% of total rice production and 42% of total wheat production in the country. In view of the wide area cultivated and its major contribution to the food pool, this system needs careful attention from researchers, especially on the following issues:

- crop establishment and tillage,
- weed problems, particularly the build up of *Phalaris minor* in wheat,
- low input use efficiency in north western plains,
- low use of fertilizer in eastern and central India,
- lack of appropriate varietal combinations.

Rice-rice cropping system

Rice-rice is the popular cropping system in irrigated lands in humid and coastal ecosystems of Orissa, Tamilnadu, Andhra Pradesh, Karnataka and Kerala states. The total area under this system is estimated to be about 6 m ha. The major issues in sustaining productivity of the rice-rice system are:

- deterioration in soil physical conditions,
- micronutrient deficiency,
- poor efficiency of nitrogen use,
- imbalanced use of nutrients,
- lack of an appropriate transplanter to mitigate labour shortage during the critical period of transplanting,
- build up of obnoxious weeds such as *Echinochloa crusgalli* and lack of suitable control measures.

Cotton-wheat cropping system

Cotton is widely grown in alluvial soils of north India (Punjab, Haryana, Rajasthan-and Western U.P.) and black cotton soils of central India (A.P., Tamilnadu and Karnataka). With the availability of short duration varieties of cotton, the cotton-wheat cropping system has become dominant in the north. About 70-80% of cotton is covered under this system. In the central region also, wherever irrigation is available, cotton-wheat is grown. The major issues of concern in the cotton-wheat cropping system are:

- delayed planting of wheat following harvesting of cotton,
- stubble of cotton creates a problem of tillage operations and poor tilth for wheat,
- susceptibility of high yielding varieties of cotton to boll worm and white fly and consequently high cost of their control leading to unsustainability,
- poor nitrogen use efficiency in cotton results in low productivity of the system,
- appropriate technology for intercropping in widely spaced cotton needs to be developed.

Sugarcane-wheat cropping system

Sugarcane is grown on about 3.4 m ha in north India (U.P., Punjab, Haryana and Bihar) which share 68% of the total area under sugarcane. Sugarcane-ratoon-wheat is the most important crop sequence. The main issues of concern in the sugarcane-wheat cropping system are:

- late planting of sugarcane as well as wheat,
- imbalance and inadequate use of nutrients. The majority of farmers apply only N in sugarcane and the use of P and K is limited. The emerging deficiencies of P, K, S and micro-nutrients are limiting system productivity directly and through interactions with other nutrients,

- poor nitrogen use efficiency in sugarcane,
- low productivity of ratoon due to poor sprouting of winter harvested sugarcane in north India,
- build up of *Trianthema portulacastrum and Cyprus rotundus* in sugarcane,
- stubble of sugarcane poses a tillage problem for succeeding crops and needs to be managed properly.

Pulse-based cropping system

Pulse crops are popular for their suitability in different cropping systems. Recent advances in the development of a large number of varieties of pulse crops, varying largely in the duration to maturity, have made it possible to include them in irrigated crop sequences. The popular cropping systems are pigeonpea-wheat in Punjab, Haryana, Uttar Pradesh, and Rajasthan, soybean-wheat in M.P., groundnut-wheat in Gujarat, Maharashtra and Madhya Pradesh and groundnut-sorghum in Andhra Pradesh and Karnaraka. The major issues in pulse-based cropping systems are:

- no technological breakthrough has been achieved so far with respect to yield barriers in pulse crops,
- susceptibility of pulses to aberrant weather conditions especially water logging and adverse soils making them highly unstable in performance,
- high susceptibility to diseases and pests,
- low harvest index, flower drop, indeterminate growth habits and response to fertilizers and water for most pulses,
- nutrient needs of the system have to be worked out considering N fixation capacity of pulse crops.

Economic Assessment of Selected Resource Management Techniques in Marginal Upland Agriculture of Mawlasnai, Meghalaya, N.E. Region of India

Gour Chandra Munda[*]

Introduction

The issues of sustainability are well enunciated globally and thus there is a general understanding of the challenges. In India, many serious problems of sustainable agriculture are observed in major agroecosystems. Some of these problems are observed in the state of Meghalaya, northeastern region of India. The typical agricultural practice in the region is subsistence farming and it is strongly associated with the increasing population cultivating sloping land leading to soil erosion and land degradation.

This report briefly characterizes the sloping land farming practice in the state of Meghalaya and then discusses some promising solutions of the issues related to sustainable agriculture for the northeastern region.

The objectives of the study are:

- To study the constraints and prospects for sustainable resource management of marginal upland areas with emphasis on economic aspects of resource management, and
- To characterize the transfer/adoption mechanism of resource management techniques and suggest directions for sustainable resource management.

Sustainability problems

In India, agriculture continues to be the backbone of economy. About 70% of the total human population is engaged directly or indirectly in this occupation. Over the past three decades, India moved from a food deficit state to a self-sufficient state in foodgrain production although at a low level of availability (514.2 g per capita per day). Presently, about 140 million hectares of the country's total area of 328 million hectares have been brought under cultivation and there is limited scope to bring more area under cultivation to meet all the basic requirements of the people. It is obvious that high yield technologies made an immediate impact on production in many parts of the country and Indian agriculture shall continue to play a crucial role in the country's development. The contribution of agriculture to the gross domestic product of the country during 1990/91 remained at about 30%.

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No doubt, it was possible through combined efforts for agricultural production to keep pace with the rising population, but sustainable agriculture production on a long-term basis has become a cause of concern. Intensive agriculture has led to accelerated degradation of the production base (land, water and forest). There is evidence of second generation problems coming up in the form of increased input cost in production, nutrient deficiencies, water pollution and decline in crop yields. Out of a total geographical area of 328 million hectares, 187 million hectares (57%) are suffering from different soil degradation problems. It clearly suggests that unless short and long-term measures are taken to assess our basic resources in order to arrest degradation and restore productivity, it will be difficult to achieve targeted agricultural production.

Overview of agriculture in the northeastern region of India

The northeastern region of India is mostly hilly and mountainous. Agriculture is the main occupation of the people. Crop production activities in this region are carried out under varying slopes (0-100%) and altitudes (50 - 3000 m MSL). The area under cultivation in this region is rather low and concentrated mainly on hill slopes, plateaus, foothills and small valleys. Rainfed crops (rice, maize, millets, potato, ginger, turmeric, etc.) are grown at a subsistence level. Low input use, low use of irrigation potential, low cropping intensity and different land tenure systems are the primary features of existing cropping systems of farming (*juming* or *bun or kheti*).

Several issues need immediate attention to attain sustainable agriculture in this region. The major resource management constraints towards achieving sustainability in this area are listed below:

- *Jhuming* (slash and bum method) on steep hill slopes.
- Bun cultivation (raised bed method) along the steep slopes.
- Loss of top soil.
- Deforestation.
- Non-adoption of HYV crops.
- Apathy towards the use of fertilizers and other agrochemicals.
- No storage facilities for ginger.
- Drudgery in farm operations.
- Poor returns from piggeries and other subsidiary sources of income.
- Lack of transport facilities.
- Lack of banking and co-operative facilities.
- Poor economic conditions of farmers.

Most of the farmers in this area face problems arising from inadequacies in the appropriate crop production technology, and lack of much needed services and government policies to overcome the sustainability constraints.

Important resource management techniques in Mawlasnai

The cultivated area in the Mawlasnai area (Meghalaya) is concentrated mostly on hill slopes, small valleys and foothills. The important land use and management practices for livelihood by the farmers of Mawlasnai are described below:

Jhuming (*slash and burn method*)

Jhuming is a primitive form of agriculture. This is a slash and bum method of cultivation practiced on hill slopes. In this method of farming, virgin forest land is cleared by cutting forests and bushes during December-January. The cut materials (trees, shrubs, grasses etc.) are left to dry for some period and then burnt to make the land ready for dibbling of seeds of different crops just before the onset of rain. *Jhum* rice is the main crop grown alone or in mixture with other crops such as finger millet, maize, yam, ginger, vegetables etc. Crops are harvested at maturity beginning from September-October to December-January. Yield levels of the crops are very low. No soil conservation measures are adopted in *jhum* and as a result there is tremendous loss of topsoil reducing the productivity of jhum drastically. In the second year, usually single crop rice is grown. After two to three years, the *jhum* is abandoned and a new site is chosen for *jhuming*.

Bun cultivation

Bun method of cultivation is also an age-old resource management practice in uplands prevailing mainly in East and West Khasi hills of Meghalaya. In the bun method of cultivation, raised beds of about 5 metres length, 1 meter width and 30 cm high are made along the hill slopes. Sole cropping as well as mixed cropping is practiced on the bun without using chemical fertilizers or other agro-chemicals. However, application of FYM or burning of organic residues on the bun enriches the soil fertility. Usually, sole cropping of ginger is the first choice in the first year of bun cultivation. However, as per the needs of the family, a combination of crops (ginger, chilli, brinjal, yam, etc.) is also grown in the first year itself. In the second year, the raised beds are leveled and rice or maize is grown as a sole crop. During the third year, sole cropping of maize or mixed cropping is practiced (sweet potato, brinjal, cucumber, etc.). In the fourth year, sole cropping of sweet potato or mixed cropping of ginger, chilli, cucumber, etc. is done. The *bun* is abandoned from the fifth year onward for a period of 3-4 years and farmers shift to a new site for bun cultivation. As in the case of *jhuming,* no soil conservation measures are adopted in *bun* cultivation although there is loss of topsoil right from the first year of its cultivation. As a result, productivity of the bun declines.

Broom grass cultivation

Broom grass (*Thysanelaena maxima*) is cultivated as a cash crop on a limited area in Mawlasnai. Root stumps of broom grass are planted on hill slopes or near the homestead. Harvesting of broom is done the third year onward up to 10-12 years, after which the land is kept fallow for few years (3-4 years). The broom excess is sold out of the N.E. region. In broom grass cultivation, also, no soil conservation measures are adopted, but loss of topsoil is expected to be low under broom grass cover.

Selection of resource management techniques for economic assessment

Farmers of the northeastern hills region are prone to several constraints resulting in low income level and subsistence agriculture. The basic characteristics of resource management techniques adopted by the farmers here are low input use and labour intensiveness. Usually, low input low risk low yield technology is practiced by the farmers. Considering the level of productivity and vulnerability of hilly upland ecosystems, the following resource management techniques were considered for economic assessment:

- *Jhuming* (slash and burn cultivation)
- Bun cultivation (raised bed cultivation)
- Broom grass cultivation
- Bench terrace cultivation.

Results of economic analysis of resource management techniques

Analysis of the economic assessment for different resource management techniques revealed the following facts:

- Benefit/cost analysis showed that broom grass cultivation was the most profitable enterprise compared to other resource management techniques.
- Productivity and economic returns were low in *jhum* but showed marginal profits in the first year only. In the second year onwards *jhuming* was not profitable.
- Sole cropping on bun fetched greater economic returns compared to *jhuming.* Mixed cropping in bun fetched less economic return than sole cropping in bun.
- For bun cultivation, either as sole or mixed cropping, productivity and economic return declined in the successive years.
- Rainfed dry terrace cultivation showed stability in productivity over time. Although the productivity of upland rice and maize varieties tested was not optimum, stable yield was obtained over the years.
- Groundnut, french bean and popcorn were found to be highly productive and profitable crops on dry terraces.

Present value analysis for a period of 15 years revealed that broom grass cultivation fetched highest economic returns and gave a b/c ratio of 1:9.245. Sole cropping in bun ranked next to broom grass cultivation and produced a net economic return of Rs 19,356 and maintained a b/c ratio 1:1.377 over a period of 15 years. *Jhum* cultivation gave a negligible net return of Rs 42 and a b/c ratio of 0.997 over the same period of 15 years. Present value analysis for a period of 15 years under rainfed dry terrace cultivation showed that popcorn was most profitable with a b/c ration of 1:2.185 followed by groundnut (1:2.051). Rice and maize remained marginal in terms on net economic return and b/c ratio.

Discussion

Initially the practice of *jhuming* or bun cultivation might have been useful as there was no population pressure and no infrastructure facilities were available at that time. But it is obvious that the practice of *jhuming* or bun cultivation can not sustain productivity in the long run as the *jhuming* or bun cycle is decreasing at faster rate with the increase in population. The practice of *jhuming* or buning has to be either replaced or improved.

Introduction of contour bunding or contour trenching, toposequential cropping, use of HYV crops, use of fertilizers and plant protection measures would be useful to improve or sustain productivity on hill slopes. Contour bunding or contour trenching facilitates continuous cropping which in turn will help in converting the slopes into bench terraces within 8-10 years.

The replacement approach involves terracing on hill slopes. Bench terracing reduces the slope as well as retaining runoff to a great extent minimizing soil loss and nutrient loss. Field crops or a combination of crops can be grown on bench terraces. The terrace risers, which constitute about 35% to 40% of total area, can be effectively utilized for growing fodder grasses and legumes for maintaining livestock as a subsidiary source of income

Transfer/adoption mechanisms of resource management techniques

The agricultural situation in India includes three distinct types of agriculture, viz. commercial, green revolution and complex, diverse, risk-prone agriculture. The complex, diverse and riskprone agriculture is mostly practiced in the northeastern region of India. In this area, the farming system research approach would be more applicable for the improvement and adoption of technology. A farming system research approach provides an important tool to identify the production constraints of farmers. The farming systems are relatively complex and diverse in this environment.

However, there is some definite indication of trends prevailing in this area, which needs a reexamination into the whole problems to develop suitable strategies. The indications are as follows:

- The farmers of this area have become aware of the ill effects of shifting cultivation.
- Dwindling productivity of *jhum* land is a clear indication.
- Specific-location cum need-based alternatives are required instead of a common programme for control of shifting or bun cultivation.
- Allotment of wetland terraces with assured irrigation is the most effective means of attracting shifting cultivators to settled agriculture. This is very much applicable for rice production systems.
- Projects should be allotted on the basis of assured returns provided marketing facilities exist without exploitation by middlemen.

The present scenario of agriculture development in the N.E. region indicates that the farming systems approach would be more useful. Integration of technology for crop production, horticulture and livestock production systems is needed for individual farmers. For this purpose, the institute-village-linkage programme (IVLP) is ideal to assess the existing technology as per the needs of farmers. Efforts are also needed to integrate central as well as the state government agricultural extension programmes for successful adoption of technology by the farmers.

The agro-ecosystem analysis survey is very important before advocating technology for adoption by an individual farmer. Participatory rural appraisal (PRA) tools may be used for this. It will provide information about the resource availability under the farmers' present production practices. It will also reflect the interaction amongst various enterprises of the farm family.

A multi-disciplinary core team of scientists whose disciplines are needed should be constituted. The size of such a team may be limited to 4-5 for better functioning. The core team should draw scientists from crop production, plant protection, economics, soil and water conservation technology and an extension scientist. If some disciplines are not available at the programme implementing centre, efforts need to be made to get the services of such disciplines from the State Agricultural University (Jorhat, Assam), ICAR Research Complex for N.E.H. Region (Barapani, Meghalaya) and the Departments of Agriculture of the N.E. States. This core team should be involved in the institute-village-linkage programme, which will assess and refine the technology before adoption.

Emphasis should be given to development of multiple options for different target groups through the participatory approach. For small farmers emphasis should be given to fine tuning of technologies for different farming situations. In the case of well-defined production systems, emphasis should be given to on-farm trials and demonstrations. On-farm research will help to increase productivity along with stability and thus risk will be minimized

Conclusion

It has been observed that the various farming systems viz. agrobased farming, agri-horti farming or agro-forestry land use systems with animal husbandry as a subsidiary source of income are viable and can sustain productivity. Farming systems must be prepared keeping in view the slope of the watershed, hydrological behaviour of the watershed, soil depth, availability of markets and the needs of the farmers.

Policy implications

The northeastern region has special problems in resource management constraining its sustainability. Short-term as well long-term measures need to be integrated for production advance, as these sustainability factors are interrelated and inter-dependent. Thus, the following policy implications are envisaged:

- Co-ordination among the Indian Council of Agricultural Research, North Eastern Council, North Eastern Hill University, State Agricultural University and the Departments of Agriculture for development activities in the N.E. region. Policy backup should be well coordinated by the line departments.
- Presently, agricultural extension services of the States are inadequate. Competent, skilled and dedicated manpower should be inducted into the extension network to achieve the goal of sustainability.
- NGOs should be involved in the transfer of technology programme.
- The village headman needs to be informed of the usefulness of improved resource management techniques, as he plays an important role in all round agro-economic development of the village.
- Infrastructure facilities for transport, banking/cooperatives and storage of ginger should be developed.
- The procurement policy of the Department of Agriculture for the farmers produce must be defined well in advance.
- Training activities should be strengthened to provide adequate training to the core trainers as well as to the village farmers to impart skills and make them aware of the importance of modern crop production technology.

Recommendations

- Immediate priority should be given on the improvement approach to gradually replace *jhuming* or bun methods with appropriate farming system research approaches.
- In the long run, the replacement approach as an alternative to *jhuming* or bun systems should be adopted. Preference should be given to mixed land use (forestry in the higher ridges, horticulture plantation with half-moon terraces in the middle portion, agricultural and horticultural crops at the lower terraces). However, the replacement approach should be adopted on hill slopes with gentle slopes (up to 50%).
- Hills with steep slopes (100%) should be utilized for forestry to produce fuel and timber.
- Foothills should be used for field crops as well as vegetable crops.

- Upland rice is very uneconomical and should be substituted by productive and remunerative crops such as groundnut, soybean and popcorn. Broom grass should also be included in the cropping systems in the upland as it highly remunerative and has soil binding capacity.
- Production of rice under wetland conditions should be intensified by using HYV during the monsoon season with proper drainage and growing of a second crop of *boro* rice during the winter/summer months with assured irrigation.
- On-farm research and demonstration of the improved package of practices for crop production and soil conservation measures by the core team of scientists are essential.
- Training and visit programmes should be arranged for farmers in the transfer of technology programme.

Future projections

The ICAR Research Complex for N.E.H. Region, Barapani has developed watershed based resource management techniques through its Farming System Research Project. It has not been tested so far in the villages. It would be useful to demonstrate these watershed-based technologies in selected villages to promote sustainable development of agriculture and attain sustainability in agriculture in the N.E. region of India.

Sustainable Upland Agriculture in the North Eastern Hills (N.E.H.) Region of India

N.D. Verma[*]

Introduction

India has a vast area (more than 1.8 million ha) of uplands varying from alpine to subtropical agroclimatic zones in the North Eastern Hills Region. These areas are mostly inhabited by tribals, who have their district and traditional socio-economical and socio-cultural background. Due to difficult terrain and inaccessibility, the potential of these areas could not be explored in past. Now the Government of India is giving top priority to improving the conditions of these areas. In the agriculture sector, the Indian Council of Agricultural Research (ICAR), Research Complex for North Eastern Hills Region Umiam is exclusively engaged in solving their problems by a multidisciplinary approach. Twenty years of experimentation have shown that their production and natural resource preservation can be enhanced by adopting modern technologies. Improved seeds and varieties (plant and animals), soil and water conservation measures and adopting agri-horti silvi-pastural farming systems have increased the input/output ratio quite significantly.

The northeastern hills (N.E.H.) region of India comprising the states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura lies between 21.5-29.5 N latitude and 85.5-97.5 E longitude. The region is bounded by China to the north of Sikkim and Arunachal Pradesh, Bhutan to the east of Sikkim, China and Myanmar to the east and north east of Arunachal Pradesh, Nagland, Manipur and Mizoram and Myanmar and Bangladesh to the south of Manipur, Mizoram, Tripura and Meghalaya. It has a total geographical area of 18.4 million ha and a population of 9.5 million people representing 5.6% and 1.20% of the total area and population of the country (Table 1).

Table 1 Area and population of northeast India.

State	Area ('000 ha)	Population (1991 census)	Percentage (to all India)
Arunachal Pradesh	8,374	8,64,558	0.10
Manipur	2,232	18,37,119	0.22
Meghalaya	21242	17,74,778	0.21
Mizoram	2,108	6,89,756	0.08
Nag land	1,658	12,09,546	0.14
Sikkim	709.6	4,06,457	0.05
Tripura	1,048	-27,57,205	0.35
N.E.H.	18,375	95,39,419	1.20

The region falls under the high rainfall zone and the climate ranges from mild-tropical to alpine. The region is characterized by difficult terrain and wide variations in slopes and

[*] ICAR Research Complex for N.E.H. Region, India.

altitudes, land tenure systems and cultivation practices. Although cereals dominate the area under the rainfed hill ecosystem, dependence on livestock and horticulture as alternative sources of income is quite high. There is a wide range of farming systems (FS) in the region of which the rice-based FS is the most common. Even though most of the FS are rice-based, they present a lot of variability in their form and evolution throughout the region. The major factors of variability of the FS include i) ethnic diversity, ii) physiographic and topographic variation, iii) different levels of accessibility, iv) varying agroclimatic conditions and v) differences in natural resource base. Cropping systems based on perennial crops generally consist of mixed gardens located near the homestead which contain a combination of fruit trees, vegetables, plantation crops and multipurpose agro-forestry trees. Animal husbandry is a wider spread activity in the upland FS.

On the basis of topography, rainfall and temperature, soil type, cropping system and geographical continuity/proximity, the N.E.H. region is classified into following three broadly homogenous sub-regions: i) Himalayan hill comprising Sikkim and Darjeeling. ii) N.E. hills comprising Anurachal Pradesh, Meghalaya, Nagaland and Assam hills, and iii) Southern hills and valleys comprising Manipur, Tripura and Mizoram.

The hilly areas of the region are sparsely populated. The altitude ranges from 97 m in the plains to 5,000 m asl. The minimum average rainfall is 2,809 mm and the maximum 12,000 mm. About 60% of the reporting area is classified as forestland, 15.59% under crops and 7.07% under non-agriculture use. The land use classification of the region is shown in Table 2. Soils of the region are usually rich in organic matter and range from acidic to strongly acidic (pH 4.5-5.0) in reaction. The depth of soil varies from shallow in the inceptisols and antisols to very deep in the alluvial soil. The low pH status of soil is attributable to leaching of bases under the influence of high rainfall in the hills.

Table 2 Land use classification in northeastern hill states ('000 ha).

State	Geographical Area	Forest Area	Area Not Available for Cultivation	Other Uncultivable Land	Net Sown Area
Arunachal Pradesh	8,374	5,154	77	44	149
Manipur	2,233	1,515	545	24	140
Meghalaya	2,243	851	226	646	202
Mizoram	2,108	1,593	211	81	65
Nagaland	1,658	862	28	224	190
Sikkim	710	310	3	10	62
Tripura	1,049	631	131	40	270
N.E.H. region	18,373	1,092	1,221	1,069	1,078

Source: Directorate of Economics and Statistics, Government of India.

The two agricultural practices of the region are settled farming practiced in the plains, valleys, foothills and terraced slopes and shifting cultivation in the hills. The extent of shifting cultivation in the region is presented in Table 3. The cropping pattern is rice based with the exception of Sikkim where the dominant crop is maize. More than 80% of the gross cropped area is under food crops and farming is basically subsistence oriented. Crop intensity, due to inadequate exploitation of water resources, is as low as 118%. The region produces 1,360 thousand tons of rice, but per capita daily availability at 300 g of rice is below the estimated subsistence requirement of 450 g. The area, production and yield of rice, total foodgrains, total pulses, and total oilseeds are collated in Table 4.

Table 3 Extent of shifting cultivation in N.E.H. region.

State	Area under Shifting Cultivation ('000 ha)	Area Sown at One Point of Time ('000 ha)	Number of Tribal Families Involved ('000 families)
Arunachal Pradesh	248.6	92.0	81.0
Meghalaya	416.0	76.0	68.0
Nagaland	608.0	73.0	80.0
Manipur	100.0	60.0	50.0
Tripura	220.8	22.0	43.0
Mizoram	604.0	61.6	45.0
Sikkim	-	-	-
N.E.H. Total	2,197.4	385.4	367.0

Source: North Eastern Council, Shillong.

Table 4 Area production and productivity of principal crops of N.E.H. region (1994/95).

Crop	Area ('000 ha)	Production ('000 t)	Yield (kg/ha)
Rice	861.0	1,360.0	1,500
Coarse cereals	177.0	212.0	1,198
Total pulses	42.0	39.0	929
Total oilseeds	89.0	80.0	899
Potato	38.4	303.0	7,891
Spices	36.4	34.7	2,327
Tuber crops	12.6	69.0	5,476
Vegetables	39.9	158.7	3,977
Fruit crops	97.9	544.5	5,562

Land resources

The N.E.H. states have a total geographical area of 18,348,000 ha of which about 60.7% is under forest cover (Table 5). About 1,078,000 ha of the total area is under cultivation in the region. Total wasteland in the region is estimated to be 29,003 km^2, covering 31% of the total geographical area of Tripura and 10% area of Arunachal Pradesh (Table 6). The overall terrain of the region is predominantly hilly, characterized by different agroclimatic and geophysical situations. The region can be broadly divided into three physiographic zones, viz. i) hills and mountains of folded topography, ii) peninsular plateaus and iii) the plains.

Table 5 Classification of forests in northeastern states (km^2).

State	Geographical Area	Forest Area	% of Geographical Area
Arunachal Pradesh	83,470	51,540	61.5
Manipur	22,330	15,154	67.8
Meghalaya	22,430	8,514	37.9
Mizoram	21,080	15,935	75.6
Nagaland	16,580	8,625	52.0
Sikkim	7,100	3,103	43.7
Tripura	10,490	6,309	60.1
N.E.H. states	183,480	109,180	60.7
India	3,287,263	633,400	19.5

Table 6 Wasteland in northeastern hill states of India.

State	Wasteland Area ('000 ha)	% of Geographical Area
Arunachal Pradesh	893.4	10.67
Manipur	559.4	25.05
Meghalaya	474.5	21.15
Mizoram	445.6	21.14
Nagaland	205.3	12.40
Sikkim	2.4	0.34
Tripura	320.4	31.00
N.E.H. region	2,903.1	15.80

Land is the key asset and the most critical factor, which determines the economic status in rural areas. Hence, the trends in land availability and land distribution can provide important clues to the impoverishment process. Over the years the population in the northeast region registered a massive increase much above the national average (Table 7).

Table 7 Population increase 1951 - 1991 in N.E.H. and India.

	Population ('000 persons)		% Increase
	1951	1991	
India	361,088	846,303	13,4.38
N.E.H.	2,332	9,134	29,1.68

During this period, the net sown area also increased, but at a much lower rate. The combined effect is reflected in the land : man ratios (0.13 in 1971/72 and 0.29 in 1991/92), which present the relation between the net sown area and the rural population, which is essentially dependent on agriculture. While the land : man ratio represents the problem at a macro level, the size of holdings offers further explanation at a micro level. The minimum size of a viable holding is estimated to be between 2 and 3 ha. The average size of an operational holding in N.E.H. region is calculated to be 3.01 ha. This size of holding is minimum in order to be economically viable. However, existence of a large number of unviable holdings in the states of Tripura, Manipur and Mizoram has a direct relation to the large-scale incidence of poverty, which underscores the inherent non-viability of agriculture in the region.

Water resources

The region has two major river basins, the Brahmputra and the Barak. The Brahmputra basin drains an area of 194,413 km^2 stretching entire length of Arunachal Pradesh and greater parts of Assam, Meghalaya, and Nagaland. The Barak and other basins drain an area of 78,150 km^2 and occupy the northern and western parts of Manipur, southern parts of Meghalaya, and Assam (Table 8).

The N.E. states of the region, with 5.6% of the geographical area of the country, receive 12.7% of the total precipitation in the country. The region can be divided into three climatic regions: i) the cold humid monsoon climate of the hilly region (above 2000 m altitude), ii) the wet subtropical monsoon climate, and iii) the humid mesothermal monsoon climate with heavy monsoon showers. The region has large surface and groundwater resources mainly because of its location in high rainfall areas with an extensive river system. However, all the water resources cannot be utilized since they are inaccessible or non-reservable. The availability of these resources has not been adequately documented and as such full information is not available. The total surface water potential of the region (except Sikkim which is not available) is 928,873 mm.

Table 8 Water availability from major rivers of N.E.H. states.

River Basin	Drainage Area (km^2)	Annual Runoff (million tons)	Average Annual Runoff (million tons per capita)	Average Annual Runoff (million tons per ha)
Bhramhaputra	194,413	537,240	21,060	4,432
Barak and others	78,150	59,800	7,475	53,680

Forest resources

A large variety of forest vegetation exists in this region. About 40% of the country is said to be represented in this region, which means an approximate number of 6,000 to 7,000 species. Ordinarily, the flora of the district in the upper Gangetic plains or the plains of peninsular region India has only about 600 to 700 species, but in North-Eastern India 1,000 to 1,500 species have been recorded. Still very little is known of the rich forest vegetation of this region. The large variety of economic plants such as medicinal and aromatic species, tree fodder, fruit and food producing trees, oilseed producing trees, dye and spices, orchids and other flowering plants grow wild in nature.

The N.E.H. region has 109,180 km^2 under forest, which constitutes 60% of the total geographical area (Table 5). Important forest species found in the region are *Dedrocalamus hamiltonil, Gmoli arborea, Shorea robusta, Vitex penducularis, Terminalia belerica, Emblica officianalis, Schima wallichi, Bauhinia purpurea,* etc. There are several grasses, bamboos and canes and also a wide variety of tree species of economic importance. The region is, therefore, considered to be as mega biodiversity area.

Livestock

Livestock rearing is an important enterprise. The livestock status of the region according to the 1992 census is shown in Table 9.

Table 9 Livestock populations in N.E.H. region and India.

Livestock ('000)	N.E.H. Region	India	% in N.E.H. Region
Cattle	2,518	192,453	1.30
Buffalo	212	69,784	0.30
Sheep	133	48,764	0.28
Goat	909	95,253	0.95
Pig	1,246	10,072	12.37
Yak	89	166	53.61
Poultry	8,044	207,739	3.87

Livestock in this region includes cattle, buffalo, sheep, goat, pig, yak and mithun. In the hills, draught power is rarely used for tilling soil and many of the tribal populations have no tradition of rearing cattle in the usual sense. They used to depend on semi-wild animals called mithun for meat and the cattle are generally loose to graze and stray in the open. A basic problem of livestock rearing is the shortage of feed and fodder and absence of any commercialized dairy, piggery, etc.

Problems and constraints

The N.E.H. region is prone to a number of biophysical, institutional and socio-economical problems resulting in subsistence agriculture with low input low yield low risk technology. The major problems confronting the agricultural growth of the region are enumerated here.

Acidic soil

The acid soils of the region lead to low availability of phosphorus, which gets fixed, thus leading to low response to fertilizers. The soil also has a high concentration of iron leading sometimes to iron toxicity and zinc deficiency.

High rainfall and humidity

The high rainfall and humidity not only create favourable environment for a wide range of pests, diseases and weeds but also create problems in their chemical control through spraying. Such a climate also creates problems in storage of grains and haymaking. The high rainfall and cloudy sky again reduce the total sunshine hours so essential for food production. The humid climate is also favourable for a high incidence of crop and animal diseases resulting in low productivity.

Low temperature

The low temperature prevailing for a considerable period during winter limits the total period of time available during a year for crop production.

Undulating topography, hill slopes and altitude

The undulating topography, hill slopes and varying altitudes create problems of agricultural production. In many cases, varieties suited to low altitude areas do not perform well or are not suitable at all for medium and high altitudes. Consequently, separate sets of varieties of the same crop needed to be developed in such cases.

Shifting cultivation

Shifting cultivation known as *jhuming* is the dominant FS in the N.E.H. region. Although the system may have been good at one point of time when it emerged, it has lost much of its relevance with growing population pressure and shrinking of land resources. Continuation of shifting cultivation leads to large-scale deforestation and denudation of hill tops and slopes results in silting of reservoirs and streams and flooding in plain areas. Removal of topsoil leads to loss of soil fertility, which is not easily built up. This leads to low productivity and subsequent pressure on land. Persistence of this system of farming offers very little scope for introduction of modern/improved technology.

Land tenure systems/operational holding

The ownership of land by the community or the village chief and the prevailing land tenure system often act as a disincentive for proper development and maintenance of land for cultivation. Similarly, the average operational holdings are too small for proper growth of agriculture in the region.

Soil erosion and land degradation

A major problem in the N.E.H. region is that the available land is subjected to heavy soil erosion and degradation resulting from deforestation. This is largely attributable to the slash and burn technique of production associated with *jhum* and also to indiscriminate cutting and sale of timber to private contractors. In Sikkim, soil erosion is caused by unterraced farming on the slopes and by canal irrigation systems without protective cover.

Major research achievements

Crop improvement

More than 15,000 germplasms of crops were collected and evaluated. Five varieties of rice viz., TRC Boro Dhan I with vegetative phase cold tolerance, RC Maniphou 4 and RC Maniphou 5 suitable for *pre-kharif* and main *kharif* in Manipur valley and two cold tolerant varieties (N.E.H. Megha Rice 1 and 2) for high altitude areas possessing cold tolerance at reproductive phase were developed and released. Two upland rice lines viz., TRC 87-251 for Tripura and IET 13-459 for Meghalaya, two varieties (RCPL 3-2 and RCPL 3-6) for Sikkim and one variety (VL 206) for Mizoram were identified and recommended. Protocols for isolation, culture and plant regeneration and direct gene transfer from protoplast rice varieties (Japonica and Indica) were standardized. Transfer of wild abortive cytoplasmic male sterility in rice was accomplished through protoplast fusion. Herbicide resistant rice, IR 36 was produced by introducing the bar gene. Standardized protocols for anther callusing and production of haploids from local rice varieties as well as improved lines cultivated in the region were produced. Extra early pigeonpea varieties to fit in the cropping sequence and suitable for intercropping were identified. Ten lines of fieldpea were developed in Tripura. Varieties of mungbean, urdbean and cowpea were identified and recommended for low and mid altitude. Two local selections of rice bean (RCRB 1-6 and RCRB 6-10) were also made. Several varieties of soybean, groundnut, rapeseed-mustard, sesamum and sunflower have been identified for various situations. Two groundnut varieties viz., RCG 3 and ICGS 76 were also selected. Three varieties of yellow sarson (Sikkim sarson 1, 2 and 3) were developed for Sikkim. Five advanced lines of sesamum are in the pipeline in Tripura. One soybean variety (JS 80-2 1) was recommended and released for commercial cultivation in Meghalaya. Four maize populations viz., RCM 1-1, RCM 1-2, RCM 1-3, and RCM 1-4 were developed for different agro-ecological situations.

Agronomic management

The production potential of major crops was determined both under upland and lowland situations. Groundnut and soybean performed well as sole as well as intercrops. Popcorn + groundnut (paired rows) and maize + groundnut were found to produce maximum maize equivalent yield under a maize based cropping system in mid hill terraces. Natural farming of rice under wetland conditions was successful at the mid altitude of Meghalaya through release of azola @ 100 g/m^2 only after transplanting. Relative contributions of different management factors towards grain yield in upland terraces and wetland rice showed that weed control contributed most (35%) in upland and application of an optimum dose of fertilizer contributed most (77%) in lowland rice. Use of rock phosphate to enrich FYM produced a higher yield of rice, maize, groundnut, soybean and mustard. Pre-emergence application of butachlor @ 1 kg ai/ha in maize and post-emergence application of glyphosate (41%) @ 1.0-1.5 kg ai/ha in fallow lands/orchards were found effective in pineapple for controlling weeds

Water management

Different water management practices in rice controlled weeds 50-85% over the rainfed conditions on a green biomass basis. Continuous submergence (3-5 cm) was found most congenial for checking grass and sedge weed populations along with increase in rice yield (68%). Under upland conditions a higher moisture regime with furrow sowing produced a significantly higher yield over low moisture regime of plain sowing of rice. Soil moisture studies on hill slopes indicated that the higher soil moisture storage (30-50%) from April to October was found most favourable for growth of many crops on lower terraces. Soil moisture conservation in situ with a 10-15 cm bund height significantly increased grain yield of rice (34-42%) over the unbunded crop. A higher yield of mustard grain was obtained with application of 60 kg nitrogen/ha and 0.3 IW/CPE ratio interaction. Application of 60 kg P_20_5 with two irrigations one at 40 DAS and the other at 60 DAS increased the yield of mustard (cv M 27) by 45% over the rainfed crop.

Soil management

The lime requirement of soils, optimum dose and frequency of lime requirement and optimum time of sowing after lime application were determined. Distribution of different forms of phosphorus, mechanism of P absorption and fixation availability indices, critical limits, methods of P placement and P requirement of crops were worked out. Methods of potassium application, critical limits and Q/I parameters were determined for management of potassium in soils.

Insect pest management

Major insect pests of important agricultural and horticultural crops were surveyed and identified. Insect pest resistant/tolerant lines were identified through screening of germplasm. Component technologies for IPM were developed and yield losses for major crops were estimated. Fourteen species of rodents were collected from the N.E.H. region. Sherman traps were found most effective for capturing rodents. Yield losses up to 12%, 9% and 8% was recorded in paddy, maize and pineapple, respectively. Zinc phosphide was found the most effective acute rodenticide.

Plant disease management

In rice, meteorological factors conducive for blast development were identified for forecasting. Seven hundred fifty indigenous and exotic rice cultures were identified as resistant/tolerant to blast disease. Seed soaking for 12 hours in 0.1% carbendezim for nursery and upland or seedling root-dip treatment for 12 hours in 0.1% carbendezim solution before transplanting followed by two sprays of carbendazim (0.05%) at tillering and panicle initiation/heading stage controlled blast disease. In maize, genes of resistance to northern leaf blight disease (an important disease of maize in N.E.H. region) and the effect of NPK on disease severity were worked out. Ten lines were identified as resistant to blast of ragi. Early maturing cultivars sown up to the first week of June escape rust disease of soybean. Propiconazole (0.025%) and mancozeb (0.2%) effectively controlled rust disease of soybean. In groundnut, yield loss due to early leaf spot (ELS) disease was recorded up to 56-82% in Meghalaya. A single spray of a mixture of mancozeb (0.2%) + carbendazim (0.05%) at 40 to 50 DAS was found economical. Resistant varieties of groundnut to ELS were identified. In rapeseed-mustard, resistant varieties to white rust and Alternaria blight diseases were identified. Copper oxychloride (0.025%) and carbendazim (0.05%) were effective against Alternaria blight. Sixty-seven lines were identified as resistant to rust and 19 lines to powdery mildew disease of fieldpea. In citrus, carbendazim (0.05%) was effective against citrus scab. Fourteen wild mushrooms were identified from survey in Arunachal Pradesh, Nagaland, Tripural and Meghalaya. Neem formulations (azadirachtin 0. 15 EC at 0.3%) could control Dipteran and Coleopteran insect pests.

Horticulture

Surveys were conducted in N.E.H. states to ascertain the status of orange orchards. Technology for rejuvenation of run-down orange orchards was developed. A manuring schedule for orange orchards was standardized. *Citrus volkameriana* and *Rangpur lime* were found to be suitable rootstock for Khasi mandarin orange to get maximum yield. Suitable varieties of guava (Lucknow 49 and Allahabad Safeda), peach (Florodasun and Shan-e-Punjab), tomato (BT 2, Arka Alok, Arka Abha, Floradade, LE 79, Arka Vardhan, CTH 708, HOE 303, BSS 39), brinjal (pant Samrat, Arka Shirishi, Hybrid HOE), colocasia (C 7, TVM 293) and sweet potato (S 162, X 69 and S 30) were identified and recommended. Tongue grafting in December and softwood grafting in August were the best propagation methods for peach. Nadia, Poona and Maran in ginger and PCT 13, PCT I 1, PCT 15, GL Puram and Sugandham in turmeric were identified as most suitable varieties. A turmeric clone viz. RCT-1 was selected from a local collection of Meghalaya possessing high yield, good quality and resistance to diseases. Protocols were perfected for large-scale multiplication of disease free plants of Khasi mandarin and other citrus species. Successful and cheap acclimatization methods were developed for acclimatizing micropropagated citrus plantlets. Protocols for *in vitro* shoot tip grafting were standardized. Supplementation of 0.5 to 0.75 mg/l BAP to the MS medium was found sufficient for shoot proliferation. Gerbera hybrids viz. RCGH 1 and RCGH 2 were developed and identified as most promising in respect of colour, size and keeping quality. Besides, J.S. Lal, Carona, Orange glem, Popular, Favoury Rahman and Jamesoni Hybrid were also identified as promising gerbera varieties. Techniques for micropropagation/cormel, and production of gerbera/gladiolus were standardized. Agnirekha, American Beauty, Apasara, Blumoon and Her Majesty were found most promising gladiolus varieties. Cultivation techniques of large cardamom were standardized along with package of practices.

Agroforestry

Indigenous potential agroforesty systems were surveyed on sloping land. A remunerative and employment generating agro-aquaculture system was developed. A fruit crop based agroforesty system for hilly terrain was developed. As sericulture based agroforestry system for higher returns was established. Multi purpose tree species were identified suitable for agroforestry.

Farm machinery and power

Land clearing implements (hand grass slasher and garden rake), seedbed preparation machinery (mould board plough and light ridger plough), sowing implements (metallic tip dibbler, adjustable row marker, wheel hoe drill), interculture implements (multi-purpose weeder, hand fork, wheel hoe with attachments) and harvesting and other implements (axial flow thrasher, tubular maize sheller, fruit harvester and grass/bush cutter) were developed, tested and evaluated.

Soil and water conservation

Runoff and soil erosion studies provided quantitative data on soil erosion hazards associated with various land use systems on hill slopes. Potential land use systems and soil conservation measures on hilly watersheds were evaluated hydrologically. Conservation practices involving hilly watershed projects were supported by development of rainfall runoff models. The technology of gradual conversion of contour bunds was developed. A water harvesting tank was designed and constructed. Rainfall erosivity models were developed for estimating erosion index from daily precipitation.

Farming systems

Alternative farming systems to replace shifting cultivation were developed. Land use systems for hilly watersheds were developed. Potential indigenous farming systems of the N.E.H. region were surveyed and documented. An agro-horti-silvo-pastoral system was identified as an economically viable, ecofriendly and sustainable land use system. Agro-pastoral and dairy farming systems with bench terracing and contour bunding were developed as highly profitable and effective for soil conservation.

Animal production

A suitable upgraded variety of pig with 87.5% exotic inheritance was developed involving selected Hampshire and indigenous germplasm. Different types of housing systems for different breeds of pig were designed and developed with locally available housing materials. The procedure of training and collecting semen artificially from selected boars was standardized. Among the meat producing rabbits, New Zealand White and Soviet Chinchilla were found to be the breeds of choice for the N.E.H. region. Two strains of poultry layers viz. HI and HJ were recommended to farmers. The Black Bengal goat was found to be well adopted in the region.

Animal nutrition

Ensilage technology consisting of a bamboo basket lined with polythene was developed with molasses/pineapple waste to alleviate the scarcity of fodder during the lean season of winter by conserving excess green vegetation plentiful during the rainy season. A growth of 40-45 g per day in BB goat was obtained on **c**ongosignal grass in comparison to 35 g per day on native pasture grass. Perennial grasses such as congosignal (*Brachiaria ruziensis*), *guinea* (*Panicum maximum*), *Setaria sphacellata* and broom grass (*Thysanolaena agrostis and T. maxima*) were found nutritious and suitable for pasture development to economize milk, beef and chevon production in the hilly region. *Nevaro*, *Gamari*, *Kachnar* and *Parari* were found suitable for fodder trees. Urea and ammonia paddy straw and broom grass were found economic roughage for the lean period of winter feeding to reduce the cost of feed in dairy farming. A cheap and economical ration with a rice polish base for pig feed was formulated. Roasted damaged soybean and rice bean (*Vigna umbellata*) grains were found to be an excellent source of protein in place of oilcake in poultry feeding. In rabbit feeding, 25% dry matter of concentrate mash was safely replaced with fodder meals of grasses and legumes. Job’s tear was safely incorporated up to 30% in grower pellet and up to 40% in adult ration. Green rice bean fodder safely replaced 50% of commercial feed pellet and substantially reduced the cost of feeding in rabbits with good feeding value for commercial meat rabbit production in the hills.

Animal diseases

Health calendars indicating the schedule of prophylactic and control measures of major diseases of cattle and goats were developed. An effective vaccine against black quarter disease of cattle in Manipure, an oil adjuvant vaccine against chick mortality in Nagaland and duck cholera vaccine in Tripura were developed. *Pasteurela multocida* biotype 2 was isolated for the first time in India during an outbreak of swine pasteurellosis. The pattern of Salmonella infection in pigs, goats, rabbits, poultry and ducks was investigated. The major viral diseases of economic importance such as FMD, swine fever, Newcastle disease, fowl pox and IBD and bacterial diseases like black quarter, pasteurellosis, brucellosis, mycoplasmosis, fowl cholera, CRD and swine erysipelas were identified. Gastrointestinal parasites, tick and mite infestations of pig, poultry, cattle, goat and rabbit were identified with their seasonal and latitudinal variation. Babesiosis and anaplasmosis were found to be major blood protozoan parasites affecting cattle and goats. Coccidial infections of pig, goat and rabbit, sarcocystis infection in different organs of pig and cattle and trematode infection due to aquatic snails and their cercarial fauna in different domestic animals were identified with seasonal and latitudinal variation. Control measures against different parasites were evolved through prophylactic, curative anthelmintic and chemotherapeutic drug schedules. A computer programme for identification of parasitic eggs and larva was developed.

Fishery

One hundred seventy-two fish species belonging to 27 families were identified from a survey of icthyofauna in the N.E.H. region and catalogued. Technologies for paddy-cum-fish culture, composite fish culture, cage fish culture and production of common carp seeds were developed. Technology for fresh water fish culture in small streams with locally available hill stream carp was developed.

Agricultural extension

Socio-economic characteristics of Meghalaya farmers were surveyed. Village leadership patterns, problems and prospects of livestock production, working environment of VLWs and the role of tribal women in decision-making in farm activities were identified. Constraints to agricultural activities in Summer village of Meghalaya were identified through participatory rural appraisal (PRA). Three hundred forty-one training courses on crop production, fruit and vegetable production, soil and water conservation, livestock production, home science, mushroom production and integrated farming systems involving 4,259 participants were organized by the Trainers' Training Centre during the last 20 years. Likewise, more than 2,500 on/off campus training programmes on various subjects of agriculture and allied sectors were conducted by KVKs of Arunachal Pradesh, Manipur, Meghalaya (Tura), Nagaland, Sikkim and Tripura involving 37,004 ST, SC and women farmers.

Economic Assessment of Terracing in Guizhou Province of China

Gu Shuzhong[*]

Agricultural situation in Guizhou Province

Guizhou Province is located in the sub-tropical Yunnan-Guizhou Plateau, southwest China. It covers an area of 176,128 square kilometers. This province is one the most under-developed regions in China.

The agricultural gross product in 1995 was 2.27 billion dollars. The farmers' per capita income in 1995 was only 118 US dollars. Guizhou Province is a grain-deficit region of China, with a regional per capita grain production in 1995 of 272 kilograms, only 72% of the national average level.

There are 8 land use types in Guizhou Province (Table 1). Cultivated land, horticulture land, grassland and pasture, and some inland waters (especially lakes and reservoirs) are called farmland.

Table 1 Land utilization types in Guizhou Province.

Land Use	Land Area ('000 ha)	Share of Total Territory (%)
1. Cultivated land	4,147	23.5
Paddy field	1,416	8.0
Dry field	2,731	15.5
2. Horticulture land	73	0.4
3. Forestland	7,679	43.6
4. Grassland and pasture	2,365	11.7
5. Residential, industrial and mineral uses	411	2.3
6. Waters	192	1.1
7. Traffic use	81	0.5
8. Non-used land	2,967	16.8
Total territory	17,615	100.0

Source: China Statistical Yearbook, China Statistical Publishing House, 1996.

There are three main topographies, including mountains, hills and hilly areas, and basins. The diversity of topographies provides an important basis for multi-functional development of natural resources.

Karst area constitutes 73% of the total area. This province is one of the typical regions of karst terrain. The main characteristics of karst area are: covered with stones and gravel; with high percentage of sloping land; with fast runoff of rainfall, poor water and soil nutrient preserving capacity; and poor traffic accessibility.

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Main constraints to sustainable development

The shortage of arable land is one of the most serious constraints to sustainable agriculture in the province. Other constraints are low quality of the farmland, frequent drought and disasters such as land slides and mud-rock flows, poor capacity for utilizing rainfall and ground water, shortage of agricultural investment, poor education of rural residents, and poor capacity for technological application and adoption by farmers.

Main advantages for sustainable development

Some advantages for the sustainable development of agriculture in Guizhou Province are: plentiful reserve farmland; great potential for increasing the agricultural productivity; plentiful cheap rural labour; attention to management of agricultural natural resources by local government including the legislation related to agricultural natural resource management and some basic works completed.

Existing legislation on the management of agricultural resources include the following:

- Measure for Implementing Land Management Law of PRC in Guizhou Province;
- Measure for Implementing Water Law of PRC in Guizhou Province;
- Measure for Implementing Soil and Water Conservation Law of PRC in Guizhou Province;
- Forestland Management Measure of Guizhou Province;
- Implementing Ordinance for Basic Farmland Protection and Conservation of Guizhou Province;
- Environmental Protection Ordinance of Guizhou Province;
- Land Reclamation Measure of Guizhou Province (forthcoming).

Considerable work has been done by local governments to manage agricultural natural resources. The following are the major components:

- Agricultural resource surveys: soil census; agricultural natural resource investigation and agricultural zoning; land resource comprehensive survey; detailed survey of forest resources; grassland resource census; investigation and evaluation of poor productivity land and wasteland;
- The “Population-Grain-Ecology” way of agricultural development has been espoused by the local government, which means controlling population, increasing grain production, and protecting ecology;
- A series of agricultural development projects has been implemented: poverty alleviation programme, agricultural integrated development, green project, watershed management, etc.

Techniques for agricultural resource management

There are a lot of techniques for managing agricultural natural resources. All of these aim at taking full use of the existing advantages and avoiding or preventing the existing constraints to agricultural growth. These techniques mainly include the following:

- terracing of sloping farmland and wasteland;
- irrigation in drought-stricken areas;
- drainage in flood-stricken and wetland areas;
- adoption of multiple cropping systems; and
- use of pesticides and chemicals in agricultural production.

Terracing practices in Guizhou Province

Primary objectives of terracing

Terracing has four main objectives in Guizhou Province. The first is to alleviate the shortage of cultivated land resources. The second is to improve the quality of cultivated land. The third is to manage soil and water erosion. The last objective is to supply more employment opportunities for the rural labour force.

The option orders for identifying priority areas for terracing

There are four options for identifying priority areas for terracing based on:

- land utilization situation: the first priority is presently cultivated land, the second wasteland, and finally land in other use categories including forestland, grassland, etc.
- slope situation: the first priority is land with slope between 15° and 25°, the second is land with slope between 10° and 15°, and finally land with slope over 25°.
- economic development level: first priority is the poverty-stricken areas, and then other areas.
- land area: first priority is the area with potential large-scale contiguous cultivated land after terracing.
- cultivated land with slope between 15° and 25° and potential large-scale contiguous plots in poverty-stricken areas should be the first priority for terracing.

Terraced areas

The terraced area from 1991 to 1995 was relatively stable (Table 2). This was mainly because nearly all of the terraces were planned by local governments. The terracing plans were based on allocated terracing investment.

Table 2 Terraced areas in Guizhou Province from 1991 to 1996.

Year	1991	1992	1993	1994	1995	1996	Total
Area (ha)	42,811	40,230	37,776	42,355	50,416	49,071	262,659

There are five main types of terracing in Guizhou Province. The first is the transfer of dry sloping field into terraced dry field, constituting the largest portion of the total terraced area. This type of terracing is irrigated or rain-fed, and is mainly used to plant maize. The second is the transfer of dry sloping field into terraced paddy field, which is used to plant rice. Details are given in Table 3.

Table 3 Main types of terracing in Guizhou Province.

Terrace Type	Share in Total Terraced Area (%)
Transfer dry slope field into terraced dry field	74
Transfer dry slope field into terraced paddy field	5
Transfer slope wasteland into terraced dry field	8
Transfer slope wasteland into terraced paddy field	1.3
Restore terraces destroyed by floods	8.7
Other types	3

Organization system for terracing

There are five levels of administration for terracing in this province. The top level is the Provincial Terracing Headquarters. The second level organization is the Prefecture Terracing Headquarters. The third level organization is the County Terracing Headquarters. Its members come from the County Finance Bureau, Agriculture Bureau, Traffic Bureau, Forestry Bureau, Water Conservancy Bureau and Planning Commission. The fourth level organization is the Township Terracing Headquarters. The fifth level organization is the Village Leading Group.

Priority policies for terracing

In Guizhou Province and other areas of China, farmland is mainly owned by village collectives. Private land ownership is forbidden. The land tenure is always obtained by signing contracts with collectives. There is a policy stating that "those who contract, terrace; those who terrace, utilize; those who utilize, are benefited".

Agricultural productivity can be increased remarkably after sloping land has been terraced. In order to protect farmers' rights as beneficiaries of terracing, the provincial government has stipulated that agricultural taxes, contract fees and collective administrative costs are not permitted to increase within at least three years of land being terraced.

The government has always emphasized that terraced cultivated land should not be occupied. When requisition is not avoidable, the requested terraced land should be compensated according to the actual total predictable loss of farmers. This kind of loss should include agricultural gross production for five years and terracing costs.

General procedure for terracing

Terracing in Guizhou Province has the following nine steps: selecting terracing sites; field survey of the terracing sites; designing construction blueprint for terracing; training of technicians, skilled masons, bricklayers; organizing terracing construction; physical construction; supervising of construction progress and quality; monitoring and auditing expenditure of terracing funds; and project check and acceptation by special group composed of specialists and officials. Table 4 is a terracing checklist.

Table 4 Terracing checklist.

Item	Sub-item	Possible Points	Actual Obtained Points
1. Site selection and blueprint design	1.1 Site selection	10	
	1.2 Blueprint design	10	
2. Construction quality	2.1 Basement quality	10	
	2.2 Wall solidity	12	
	2.3 Wall thickness	5	
	2.4 Wall appearance	5	
	2.5 Scale of stones	2	
	2.6 Land even or not	10	
	2.7 Clear of stones and gravel	8	
	2.8 Soil depth	3	
	2.9 Project integrity	5	
3. Project management and efficiency	3.1 Project security management	3	
	3.2 Project financial management	7	
	3.3 Follow-up management	5	
	3.4 Project efficiency	5	
4. Total Points		100	

Excellent Project: points over 90; Good Project: 80 - 90 points; OK Project: 70-80 points; Marginal Passable Project: 60 - 70 points; Unacceptable Project: points below 60.

Economic assessment of terracing

Methodology of assessment

Data were collected through a structured survey in Pingba County. Steps of data collection are as follows: (i) selection of study site; secondary data collection; (ii) primary data collection through structured survey; (iii) observation on the existing farming practices; and (iv) observation on terracing techniques.

The benefit-cost analysis method was applied for economic assessment of terracing techniques in this project. The total benefits include the following: resource benefits, ecological benefits, economic benefits and social. The costs include material costs and labour costs.

Reasons for selecting Pingba County as the specific research area

Pingba County was selected as the specific research area for three reasons. The first reason is that it is representative of Guizhou Province with regard to natural resources and natural conditions. The second reason for selecting Pingba County as the specific research area is that this county has been listed in the SARD Programme, or Sustainable Agriculture and Rural Development in China, organized by the Department of Agricultural Resource Management and Regional Planning under the Ministry of Agriculture. The third reason is the relatively easy traffic accessibility of Pingba County in Guizhou Province. Guizhou's traffic situation is the poorest in China.

Overview of terracing project area in Pingba County

The terracing project in Pingba County covers 7 townships, 34 villages, and 5,796 rural households. The total number of rural residents benefiting from the project is 30,319 persons. The duration of the project was five years, i.e. from 1991 to 1995. The total completed terraced area was 807 ha in these five years. There were two types of terraces in Pingba County. One transfers sloping dry field into terraced dry field, making up 98.27% of the total terraced area. The other transfers sloping dry field into terraced paddy field, making up only 1.73% of the total terraced area (Table 5).

Table 5 Terraced areas completed in Pingba County from 1991 to 1995.

	Total	1991	1992	1993	1994	1995
Areas planned by prefecture terracing headquarters (ha)	800	130	130	130	220	190
Terraced areas actually completed (ha)	807	130	130	137	210	200
Completion percentage of planned terraced area (%)	109	100	100	105	96	105

Cost calculation for terracing

Terracing has two kinds of costs. The first is material costs: explosives and detonators, drill rods, hammers and rock drills, cubic stones, electricity, machinery, diesel oil, spades, etc. The second is labour costs: project management, blueprint design, survey, masonry, land leveling, clearing stones and gravel in field, terrace wall building, etc.

From the following general analysis, it will be seen that the total cost per hectare was 6,030 RMB Yuan or $ 710, of which the labour cost is 71% (Table 6).

Table 6 Total cost per hectare for terracing.

Total Cost (¥/ha)	Cash Cost (¥/ha)	Labour Cost (¥/ha)	Working Days (day/ha)	Labour Fee (¥/day)
6,030	1,755	4,275	855	5

Source: Pingba County Terracing Headquarters.

The cost depends upon the slope. In areas with slope over 20°, the total terracing cost per hectare was 12,750 RMB Yuan, twice the average level. In areas with slope below 20°, the total terracing cost per hectare was only 5,700 RMB Yuan or 94.5% of the average level (Table 7).

Table 7 Total cost per hectare for terracing areas with different slopes.

Slope	Total Cost (¥/ha)	Cash Cost (¥/ha)	Labour Cost (¥/ha)	Working Days (day/ha)	Labour Fee (¥/day)
Over 20°	12,750	3,750	9,000	1,800	5
Below 20°	5,700	1,650	4,050	810	5

Source: Pingba County Terracing Headquarters.

Resource benefit calculation for terracing

Terracing can expand the former cultivated area by an average rate of 8%. The average plot scale can be expanded from 0.03 ha to 0.9 ha after terracing. The soil layer was thickened from 15-30cm to 40-60cm. The capacity for preserving soil, water and nutrients can be greatly improved, and the fertility can be greatly improved, too.

Ecological benefit calculation for terracing

As the survey results show, 807 ha of former soil and water eroded sloping cultivated land was controlled and managed. The soil erosion was decreased by 149 thousand tons of soil. Decease in soil and water erosion resulted in a remarkable increase in agricultural productivity.

The average grain yield could be increased by 20% after terracing due solely to improvement in anti-disaster capability. The destruction from flood and drought disasters was alleviated greatly after terracing.

Economic benefit calculation for terracing

The growth of agricultural productivity can be seen in comparison between yields of terraced cultivated land and sloping cultivated land. The average grain growth rate after terracing was 16% (Table 8).

Table 8 Growth rate of grain (maize) yield after terracing.

First Year	Second Year	Third Year	Fourth Year and Later
5%	11%	18%	22%

The following tables show the total increased grains solely because of yield increase (Table 9), total increased grain output due to area expansion (Table 10), increased grain output because of improvement in anti-disaster capability (Table 11), total increased grain output due to terracing from 1992 to 2000 (Table 12), and the total added value from terracing (Table 12).

Table 9 Increased grain output only because of yield increase (kg).

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Land Terraced in 1991	17,940	39,470	64,580	78,940	78,940	78,940	78,940	78,940	78,940
Land Terraced in 1992		18,630	40,990	67,070	81,970	81,970	81,970	81,970	81,970
Land Terraced in 1993			19,320	42,500	69,500	84,940	84,940	84,940	84,940
Land Terraced in 1994				23,460	51,610	84,450	103,220	103,220	103,220
Land Terraced in 1995					30,360	66,790	109,320	133,610	133,610
Total Increased Grain	17,940	58,100	124,890	211,970	312,430	397,090	458,390	482,680	482,680

Table 10 Increased grain output due solely to expansion of cultivated land (kg).

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Land Terraced in 1991	30,140	31,860	33,870	35,000	35,000	35,000	35,000	35,000	35,000
Land Terraced in 1992		30,140	31,860	33,870	35,000	35,000	35,000	35,000	35,000
Land Terraced in 1993			32,500	.34,310	36,470	36,900	36,900	36,900	36,900
Land Terraced in 1994				39,410	41,660	54,710	56,570	56,570	56,570
Land Terraced in 1995					46,370	49,020	52,110	53,880	53,880
Total Increased Grain	30,140	62,000	98,230	142,590	199,140	210,630	215,580	217,350	217,350

Table11 Increased grain output only because of improvement in anti-disaster capability (kg).

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Land terraced in 1991	97,500	97,500	97,500	97,500	97,500	97,500	97,500	97,500	97,500
Land terraced in 1992		97,500	97,500	97,500	97,500	97,500	97,500	97,500	97,500
Land terraced in 1993			102,750	102,750	102,750	102,750	102,750	10,275	102,750
Land terraced in 1994				157,500	157,500	157,500	157,500	157,500	157,500
Land terraced in 1995					150,000	150,000	150,000	150,000	150,000
Total Increased Grain	97,500	195,000	297,750	455,250	605,250	605,250	605,250	605,250	605,250

Table 12 Total increased grain output (kg).

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Land terraced in 1991	145,580	168,830	195,950	211,440	211,440	211,440	211,440	211,440	211,440
Land terraced in 1992		146,270	170,350	198,440	211,470	211,470	211,470	211,470	211,470
Land terraced in 1993			154,570	179,560	208,720	224,590	224,590	224,590	224,590
Land terraced in 1994				220,370	250,770	296,660	317,290	317,290	317,290
Land terraced in 1995					226,730	265,810	311,430	337,490	337,490
Total Increased Grain	145,580	315,100	520,870	909,810	1,109,130	1,209,970	1,276,220	1,302,280	1,302,280
Total Added Value	232,928	504,160	833,392	1,295,696	1,774,608	1,935,952	2,041,952	2,083,648	2,083,648

Social benefit calculation for terracing

The local grain security improved remarkably after terracing. The total increased grain output reached 2,775 tons over 1992-1996 or 555 tons per year. The per capita grain increased by 96 kilograms. The farmers' income growth due to terracing was 223 thousand dollars, for a per capita income increase of 63 RMB Yuan or 7.5%. The total increased work opportunity in 1992-1996 was 690 thousand working days. This provided additional 45.5 working days per farmer per year for these five years.

Calculation of net benefit and identification of the break-even point for terracing

The total terracing costs and benefits are calculated in dynamic terms. That is to say the interest rate is used in calculating accumulated terracing costs and accumulated terracing benefits. Taking into account China's actual interest rates from 1991 to 1997, an average interest rate of 10% was applied here. The general formulation for calculating accumulated costs or benefits is: $PVn=P_1(1+10\%)^{n-1}+P_2(1+10\%)^{n-2+} \ldots\ldots +P_{n-1}(1+10\%)^1$, where, n, n-1, n-2, ... and 1 are the years n, (n-1), (n-2), ... and 1. P_1 , P_2, P_{n-1} and PV_n are the accumulated value (costs or benefits) in the first year, second year and the year of (n-1) and n, respectively.

From Table 13, an important conclusion can be obtained: terracing did not begin to produce net benefit until 1997 and thereafter, that is to say the break-even point was around 1997.

Table 13 Net benefit of terracing.

	Actual Cost	Accumulated Cost	Actual Benefit	Accumulated Benefit	Net Benefit
1991	783,900	783,900			-783,900
1992	783,900	1,646,190	232,928	232,928	-1,413,262
1993	826,110	2,558,529	504,160	760,380	-2,482,491
1994	1,266,300	4,166,911	833,392	1,669,810	-2,497,101
1995	1,206,000	5,789,602	1,295,698	3,132,488	-2,657,114
1996		6,368,562	1,774,608	5,220,344	-1,148,218
1997		7,005,418	1,935,952	7,678,332	672,914
1998		7,705,960	2,041,952	10,488,116	2,782,156
1999		8,476,556	2,083,648	13,620,576	5,144,020
2000		9,324,212	2,083,648	17,066,282	7,742,070

Sustainability effects of terracing

Sustainability effects

Terracing in regions like Guizhou Province is one of the most effective and efficient technologies for sustainable agricultural development. It can effectively and efficiently increase the area of cultivated land on the basis of improving the natural conservation situation without destroying the ecological balance. It can remarkably increase the output of grains and other agricultural products, resulting in great improvement in grain security. It can also greatly increase the farmer’s income level, and alleviate and finally eliminate local poverty. It can increase employment opportunities for local farmers.

Views of local farmers on terracing (questionnaires)

The selection of farmers or rural householders to be interviewed was based on the following considerations: per capita income; per capita grain possessed; per capita contracted cultivated land; education; size, age and gender composition of the family; householder’s occupation, etc. One hundred rural households were visited and questioned. Ten key questions were asked. The results are summarized below.

- What kind of agricultural technologies do you prefer?
  - Seed improvement: 86%
  - Soil fertilization: 34%
  - Water-saving irrigation: 12%
  - Produce processing: 67%
  - High-efficiency chemical fertilizer: 88%
  - High-efficiency pesticides: 52%
  - Terracing: 78%

  Analysis: terracing is one of the available approaches welcomed by local farmers, ranked third only after high-efficiency chemical fertilizers and high-quality improved crop seed.

- Farmers' acceptation of terracing?
  - Complete acceptation: 68%
  - Conservative acceptation: 26%
  - Rejection: 6%

  Analysis: two-thirds of farmers completely accepted terracing mainly because of the remarkable expansion of cultivated land area and improvement in irrigation condition.
- What are the problems of terracing?
  - Corruption of officials: 32%
  - Flood destruction: 52%
  - Changes in land tenure after terracing: 67%
  - Changes in land ownership: 0%
  - Can't obtain the deserved terracing subsidies: 18%

  Analysis: farmland is owned by the local collectives and there is little change in land ownership. That is the reason why Chinese farmers were not afraid of changes in land ownership. But land tenure changed frequency in some areas because of the adjustment in allocation of plots, especially after terracing. Strict control over terracing investment appropriation and utilization was the reason for lower corruption in terracing in Guizhou Province.
- Why do you participate in terracing?
  - To expand cultivated land area: 89%
  - To get subsidies from participating into terracing construction: 26%
  - Forced by local leaders: 3%
  - To prevent soil and water erosion: 15%

  Analysis: almost all of the farmers said terracing could expand cultivated area greatly. That was the main reason for farmers participating in terracing. Nearly one-fourth of the farmers said subsidies (generally given in grain form) attracted them to participate in terracing.
- Are you satisfied with the existing terracing organizing and management system?
  - Whole satisfied with: 51%
  - Conservatively satisfied with: 36%
  - Unsatisfied with: 13%

  Analysis: the reason for the high percentage of satisfaction was that existing terracing organizations are operating efficiently and effectively, and that corruption is under control. However, some farmers were not satisfied with officials of county and township terracing organizations.
- To what degree can terracing expand cultivated land?
  - Can expand area by 20% and over: 6%
  - Can expand area by 10-20%: 24%
  - Can expand area by 5-10%: 65%
  - Can expand area by 5% and below: 5%

  Analysis: all of the farmers said terracing could expand cultivated land area in Pingba County. From the answers above, the average expansion rate can be calculated as about 8%.
- To what degree can terracing increase grain yield on your cultivated land?
  - Increase by 30% and over: 15%
  - Increase by 20 to 30%: 28%

  - Increase by 10 to 20%: 48%
  - Increase by 10% and below: 8%
  - Decrease cultivated land after terracing: 1%

  Analysis: all of the farmers noted an increase in grain output after terracing. The reason for different answers may be because they planted in cultivated land with different slopes and different irrigation conditions. Farmers who planted sloping land with convenient irrigation conditions noted a greater increase of grain output.
- How long did you work in terracing construction in 1995?
  - Sixty days and over: 31%
  - Fifty to sixty days: 38%
  - Twenty to forty days: 23%
  - One to twenty days: 6%
  - None: 2%

  Analysis: the reason for different working time in terracing was the differences in age, gender, full-time occupation, etc. Young male full-time farmers worked longer in terracing.
- How much was your family's per capita income last year (in RMB Yuan)
  - Two thousand and over: 5%
  - One thousand and five hundred to two thousand: 14%
  - One thousand and two hundred to one thousand and five hundred: 29%
  - Eight hundred to one thousand and two hundred: 41%
  - Six hundred to eight hundred: 9%
  - Six hundred (the local poverty-line in current price) and below: 2%

Conclusions and recommendations

Conclusions

- Terracing is accepted by most farmers in Pingba County of Guizhou Province.
- Terracing is one of the most effective and efficient ways for simultaneously realizing economic, resource, environmental, ecological and social purposes in Pingba County, and this may be true for Guizhou Province as a whole.
- Terracing is one of the most feasible ways for realizing sustainable agricultural development in Pingba County, and this may be true for Guizhou Province as well.
- There is a severe shortage of terracing investment in both Pingba County and Guizhou Province.
- State investment played, plays and will play a catalytic role in terracing. State investment attracted more investment from local government and enterprises.
- Farmers played, play and will play an indispensable and active role in terracing in Pingba County and the same in Guizhou Province.
- An effective organization system is important insurance for successful terracing.

Recommendations

- Specific-purpose terracing investment should be increased through common efforts. Local leaders should try to attract foreign investors' attention, including every kind of monetary organization.

- The selection procedure for terracing project areas should be greatly improved downward from provincial government officials to village heads.
- The recommended procedure is: organizing a special provincial technical group including officials and technicians; ordering counties according their actual need for terracing by group; selecting key terracing project areas by county terracing headquarter.
- The terracing standard should be improved
- More attention should be given to fund diversion in terracing. Fund supervising and auditing should be strengthened and improved.

Comments Concerning Terracing in Guizhou Province

*Cheng Shengkui**

General perspectives

The message from The Earth Summit (1992): ”without better environmental stewardship, development will be undermined; and without accelerated development in poor areas/countries environmental policies will fall” was clear. Agriculture is a fundamental activity in the process of human development, in which the farmer manages an interaction between socio-economic resources and natural resources, under different social and economic systems. The focus of sustainable agriculture is on rational utilization of resources with a reasonable policy and effective technology options, with the aim of more products for greater population needs.

Tables 1 to 3 compare some socio-economic and agricultural aspects of Guizhou Province with other parts of China, China as a whole and the Republic of Korea.

Table 1 Employed population and distribution in production, China (%).

	Employed Population (million)	Percentage of Total Population	Percentage in Industries		
			Primary Industry	Secondary Industry	Tertiary Industry
China					
1952	207.3	36.1	83.5	7.4	9.1
1977	393.8	41.5	74.4	14.6	11.0
1995	689.1	51.5	52.9	23.0	24.1
Eastern region	263.6		44.7	28.7	26.6
Central region	214.7		54.7	21.3	24.0
Western region	145.6		65.2	14.9	19.8
Guizhou 1995	18.6	52.9	73.7	10.0	16.3

Table 2 Comparison of major agri-indicators per capita in 1995.

Country/region	GNP per Capita (US$)	Grain (kg)	Oil-bearing Crops (kg)	Meat (kg)	Net Income per Capita (Yuan)
Korea, Rep.	7,660			30.1	
China	490	383.9	5.8	34.7	1,577.7
Guizhou	130	271.3			1,086.6

Source: China situation report, 1978-1995, China Planning Press, 1996

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Table 3 Industrial structure in 1995 (%).

Region	Primary Industry	Secondary Industry	Tertiary Industry
Korea, Rep.	7.1	43.3	49.5
China	19.7	49.0	31.3
Guizhou	44.1	31.5	24.4

Terracing in Guizhou Province

- In this report, the author paid more attention to the local experience and actual situation. The methodology used in the report for analyses and investigation was proper and scientific. The conclusions are of significance for policy-making of sustainable agriculture development in the given area.
- The author gave convincing and acceptable inferences, step by step, for the traditional technique of terracing, a key for realizing sustainable use of agricultural resources in the poor areas.
- The author systematically introduced the terracing system from its objectives, advantages, priority and achievements to its organization system, funding mechanism, policies and general procedures.
- Also he skillfully described the sustainability effects of terracing by the means of local official's and farmer's opinions.

The problems in this report

- For sustainability of agriculture in Guizhou Province terracing is a key technique, but not the only one. That is to say that in order to promote sustainability of agriculture, terracing has to be combined with other important technologies, such as effective irrigation, rational utilization of fertilizer, suitable crop varieties, multiple cropping and training, etc.
- In ecological benefit assessment, the author should focus on the agricultural ecosystem and environmental improvement after terracing, particularly on the structure and functions of the agro-ecosystem improved.
- It is difficult to differentiate the effect of increasing grain yield by terracing from the other factors that might be involved.

Economic Assessment of Selected Resource Management Techniques Focusing on Terracing in Qinghai Province of China

Ni Hongxing[*]

Introduction

In recent years, sustainable resource management has been recognized as one of the most important issues in marginal upland agriculture in Asia, particularly in areas where CGPRT crops are predominant. In this region, upland agriculture is a major source of household income and this agriculture is usually characterized by a fragile environment, inferior infrastructure and difficult access hampering development. As a result, low income and poverty still prevail among the rural population in these areas. Population pressure on the already limited arable land has resulted in cultivation of marginal lands and farmers experience problems in land conservation efforts and in increasing land productivity with proper farming technology. The adoption of appropriate resource management techniques is crucial to ensure the sustainability of agricultural development in these regions.

Qinghai Province is a typical marginal upland agricultural area characterized by harshness of climate conditions, poor natural resource base, fragile environment, backward economic development and low income level. Agriculture in Qinghai is characterized by its subsistence level and it is carried out under very poor and harsh conditions. Farmers totally rely on their limited resource base; they are not only short of purchasing power to buy products from outside of the region, but they also have many limits to moving out of this region to seek employment elsewhere. Therefore, sustainable agricultural development in this region means improving agricultural productivity while enhancing the resource base. Techniques which can improve agricultural productivity and enhance the natural resource base should be sustainable ones. In order to ensure sustainable agricultural development and to meet the challenge of feeding its ever-increasing population with very limited land and water resources, Qinghai developed a series of farming and resource management techniques to increase agricultural productivity, particularly, grain productivity. Among these technologies, the most significant and effective one is terracing. Based on a review of Qinghai natural conditions and resources, social and economic development and agricultural performance, this paper identifies the constraints to and prospects for sustainable resource management of marginal upland areas in Qinghai Province of P.R. China, and economically assesses the effect of terracing in Huangyuan County of Qinghai Province.

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Agricultural development in Qinghai Province

Qinghai Province is situated in the north-east of the Tibetan Plateau bordering Tibet and Xingjiang to the west and Gansu and Sichuan to the east. Most of the province is located some 3,000 meters above sea level with the highest point of 6,860 meters and the lowest 1,650 meters. The province covers some 72 million hectares and ranks fourth in China, but only one million hectares of the province are classified as arable land and 580,000 ha of this are under cultivation. Over 400,000 ha (about 70%) of the cultivated land are located in the mountains.

Qinghai Province experiences a continental climate and falls within the semi-arid to arid climatic zone featuring long cold winters, cool summers, wide diurnal temperature changes, low levels of precipitation and high solar radiation. The mean annual temperature for most areas is below $0^{o}C$. The regular annual total water resource is 63.1 billion cubic meters. The mean annual precipitation varies from just over 310 mm to 450 mm. The frost-free periods range from 30 to 160 days depending upon elevation.

Qinghai Province is one of the most underdeveloped regions in China. Its per capita GNP in 1995 was only 413 dollars, while the national average level was about one thousand dollars in the same year. In 1995, Qinghai Province had a population of 830 thousand living under the poverty line, which accounted for 17.3% of the total population. This province is also one of the regions with a high percentage of ethnic minorities. Of the total population of 4.812 million, 57.9% is Han nationality, 42.1% is comprised of minority communities numbering some 42 ethnic nationalities including Tibetans, Mongolians, Hui, Tu and Sale.

Agricultural development in Qinghai is limited due to low rainfall, subzero winters, limited areas suitable for arable crop production, lack of vegetation, and in more recent times a serious depletion of the resource base through sheet, till and gully erosion. Farming systems in Qinghai have remained much the same for centuries and low productivity of crops is evidence of the inefficiencies within the various production systems. The arable crops are limited to several varieties of wheat, highland barley, pea, broad bean, potato, rapeseed, oats, fruit and vegetables.

Qinghai is a low income and food deficient region in China. Agricultural production, including livestock production, is basically subsistence based and mainly for home consumption. As a result, grain production and its self-sufficiency has been regarded as an important foundation for sustainable social and economic development. In 1995, the total crop sown area was 568.81 thousand hectares in Qinghai, of which, food crops covered 384.25 thousand hectares, accounting for 67%, cash crops mainly including rapeseed and broad bean covered 149.88 thousand hectares, accounting for 26% and others took 34.68 thousand hectares, accounting for 7%.

However, grain production was stagnant in recent years due to climate, natural resource and financial constraints. From 1991 to 1995, the total annual output of grain was 1.15, 1.19, 1.19, 1.17 and 1.14 million tons, respectively. The composition of grain was as follows: wheat accounted for 67.1% in 1991 and 60.86% in 1995; potato accounted for 7.2% in 1991 and 12.94% in 1995; coarse grains and other grain crops accounted for 25.7% in 1991 and 26.2% in 1995.

Per capita grain output is a very important indicator for food security, particularly in regions where the economy is less developed and peoples' purchasing power is very limited. Per capita grain output of Qinghai Province was much lower than the national average level. From 1991 to 1995, per capita annual grain output in Qinghai was 254.2, 258.9, 255.7, 248.4, 239.1 kg, respectively, while that for all China was 376, 378, 385, 371 and 385 kg, respectively.

According to the Ninth Five-year Plan for Social and Economic Development in Qinghai Province (1996-2000), the objectives of agricultural development policies in Qinghai are as follows:

- Increase the effective supply of agricultural products and improve food self-sufficiency. By 2000, the grain output should reach 1.35 million tons, the output of oil-bearing crops should be 225 thousand tons and the output of meat should be 220 thousand tons.
- Rely on agricultural technology progress to improve agricultural productivity.
- Increase farmer's and herdsmen's per capita income up to 1,310 Yuan RMB by 2000 and basically solve the problem of absolute poverty (in 1995, there were 830 thousand people living under the poverty line).
- Save water resources and improve water resource utilization efficiency.

Main constraints and potential for sustainable agricultural development in Qinghai

In order to achieve the objectives of agricultural development for Qinghai Province and to meet the challenge of feeding the ever-increasing population with limited land and water resources, terracing is regarded by the Qinghai Government as a significant technology for sustainable development due to the specific conditions of Qinghai Province. These specific conditions determine the main constraints to and potential for sustainable agricultural development in Qinghai Province.

Climatic constraints

There are a number of climatic constraints and these relate to the meteorological extremes and latitude of the study site. The harshness of the winter limits crop production to one crop per year, that is, 100% cropping intensity. The insufficient rainfall does not fully satisfy crop water requirements. The altitude also determines the length of the crop growing period in Huangyuan County, so varieties must be selected according to elevation as the available growing days decrease markedly with height. The timing of rainfall is also critical in rainfed crop production. Meteorological data show that the most reliable rains occur in late summer and planting is often delayed due to insufficient soil moisture. In most cases, climate constraints are beyond man's control.

Topographic and soil constraints

Because most land in Qinghai is located in mountain areas, the topography of Qinghai is a major constraint to crop production and limits development possibilities. Where development opportunities exist, they are associated with high environmental risks and high investment costs. In addition, the erosion potential of the soils in the agricultural areas of Qinghai Province is high because the loess soils have a poorly developed structure, are generally low in organic carbon (on arable areas at lower altitudes), lack cohesiveness, and have poor consistency. The soils are very prone to the erosive forces of wind, water, and the physical impact of humans and livestock. The potential for erosion is exacerbated by the cultivation of sloping land. In relation to the latter, all crop residues are removed from the field with the crop at harvest which leaves the surface of the soil bare and unprotected between September and April. Soil erosion is becoming a more and more serious constraint to sustainable agricultural development.

Water resources and utilization constraints

Qinghai Province is one of the typical dryland and desert provinces in China. Its regular annual rainfall is only 280 mm, in contrast to the national average annual rainfall of 648 mm. In addition, the spatial distribution of rainfall is uneven with a range of 155 mm-540 mm; the temporal distribution of rainfall is also uneven and the rainfall in May-September is 84.6% of that for the whole year.

The capacity for utilizing water resources is poor

The annual used water resources make up only 4.5% of the total quantity of water resources, in contrast to the national average level of 30%. The total pooling capacity (capacity of reservoirs and ditches) is only 212 million cubic meters, making up only 0.58% of the total runoff and 12.8% of the total available water resources. In contrast, the national average level is 10% and 70%, respectively. Furthermore, the irrigation infrastructure in Qinghai is poor. The percentage of effectively irrigated cultivated land in the total area of cultivated land in Qinghai Province is only 30% while that for all China is 52%.

Institutional constraints

The capability for technology generation and technology dissemination at a formal institutional level is severely constrained by large extension ratios 500 to 1,500 farmers per extension agent, poor mobility of staff, complete lack of extension aids and extension material, and questionable recommendations especially for crop husbandry packages. There is no research of any nature being carried out within the prefecture and no ongoing demonstrations. Extension staff have not been trained in communication techniques or in the latest developments which have been identified by technology generation elsewhere in China. There is also no effective formal linkage between the various technical institutions - research, extension, universities, agricultural educators - farmers and government departments.

Finance constraints

The final major constraint to improved productivity in the project area is the availability of credit to small-scale resource-poor farmers for financing livestock and crop inputs, on-farm capital investments, and the acquisition of breeding stock.

Plentiful reserve farmland resources

The unused available reserve farmland resource is about 500 thousand ha, or 86% of the present cultivated land area. This means the cultivated land can be expanded by nearly 86% if conditions become suitable for reclamation. However, the main restriction to reclaiming this reserve land is water shortage. The plentiful land resources and scarce water resources are the main characteristics of agricultural natural resources in Qinghai Province.

Water resources

Precipitation over the highland watersheds is sufficient to produce run-off which feeds a myriad of watercourses, streams and river flows. Where conditions are suitable, farmers have exploited natural resources to develop small-scale gravity irrigation schemes based on stream diversion. Larger streams with assured water are available in agricultural areas for harnessing, which would permit rainfed cropland to be converted into irrigation areas. It should also be noted that the spring cereals, oilseeds and potatoes have a high water response factor - over 1.2, i.e. they respond quickly to additional soil moisture in terms of yield increase.

Great margin means great potential

There is a great margin in agricultural productivity between dryland agriculture and irrigated agriculture. The margin of water efficiency between flat and sloping cultivated land is also great.

Plentiful human resources

The largest untapped potential in Qinghai is the large rural population that is solely dependent upon farming and grazing for survival. Farmers appear ready to contribute labour to development programmes if they do not impinge upon farming operations. Furthermore, the labour cost in Qinghai is lower due to the low farm income.

Terracing - significant technology for sustainable development in Qinghai Province

In order to overcome the major constraints mentioned above and fully tap the potential for agricultural production, great efforts were made to develop and apply new techniques for sustainable resource management and production. At present, major techniques applied in Qinghai Province include terracing, irrigation, interplanting techniques (wheat-maize interplanting model, bean-potato interplanting model), plastic film coverage technique, protection planting of potatoes, protection planting of wheat, balanced application of nitrogen and phosphate fertilizers, and rainfed farming techniques. Among these, irrigation and terracing techniques were used several decades ago and played the most important role in increasing agricultural production. They also had greatest implications for resource management and sustainable development. Due to difficulties in collecting data on irrigation, this paper will focus on economic assessment of terracing in Qinghai Province. In light of the time and human resource inputted in this study, Huangyuan County was selected as the case study site.

Terracing is regarded as a major sustainable resource management technique in Huangyuan County because it can improve efficiency of utilizing rainfall through improving water conservation and pooling capacity, improve irrigation conditions through leveling land and saving water in irrigation, control water and soil erosion, and increase output of agricultural products. In short, it can not only increase current agricultural productivity to meet the needs of the present generation, but it can also improve the agricultural resource base and environment by controlling soil and water erosion so as to meet the needs of future generations.

The practice of terracing went through three stages in Qinghai Province. The first stage is from 1950 to 1967 when terracing was done on a small-scale and wholly by framers. The second stage is from 1968-1981 when terracing in Qinghai was encouraged by the government-launched Movement of Agriculture Learning from Dazhai. The investment needed was wholly provided by collectives (townships and villages). The third stage is from 1982 to now when large-scale terracing was started combined with watershed management and funded mainly by governments at various levels and farmers.

The total terraced area by the end of 1996 in Huangyuan County was around 11,133 ha, making up 56.2% of total area of farmland and accounting for 90% of total land area of suitable for terracing. There are two main types of terracing in Huangyuan County. One is changing sloping dry land into terraced irrigated field; the other is changing sloping dry land into terraced dry field. Generally, the former occupies the greater part in total terraced area. Of the total terraced land in Huangyuan, the area of terraced irrigated field is 9,240 ha, accounting for 83%; the area of terraced field is about 1,893 ha, accounting for 17%.

Benefit-cost analysis for terracing in Huangyuan County

Due to the limit of time and the availability of data, benefit-cost analyses in this paper are conducted only for terracing projects completed in 1995. The analyses focus on direct economic benefits and costs as well as an assessment of environmental effects. The base period for analysis is from 1996 to 2010. Because there are two types of terracing in Huangyuan County with different economic results (transforming sloping land into terraced dryland and transforming sloping land into terraced irrigated land), analyses will be conducted separately for these two types of terracing. Since wheat is the major grain crop in Huangyuan County, wheat is taken as an example for assessing cost and benefit of terracing.

The cost for terracing in Huangyuan County consists of three components, i.e. the investment in terracing and related activities, the cost of land reduction, and the maintenance/operation cost.

The benefits from terracing in Huangyuan County mainly consist of the benefits from grain yield improvement, the benefit from water and soil conservation and the benefit from reforestation. In addition, there are some environmental benefits.

Although it is very difficult to assess environmental impacts of terracing in terms of economic benefit, the result is very positive. Terracing improves moisture content and granular structure of soil and helps to increase the number of microorganisms and the fertility of soil. In addition, reforestation after terracing will help control wind erosion and improve the environment and micro-climate. Terracing, as a key technology of resource management, will improve the natural resource base and is environmentally sustainable.

Based on the analysis and calculations, the total economic benefit gained from transforming sloping land into terraced dryland from 1996 to 2010 was US$ 391,240. Meanwhile the total cost was US$ 388,978 (Table 1). The ratio of benefit to cost is 1.00587, which means that the total benefit is very close to the total cost. Considering its environmental effect, construction of terraced dryland is economically feasible and environmentally sound. However, due to its less profitable nature, farmers are reluctant to construct terraced dryland and should be encouraged by local government.

The total economic benefit gained from transforming sloping land into terraced irrigated land from 1996 to 2010 was US$ 3,621,805 and the total cost was US$ 2,700,198 (Table 2). The ratio of benefit to cost is 1.34, which means the total benefit is 34% higher than total cost, and the construction of terraced irrigated land is economically profitable and environmentally sound. However, the construction of terraced irrigation land should be accompanied by the construction of irrigation schemes.

Table 1 Cost and benefit (US$) of terraced dryland from 1995 to 2010.

	Investment Interest	Maintenance Fee	Land Reduction	Soil Conservation	Forestry	Output Increase
1995	75,000	-	-	-	-	-
1996	5,250	-	16,500	133	-	5,598
1997	5,250	-	16,170	133	-	13,564
1998	5,250	-	15,846	133	-	24,649
1999	5,250	-	15,530	133	-	26,200
2000	5,250	342	15,220	133	1,338	27,680
2001	5,250	342	15,220	133	1,338	27,680
2002	5,250	342	15,220	133	1,338	27,680
2003	5,250	342	15,220	133	1,338	27,680
2004	5,250	342	15,220	133	1,338	27,680
2005	5,250	342	15,220	133	1,338	27,680
2006	5,250	342	15,220	133	1,338	27,680
2007	5,250	342	15,220	133	1,338	27,680
2008	5,250	342	15,220	133	1,338	27,680
2009	5,250	342	15,220	133	1,338	27,680
2010	5,250	342	15,220	133	1,338	27,680
Sub-total	153,750	13,762	1,231,466	1,995	114,718	1,374,491

BC Ratio = 391,240/388,978=1.00587

Table 2 Cost and benefit (US$) of terraced irrigation land from 1995 to 2010.

	Investment Interest	Maintenance Fee	Water Fee	Land Reduction	Soil Conservation	Forestry	Output Increase
1995	434,000	-	-	-	-	-	
1996	30,380	-	40,095	84,795	695	-	70,843
1997	30,380	-	40,095	83,099	695	-	149,854
1998	30,380	-	40,095	81,437	695	-	240,949
1999	30,380	-	40,095	19,808	695	-	249,034
2000	30,380	1,782	40,095	78,212	695	6,957	256,743
2001	30,380	1,782	40,095	78,212	695	6,957	256,743
2002	30,380	1,782	40,095	78,212	695	6,957	256,743
2003	30,380	1,782	40,095	78,212	695	6,957	256,743
2004	30,380	1,782	40,095	78,212	695	6,957	256,743
2005	30,380	1,782	40,095	78,212	695	6,957	256,743
2006	30,380	1,782	40,095	78,212	695	6,957	256,743
2007	30,380	1,782	40,095	78,212	695	6,957	256,743
2008	30,380	1,782	40,095	78,212	695	6,957	256,743
2009	30,380	1,782	40.,095	78,212	695	6,957	256,743
2010	30,380	1,782	40,095	78,212	695	6,957	256,743
Sub-total	889,700	19,602	601,425	1,189,471	10,425	76,527	3,534,853

B-C Ratio = 3,621,805/2,700,198=1.34

Conclusions and recommendations

Conclusions

There are many constraints to sustainable agricultural development in Qinghai Province, however, soil and water erosion, shortage of water resources and low efficiency of water utilization are decisive constraints to agricultural development. Terracing is one effective technique to overcome these constraints. Terracing played a great role in increasing agricultural production, particularly, grain production in Huangyuan County, and made a significant contribution to the improvement of food security in Qinghai.

Terracing is a cost-effective method for managing and utilizing agricultural resources. It can produce significant economic efficiency, particularly when combined with the construction of an irrigation system. The result of B/C analysis indicated that terracing construction is economically profitable and sustainable.

Terracing combined with reforestation activities is not only conducive for controlling water and soil erosion, but also facilitates improving the micro-environment. It is environmentally sustainable.

For those people who have low income and few job opportunities outside the region, terracing can improve income and will contribute to poverty reduction and improvement of food security.

Recommendations

- The environmental effects of terracing such as water conservation should be advertised greatly, particularly for transforming sloping land into terraced dryland.
- Terracing should be more and more combined with improving irrigation systems so as to maximize its benefit.
- Sloping land with convenient irrigation conditions should be selected first for terracing.
- The practice of terracing combined with reforestation should be maintained so as to improve the natural resource base.

Comments on Terracing in Qinghai Province

Li Weigou[*]

Mr. Ni Hongxing's report, titled Economic Assessment of Selected Resource management Techniques Focusing on Terracing in Qinghai Province, has provided a good case study of the current state of agricultural and rural development in China, and therefore is good guidance in this regard.

The decreasing arable land and short supply of water resources have always been constraining factors in China's agricultural and rural economic development. First, the decline of arable land has greatly offset the efforts to achieve sustainable agricultural development. Now only 9.9% of the country's land, or 94,910 thousand hectares, are arable. That means the per capita arable land is 0.087 hectare. Between 1990 and 1992 the National Agricultural Regional Development Committee conducted a survey on the reserve resources for comprehensive agricultural development at the county level. According to the survey, the arable land in the whole country in 1992 was 123,000 thousand hectares, 28% more than the normal figure. Nevertheless, the per capita arable land is only 0.102 hectares.

Ever since 1958, China's arable land has been continuously decreasing. Between 1978 and 1990, China lost 3,716.6 thousand hectares of arable land after counting the increase and decrease. Every year 285.9 hectares disappeared. Between 1990 and 1993 the net loss was 571.5 hectare or 142.9 hectares annually. By the end of 1993, the per capita arable land had dropped from the 0.18 hectare at the founding of the People's Republic in 1949 to 0.087 hectare. Fort instance in 1994, the per hectare output of rice, wheat and maize was 5,83l kg, 3,426 kg and 4,693 kg, respectively. Two-thirds of the arable land is low and medium yield. The per hectare output is between 2,250 and 3,000 kg, much lower than that of high-yield fields under the same climatic conditions. The major reason is that half of the arable land is located in mountainous and hilly regions. According to a survey by the National Agricultural Regional Development Committee between 1990 and 1993, cultivated sloping land between 5 and 25 degrees takes up 29.64% of the country's total arable land. Fields in steep valleys take up 5.47% whereas flat land constitutes only 26.3%. Because of the scarcity of arable land and the low yield level, raising food grain output is the top priority in agricultural development in China.

Eighty percent of the cultivated sloping land is in poverty-stricken areas. As Mr. Ni pointed out in his report, due to the scarcity of the arable land, the low fertility of the land, the slopes, as well as the bad irrigation and climatic conditions there, the agricultural output is low. The degree of self-sufficiency of most agricultural products, especially food grain, is very low. So is the farmers' income. In many places the farmers barely have enough food and clothing. This explains why the farmers are poor.

Second, the water shortage has become a threat to sustaining agricultural growth. For places like Qinghai, Shaanxi, Gansu, Ningxia, Xinjiang and west Inner Mongolia in northwest China, even more factors hamper agricultural development. Most of the land under cultivation is slope. More importantly, there is water shortage. The average water resources in China are

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2.8124 trillion cubic meters. The northwest accounts for 40% of the country's total land yet only has less than 10% of the country's total water resources. The annual rainfall for most areas in the northwest is lower than 300 mm, whereas in the south the annual rainfall is more than 800 mm. Moreover, given the poor water storage capacity of the slopes, water utilization is inefficient. As stated in Mr. Ni's report, it is only 4.5%, much lower than the national average of 30%. Apart from this, when water conservation can not be guaranteed, increasing the extent of irrigation will result in fertility and soil loss, thus exacerbating soil degradation. Therefore, both the government and people in these places have realized that to promote agricultural development, one important prerequisite is to improve the basic conditions and irrigation facility of the slopes to achieve better water utilization efficiency.

It is against such a backdrop that terracing becomes vital in the promotion of food grain output in mountainous regions. As explained by Mr. Ni in his case study of Huangyang County in Qinghai Province, land terracing is very helpful for containing water losses on the slopes and raising agricultural productivity, thus improving food security. This will also create employment opportunities and increase income for the farmers. In cases where the slopes are turned into irrigated terraces, the result is even better. This has not only been widely accepted by people in the north, but is also being energetically promoted in the mountainous regions of the south such as Guizhou and Yunan provinces. The Chinese Government has also included it as a measure to help poverty-stricken areas to boost agriculture and achieve sustainable development and has made financing terracing a priority in its agricultural investment.

Of course, land terracing is also one aspect in our efforts to achieve sustainable agricultural development. Other supporting policies should be adopted, such as improving water conservation facilities, speeding up reforestation, improving the ecological environment and facilitating the spread of suitable advanced technologies.

Energy Audit as a Measurement of Agricultural Sustainability

*R.C. Maheshwari**

Definition

Sustainable agricultural production systems may be defined as those that can be practiced and maintained while conserving the natural resource base and quality of the environment. The sustainability concept is dynamic; the systems must be highly productive, harnessing new technologies for increasing yields so as to be able to respond to the demands of increasing human populations (Jain 1990). Sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources.

The notion of sustainability and the role of indicators

The number of definitions of sustainability (or sustainable agricultural systems) that have emerged during the last several years is too large to count. Nonetheless, many if not most of these definitions fall into several broad approaches. It should be noted that the approaches or conceptualizations described below are not mutually exclusive.

- Agroecology. Sustainability is interpreted as system resilience, or the ability of a system to recover from stress or perturbation, largely due to system diversity featuring multiple pathways for the cycling of energy and nutrients (Conway 1986).
- Stewardship. Sustainability is interpreted as human stewardship of the Earth's resources, with a responsibility to non-human species as well as to future generations, to use and conserve these resources wisely. One implication is that growth in human populations and human economic activities should be restricted (Batie 1989) and should be met from renewable energy sources as far as possible.
- Sustainable growth. Sustainability is interpreted as a need to minimize damage to the natural resource base while meeting growing demands for agricultural products. The CGIAR definition falls primarily into this category (CIMMYT 1989). This is the interpretation of sustainability that emphasized the agricultural production system. A sustainable agricultural system is one that can indefinitely meet increasing demands for food and fiber at socially acceptable economic and environmental costs (Crosson 1992).

Indicators and measures

Indicators of sustainability may be based on "measures" (quantitative variables) or "non-measures" (qualitative variables). Net soil erosion (net tons of soil lost per hectare per year) is

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an example of a measure. The perception of a group of farmers regarding changes over time in land quality is an example of a "non-measure".

Desirable characteristics of indicators

It seems reasonable that a good sustainability indicator should:

- change as a system moves away from equilibrium (provide a clear indication when the performance of a system is declining because of resource degradation),
- give particular warning of degradation processes that are irreversible (or where the costs of reversing the process are likely to be socially unacceptable),
- take account of the full cycle through which a system moves through time (indicators should reflect the effects, if any, of long term crop rotations),
- highlight links to other system levels at which degradation processes might most readily be addressed,
- distinguish clearly between causes and effects; processes of system decline (effects) should not be confounded with system characteristics that make a system vulnerable to decline (causes),
- feature relevant, complete geographic coverage,
- be easily detected, relatively simple, and cost effective, taking advantage where possible of available information, and
- provide a means of forecasting future trends in resource quality and agricultural system productivity, as well as tracking corresponding trends from the past.

Total productivity

One of the principal indicators of sustainability is total productivity or TP. This is as measure introduced by Lynam and Herdt (1988) as reported by Harrington et al. (1994). The TP of a system is defined as the sum of the value of all outputs divided by the sum of the value of all inputs, including all economic and environmental costs. Agricultural systems are deemed sustainable when TP shows a non-declining trend. Declining TP trends point to resource degradation or undesirable environmental spillovers as agricultural systems strive to meet growing demands for agricultural products.

Index numbers are used to assess changes over time in TP, thus removing the effects of changes in relative input and output prices. TP should be used as the primary indicator of sustainability. Better understanding of TP trends can be achieved by taking account of several processes:

- technical change within farming systems, including the adoption of new productivity-increasing inputs as well as adjustments in input use rates,
- changes in the quality of the agricultural resource base (and the effect of agricultural production practices on the resource base),
- changes in the external environment (and the effect of agricultural production practices on the external environment).

Mathematically, TP = Y/(C+F+X+E)

where TP = total productivity,

Y = value per ha of all outputs from a system including the value of all byproducts,

C = near-term on-site economic costs,

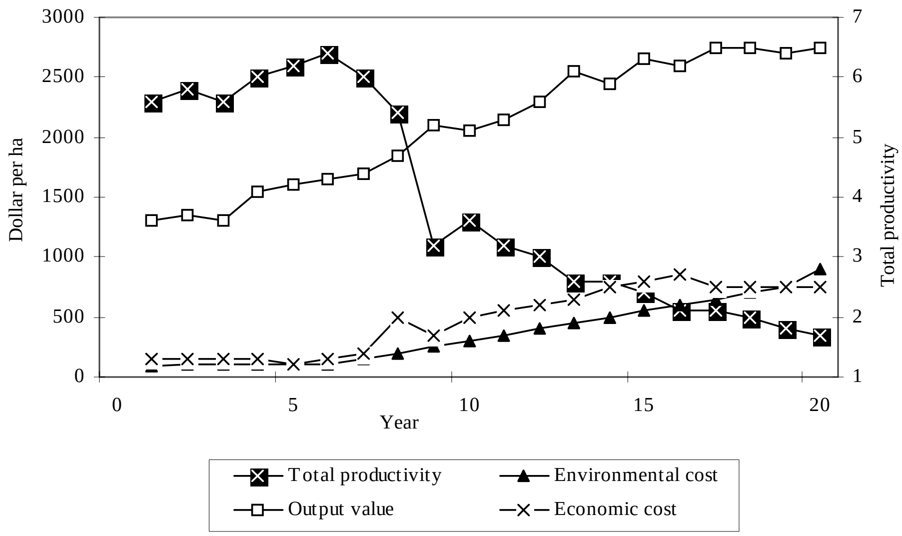
F = longer-term on-site economic costs, including "user costs",

X = off-site economic costs, and

E = environmental costs.

A hypothetical example of an unsustainable system, featuring declining TP associated with increasing economic and environment costs, is given in Figure 1. In practice, however, it is likely that estimating and forecasting trends in TP will be difficult.

Figure 1 Estimating total productivity trends: a hypothetical illustration.



Energy audit: a better indicator

Gross national product (GNP), standard of living and quality of life have all been plotted as a function of "energy use", while the monetary value price indices and yield parameters may vary from place to place and from time to time, "energy" coefficients will remain the same over time and geographical location (Figures 2 and 3). Hence, "energy" is a better and more reliable indicator for the measurement of sustainability than the concept of total productivity.

Energy for agriculture

The main sources of energy for agriculture are animals, humans, petroleum oil, electricity, firewood, crop residues and animal wastes. Direct solar energy is used for crop drying. The chief power units used in agriculture are animals, human beings, two wheeled tractors (power tillers), 4 wheeled tractors, stationary and automotive oil engines and electric motors. In the context of developing countries, the sources of energy as mentioned above are complementary. Man, animals and crops are interwoven in an integrated and interdependent pattern of life, which provides the basis of livelihood, food, income and "energy".

Energy from agriculture

In return for the inputs of commercial and non-commercial energy already discussed, as well as the solar energy directly used in photosynthesis, the food and agricultural sector is a producer of energy. By far its most important output is of course dietary energy, but crop and livestock residues, process wastes and the wood used for fuel contain much more energy, for example the potential energy contained in crop residues, dung and processing wastes is estimated at almost five times the production of dietary energy (Piemental and Verbara 1978).

Until quite recently, energy from biomass came almost entirely from fuelwood and crop and livestock residues. In the last few years, however, attention has been given to the question of the energy of production of crops specifically for the purpose of providing fuel. Efforts are now being directed to convert these sources into traditional forms of commercial energy (e.g. solid, liquid and gaseous fuels) to supplement the fossil fuels.

Figures 2 Relationship between GNP and energy consumption for 51 countries - 1971 data.

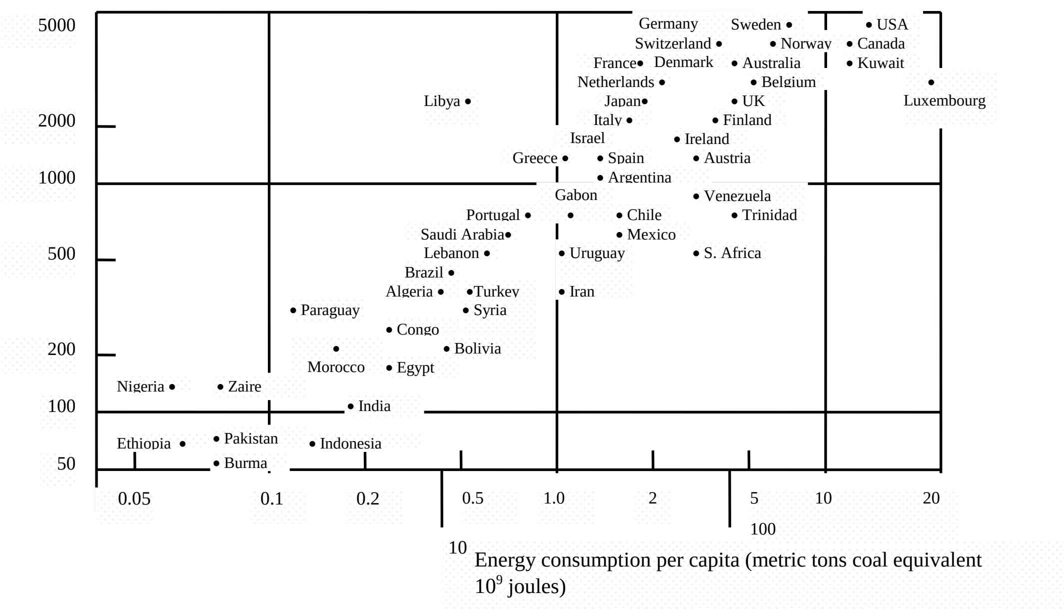
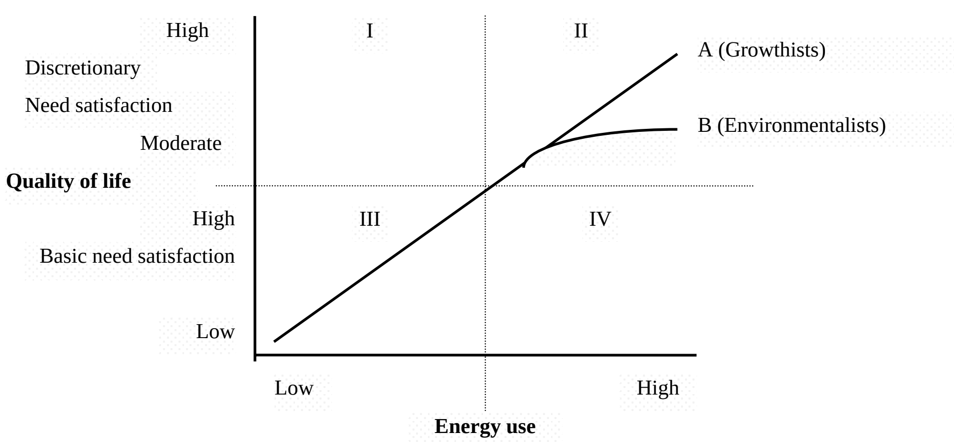


Figure 3 Conflicting growthist and environmentalist perspectives on the relationship between energy use and quality of life.



Energy use pattern at macro-level for agriculture production

Agricultural productivity is dependent upon improved seeds of high genetic potential and efficient use of water and energy of chemical or biological origin. An analysis by Bohra and Maheswari (1995) of energy use for agriculture in various states of India during the last three decades (1961-91) shows that while the input through animate energy (draught animal energy and human energy) has remained more or less constant, the use of diesel and electricity, agricultural machinery and chemical fertilizers has increased by 24.0, 3.3 and 24.5 times, respectively (Table 1).

The highest energy input use in production agriculture during 1961 to 1981 (Table 2) has been registered by Punjab (270%), followed by Haryana (212%), Gujarat (203.5%), Tamil Nadu (157%), Andhra Pradesh (120%), and Uttar Pradesh (106%). States with relatively small increase of input energy use are Assam (16 %), Orissa (31%), Jammu and Kashmir (37%), and Bihar (55%).

Table 1 Category-wise all India energy input in production agriculture.

SI No.	Category	Input Energy Source	Form and Type of Energy	Year		
				1960-61	1980-81	1990-91
1	A	Animate energy (human and animal)	Direct non-commercial	81,569 (22.10)	116,600 (14.85)	130,750 (10.39)
2.	B	Seed and farmyard manure	Indirect non-commercial	237,373 (64.45)	277,245 (35.30)	286,600 (22.77)
3.	C	Diesel and electricity	Direct commercial	10,549 (2.85)	99,461 (12.66)	253,075 (20.10)
4.	D	Farm implements and machinery	Indirect commercial	17,505 (4.75)	39,349 (5.10)	57,702 (4.58)
5.	E	Fertilizer and chemicals	Indirect commercial	21,602 (5.85)	252,670 (32.170	530,682 (42.16)
			Total	3685,97 (100%)	785,325 (100%)	1,258,809 (100%)

* Figures in parenthesis are percentage of the total energy input.

Table 2 State-wise energy input to production agriculture during the years 1961 to 1981.

SI No.	State	Level of Energy Input TJ Units		
		1961	1981	%
1.	Andra Pradesh	42,636	94,134	120.8
2.	Assam	9,193	10,672	16.1
3.	Bihar	29,450	45,600	54.8
4.	Gujarat	20,500	62,225	203.5
5.	Haryana*	9,616*	30,018	211.2
6.	Himachal Pradesh	2,036	3,347	64.4
7.	J and K	2,434	3,347	36.7
8.	Karnataka	23,574	43,778	85.7
9.	Kerala	5,989	11,507	92.1
10.	Madhya Pradesh	37,279	63,354	69.9
11.	Maharashtra	38,348	70,296	83.3
12.	Orissa	17,773	23,240	30.8
13.	Punjab	17,607*	65,234	270.5
14.	Rajasthan	25,660	45,508	77.3
15.	Tamil Nadu	24,376	62,643	157.0
16.	Uttar Pradesh	71,288	146,690	105.8
17.	West Bengal	17,302	31,853	84.1

* 1965 level as these states were formed in 1965.

The state-wise productivity index and energy use index for the period 1961-81 is presented in (Table 3). In spite of variations in factors such types of soils, cropping patterns, methods and sources of irrigation, cultural practices, sources of power used, etc., there is a co-relation between the level of energy use and productivity. So far, the increase in productivity has been realized through commercial energy sources only i.e. chemical fertilizer, diesel and electricity. A study conducted at Punjab Agricultural University has revealed that during a 15-year period from 1965/66 to 1979/80 the total food grain production of Punjab increased by 175%, 13.5% annually. During this period the total energy input increased by 387%, at a rate of 27.8% per year. In other words, each 1% increase in agricultural production required a 2% increase in commercial energy input.

Table 3 State-wise productivity index and energy use index for 1981.

SI No.	State	Yield Index*	Energy Use Index*
1.	Orissa	81.1	116
2.	Himachi Pradesh	104.8	118
3.	West Bengal	106.7	156
4.	Kerala	107.1	139
5.	Madhya Pradesh	108.9	133
6.	J & K	116.1	137
7.	Bihar	122.9	128
8.	Uttar Pradesh	127.7	144
9.	Rajasthan	134.8	130
10.	Tamil Nadu	135.4	135
11.	Andhra Pradesh	140.1	171
12.	Haryana	140.4	198
13.	Karnataka	142.5	139
14.	Gujarat	147.8	158
15.	Punjab	158.4	183
16.	Maharastra	159.0	136
	All India	123.8	149

* Based on 1971 as 100.

Energy management for enhancing the sustainability of production systems

Can the higher productivity be maintained or enhanced further by alternate energy sources or energy substitution or by more efficient energy use? To come to a logical conclusion, one may have to answer the following five questions.

- To what extent is the energy intensive model of agricultural development adopted from the developed countries feasible for developing countries?
- Are there alternate routes/sources for meeting energy demand for both production agriculture and rural living?
- To what extent can commercial energy be substituted by non-commercial energy?
- To what extent can energy demand be reduced by adopting different cultural practices?
- To what extent can the efficiencies of each unit operation be increased by way of improved implements and machinery to reduce the total energy demand?

Chemical fertilizer is the single largest energy input to production agriculture constituting 40 to 55% of the total energy employed. Recycling of dung through biogas plants provides not only cooking energy but also plant nutrients for crop production. The requirement of chemical fertilizers can also be reduced to an extent by practices that maintain soil fertility such as crop rotation and recycling of crop and livestock residues. Research has led to availability of a range bio-fertilizers such as rhizobia, blue green algae and Azolla on a commercial scale.

Under the All India Co-ordinated Research Project on Renewable Sources of Energy, results have shown that chemical fertilizer can be replaced to the extent of 50 to 75% to achieve the same yield. In addition, the residual effect of slurry gave comparatively higher yields, and resulted in improved soil conditions.

Pumping energy is the next largest energy input for crop production. There are over 0.5 million diesel pump sets and an equal number of electrical pump sets. Such pumps consume about 1,500 million kilowatt-hours of electricity and about 500 million rupees of fossil fuel. The pump sets can be energized with biogas engines and with gasifiers working on agricultural residues as feedstock. At least four designs are commercially manufactured in the country; however, there is need to improve the technology, after-sales service and repair and maintenance services for these gadgets. Alternate sources of energy are becoming cost competitive.

It has been shown that a 15 to 20% increase in food production can be obtained by timeliness of operations made possible by improved tools and equipment. The increased production is realized at lower cost and savings in energy consumption.

In one study on the use of improved animal drawn implements, a saving of 44.3, 37.7, 56.7 and 60.3% in energy for production of wheat, mustard, cotton and pearl millet, respectively has been demonstrated. Average increases in yield of 5.4, 17.4, 14.8 and 16.3% and savings in cost of operations up to 51.6, 28.8, 40.5 and 59.4%, respectively, were obtained by adopting improved technology for energy utilization in the agricultural sector. For the wheat-rice system, a major cropping system in the northern part of India, a zero till seed drill has been developed for sowing wheat without any field preparation, which has resulted in saving 15 days time and three field operations.

Energy audit at the micro-level (case study of a village)

The example of the village Islamnagar in the District Bhopal of Madhya Pradesh, which has 224 households with a total population of 1529 and livestock population of 1436 is instructive. An energy census and resource assessment survey revealed the following:

- Among the four major activities in the village, energy for crop production accounted for 14.5%, post-harvest operations about 0.5%, cattle raising about 1% and domestic activities (mainly cooking) 84%.
- Thirty-six percent of the population (the largest category) are landless people. This group accounts for 30% of total energy use in the village. There is no agency which plans for the energy supply to landless people (Figure 4).
- Energy for crop production is provided by humans (1.21%), animals (4.21%), diesel (19.26%), electricity (6.57%), seed (33.61%), fertilizer (19.85%), and machinery (15.29%).
- In post-harvest operations, the milling operation consumes the maximum energy (44.15%), followed by transport and handling (41.35%), manufacture of milling machinery (13.4%) and drying and storage (91%). The energy mix for post-harvest operations is human energy (3.13%), animal energy (4.67%), electrical (43.82%) and diesel (34.89%). The energy required for manufacture of milling machinery is 13.4%.
- Out of the total energy consumed for animal raising, 56.12% is provided by human energy, 35.26% by animal energy and only 8.48% from diesel. The animal raising activity required almost 2.6 times more man-hours than that required for crop raising.
- The annual per capita requirement of energy for domestic activities is $2.l0xl0^6$ kcal, out of which the share of firewood alone is 59.14% followed by 37.20% from dung cakes.

- Out of the 46,000 TJ of solar energy that is received annually by the geographical landmass of 717 ha of this village, only 40.44 TJ is converted into food, feed, fuel and fibre indicating an overall photosynthetic efficiency of only 0.0867% as compared to the world average of 0.16% (Figure 5).
- The village has 61 ha of wasteland and 133.6 ha of pasture land, which has the potential to make the village self-sufficient and even surplus with regard to firewood and cattle feed.
- The village was surplus in cereals, vegetables, sugarcane and milk. However, there were annual deficits for fuelwood by 20% (98.8 tons), cattle feed by 30% (812 tons), oilseeds by 71% (23 tons) and pulses by 32% (7.2 tons) (Figure 4).

Planning for self-reliance

The energy census report summarized above became the basis for planning the development of Islamnagar, keeping the following in mind:

- self-sufficiency in fuelwood supply,
- self-sufficiency in fodder supply for cattle.
- self-sufficiency in oilseeds and pulse production, and
- efficient soil and water management for increased production and productivity.

In order to implement the above plan, an Operational Research Project on Integrated Energy and Nutrient Supply System was launched by the Indian Council of Agricultural Research. Research funds came from the ICAR and hardware funds were obtained from the Department of Non-Conventional Energy Sources and the Advisory Board of Energy.

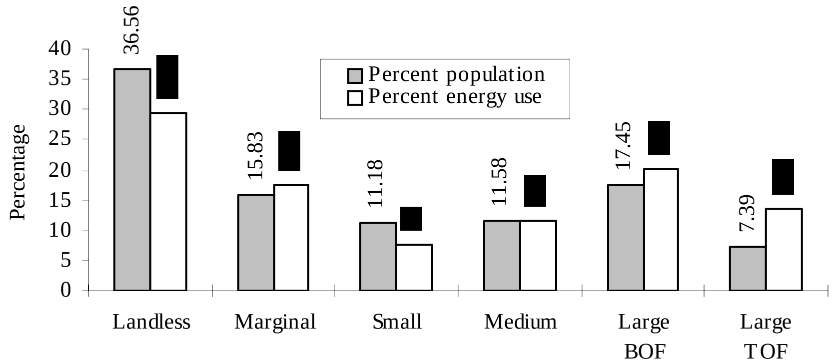
Planning for self-sufficiency in fuelwood

The annual per capita consumption of fuelwood and dung cakes for cooking amounts to 0.31 t and 0.32 t respectively. Thus, the village consumes 474 tons of wood and 448 tons of cow dung annually for cooking. Besides augmenting the fuelwood supply, attempts have been made to reduce the demand of fuelwood and cow dung for cooking by improving the thermal efficiency of wood stoves and installing individual and community biogas plants. It was estimated that 50 individual biogas plants and three community biogas plants would be able to meet most of the NPK requirements of crop production. In order to remove the 20% fuelwood deficit (about 98 tons per year), it was calculated that 40,000 trees would have to be planted, assuming a survival rate of 50% on a 40 ha plantation.

Planning for self-sufficiency in fodder

The village has pasture land of 132 ha. Berseem is the only fodder crop grown over an area of 11.47 ha. The total fodder available on a dry weight basis is 129.3 tons of berseem, 1,136.3 tons of grasses and 662.4 tons of crop residue amounting to 1,928 tons of fodder. However, the requirement of fodder on the basis of standard feed requirement works out to 2,740 tons (dry weight). Thus, there is a shortfall of 812 tons (29.65%). Some 608 tons of additional grass production is possible by planting high yielding grasses on the pasture land available, with an assured annual yield of four tons per ha, and an additional 80 t should be available from the afforested plot at a rate of 2 t/ha. Thus, the village has nearly enough land resources to become self-sufficient in fodder production.

Figure 4 Energy use versus population of various categories of farmers.



Planning for self-sufficiency in pulses and oilseeds

The village consumes about 245 t of cereals, 25 t of pulses and about 14 t of edible oils annually. Considering the standard diet given by the National Institute of Nutrition, the production system is presently deficient in pulses and oilseeds and surplus in cereals. A linear programming model was used to select the appropriate crop and its area requirements to minimize the area needed for the food system, while following nutrition guidelines for an average Indian. The linear programming model is based on the balanced nutritional needs of the village population.

Reallocation of land

The model allocated 185 ha under wheat, 33 ha under paddy, 7 ha under maize, 43 ha under Bengal gram, 35 ha under groundnut, 33 ha under soybean and 5.5 ha under mustard to make the village self-reliant in food. However, this allocation must match soil type and irrigation availability while assigning crop acreage to different categories of farmers. Thus, planting has to be done on an individual farm basis.

In order to implement the above reallocation of land under the different crops and with different categories of farmers, the black soil kharif technology developed by the Central Institute of Agricultural Engineering (CIAE) was used. A package of improved implements was worked out, which cost Rs 2.35 lakh.

The above crop production plan would also need 67.9 t of chemical fertilizers, 578.1 t of farmyard manure and 370.4 t of cow dung slurry. The annual water requirement for this crop production plan would be 104.5 ham, but with a 50% irrigation efficiency, the water requirement works out to 209 ham. When compared to the present water availability of 151.6 ham, the water deficit works out to be about 28% of the requirement. This deficit can be met through additional lift irrigation schemes, installation of hydrants, and through deepening and renovation of the water harvesting ponds in the village.

Figure 5 Sankey diagram illustrating solar energy flow in the village ecosystem

Implementation of the integrated energy and nutritional security system

Detailed soil and land use surveys identified a total of 61.6 ha of land as rocky and hilly land. Another type of wasteland is the eroded bank of two perennial nullahs that flow three km through the village. Approximately 5 m to 30 m on both sides of the nullahs is degraded land which amounts to about 30 ha. This land is also ideal for reforestation. The third source of barren land was available with the panchayat. Plantation of this barren land provided CIAE with firsthand experience with reforestation.

While reforesting these lands, care was taken to protect the existing rootstock. Four decades ago, the hill in Islamnagar supported a large number of trees of 20 local species like sagon, tendu, kaked, achar, karai, chandan and anjan.

During April and May, the small plants were cut back a few inches off the ground. In case of taller ones (1-2 m tall), unwanted stems and leaves were thinned. It was indeed exhilarating to see these trees come up quickly during the monsoon. A total of 10,886 local trees were counted in an area of only 16 ha.

Planning for runoff water drainage

Since the hillock is 65 m high, soil erosion due to water runoff is a serious problem. Due to overgrazing of the hill and felling of trees, even the red nurram soils were exposed to erosion. In order to discharge the rainwater safely, a survey of the existing gullies was made to utilize the natural topography for designing ways and means for drainage. In consultation with the department of social forestry, suitable trees were identified for different soils. Twenty-five tree species were selected for plantation at a spacing of 2 m x 2 m. A total of 38,407 trees were planted.

Grass production

The soil survey showed that out of 717 ha surveyed only 141.1 ha was suitable for reforestation and pasture development, of which 49.5 ha could be safely put under pasture development. However, the land was so scattered that it could not be enclosed for temporary protection from overgrazing. Out of 114.1 ha, 38 ha on the hillock and one ha of panchayat land was taken up for reforestation. Some 10 ha of this land was transplanted with high yielding grasses such as *Cenchrus setigerus* and *Cenchrus ciliaris*. The seeds of these grasses were obtained from the Central Arid Zone Research Institute (CAZRI) in Jodhpur and technical assistance was given by the Indian Grassland and Fodder Research Institute (IGFRI), Jhansi. The land taken for raising grasses was fenced and all wild shrubs and bushes were removed. The land was ploughed and soil conservation measures undertaken. The 1987 drought badly affected the effort to cultivate grasses.

Riverbank land

Eroded land on both sides of the river is covered with wild shrubs and some babul, mango, khajur, her and lemon trees. This land is used for cattle grazing since the pasture land (charokhar) available for grazing has been encroached by landless people and adjoining farmers. A small strip of land has been left free for the passage of grazing animals and the rest has been illegally fenced off and is being cultivated. In the 1985 rainy season, trees were planted on the riverbank on land belonging to three farmers, but their own cattle grazed these plants. A total of 10,498 trees were also distributed to the farmers through the panchayat for plantation on their private lands and on ridges.

Out of the 50 planned domestic biogas plants, 42 domestic biogas plants of seven different designs were installed. Three community biogas plants were also installed in different hamlets of the village. However, due to faults in construction, two community biogas plants could not be commissioned. Some 69 solar cookers (box type) were also installed. Out of 224 families in the village, 160 families were provided with smokeless stoves.

In order to implement the crop production plan, an area of 94.1 ha belonging to 29 farmers was identified. Crop allocation and planning was undertaken for 29 ha land of individual farmers. The participating farmers were provided with seeds, fertilizers and machinery free of cost. The average crop yields obtained by them were 20-43% higher than average village yields.

To meet the irrigation water deficit, hydrams were installed to provide irrigation to 16 ha of land. A water harvesting structure was built at a total cost of Rs 334560. A fish farm has been developed on 0.50 ha.

Impact of various technologies

The energy census and resource assessment survey was repeated in 1986 to assess the impact of the various technologies introduced over the previous five years. The impact on productivity, socio-economic conditions and employment generation in village of Islamnagar is given in Table 4 and Figure 6. The following are the salient observations:

- Total cereal, oilseed and pulse production went up from 371 tons to 758 tons and productivity increased from 0.986 t/ha to 1.43 t/ha.
- The cropping intensity increased significantly from 99.5% to 135.4%.
- The irrigated area increased from 196 ha to 267 ha. The total cultivated area increased marginally from 403 ha to 431 ha.
- The livestock population increased by 13.5%.
- The net return from agriculture increased from Rs 7,14,495 to Rs 19,72,390.
- The number of trees possessed by farmers increased by 101%. This is in addition to the 38,000 trees planted on 21 ha of forest land.

Energy audit: 1981 vs 1989

Implementation of programmes for making the village self-sufficient can lead to better resource utilization and increased harnessing of solar energy for conversion into food, feed, fuel and fibre. It is important to note that, when the ecosystem becomes self-reliant and sustainable, the actual external energy requirement of the village goes down, from 16 TJ to 15.5 TJ annually. The production efficiency increases by (i) reduction in wasteful use of thermal energy through traditional stoves and achieving higher thermal efficiency through biogas burners and (ii) harnessing of solar energy for additional food, fuelwood and grass production. The solar energy conversion goes up from 40 TJ to 67 TJ leading to overall photosynthetic efficiency to an average of 0.144% against the original efficiency of 0.0868%. The new production agriculture, post-harvest operations and reforestation programmes generate additional 1,00,000 man-hours/year (12,500 man-days). In other words, 40 persons could be gainfully employed for 300 days a year.

Figure 6 Sankey diagram illustrating solar energy flow into village ecosystem at the level of self-sufficiency.

Table 4 Impact on productivity, socio-economic conditions and employment generation in Islamnagar.

SI. No.	Item	Technological & Economic Changes		
		1981 Scenario	1986 Scenario	% Change
1.	**Changes in village ecosystem**			
	Total villagers	1,529	1,726	12.9
	No. of households	224	253	12.9
	No. of farming households	131	121	-4.5
	No. of landless households	93	132	41.9
	No. of cattle	1,427	1,648	15.5
II	**Change in agricultural system**			
	Net cultivated land (ha)	403.83	430.76	6.7
	Total cropped area (ha)	402.00	583.43	44.5
	Cropping intensity (%)	99.50	135.40	36.1
	Total irrigated area (ha)	196.27	267.28	36.0
	Use of chemical fertilizers (kg/ha)	39.00	110.72	183.9
	Productivity (tons/ha)	0.986	1.43	45.0
	Storage capacity of water harvesting pond (ham)	3.53	7.14	102.3
	Total diesel consumption (litres)	12,938	22,694	75.4
	Total electricity consumption (kwh)	43,708	75,399	72.5
III.	**Change in environment and ecology**			
	No. of trees possessed by the farmers	1,200	2,285	90.4
	Original rootstock regenerated due to protection	-	10,886	-
	Total trees in the ecosystem (no)	1,200	26,886	2,141.4
	Tree species in the ecosystem (no)	20	44	120.0
IV.	**Status of biogas technology**			
	Individual biogas plants installed (no)	-	44	-
	Community biogas plants installed (no)	-	3	-
	Biogas generated (m^3/yr)		40,647	-
	Potential		64,824	-
	Cooking energy met through biogas technology	-	-	32%
	Potential	-	-	52%
	Annual availability of slurry (ton)	-	326.8	-
	Potential	-	513.6	-
	Plant nutrient (N) met through slurry	-	-	16%
	Potential	-	-	28%
V.	**Employment generated and drudgery removed**			
	No. of person-days used for			
	a) crop production activities	20,079	23,127	15.2
	b) post-harvest activities	1,728	2,915	68.7
	c) cattle raising	52,779	54,950	22.3
	d) energy plantation	-	14,412	-
	Drudgery reduced (women-days) in domestic activities	81,277	63,188	-22.3
VI.	**Changes in economic indicators**			
	Net return/ha (Rs/ha) (base year 1988/89)	1,769	3,380	91.1
	Net return per farmer (Rs) (base year 1988/89)	737	2,125	188.4
	Benefit-cost ratio	1,583	1,895	19.7

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Evaluation of Soil and Water Conservation in Marginal Upland Areas

Pil-Kyun Jung[*]

Introduction

The time required for the development of soil is intermediate between that required for nonrenewable mineral resources, metals, coal, gas, petroleum, and for renewable resources, forests, water and crops. For example, soils form naturally at rates of 0.08 mm to 0.025 mm per year. Natural erosion is highly variable in space and time ranging from essentially zero to a maximum of 1.0 mm per year. Average man-induced erosion is 2.5 mm per year, which is far greater than natural rates of soil formation and natural erosion. Agricultural practices can accelerate the rate of soil formation to 0.8 mm per year under the most favorable conditions. This exceeds most natural but not man-accelerated erosion rates; therefore, agricultural soils are being depleted, and they must be considered to be a nonrenewable resource (Schumm and Harvey 1978).

Korean agriculture may be characterized as a small farm rice in paddy land and vegetable crops in upland of semi-monsoonal Far East Asia. The cultivated field area of farm households is so small that homestead production aimed primarily at self-supply prevails. Requirements for a staple food and the monsoonal climate have led to agricultural dependence on rice production. High population density and limited crop land have made it difficult to produce enough food in Korea.

Much emphasis has been placed on the increase of crop production and the expansion of crop land area. For the expansion of the crop land area, sloping land reclamation was initiated in the late 1950s. Several laws promoting farmland development had been promulgated earlier, and the government initiated a project to establish demonstration farms and provided technical training on reclamation.

Soils in Korea display low fertility because they are derived from the granite and granite gneiss which account for two-thirds of the lithosphere in this country. Average annual rainfall ranges from 1,000 mm to 1,330 mm per year. Since two-thirds of rainfall is concentrated in the summer season, soil erosion is accelerated by the intense rainfall. In addition, development of sloping land has progressed to expand arable land area. It is understood that the sloping land development is limited when soil and water conservation practices are not implemented. In this paper, sloping land resources and development in Korea are presented along with some recent research activities on soil and water conservation in sloping land.

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Table 1 Rate of soil erosion and soil formation.

Soil Erosion and Formation	Soil Depth (mm/year)	Amount of Soil (ton/ha)
Natural erosion rate	0.5 (0-1.0)	6.0
Average man-induced erosion rate	2.5	30.0
Natural soil formation rate	0.05 (0.02-0.08)	0.6
Accelerated soil formation rate by agricultural practices	0.8	1.0

* Source: Schumm and Harvey 1979.

Sloping land resources

Korea has a total area of 9,930 thousand hectares, of which 20.8% consists of agricultural land, while forest accounts for 65.1%, and 14.1% is devoted to other uses (MAF 1996).

Table 2 Area of land according to slope steepness ('000 ha).

Land Use	Slope (%)						Total
	< 2	2-7	7-15	15-30	30-0	60<	
Paddy	550	478	215	45	-	-	1,288
Upland	78	260	340	175	23	3	879
Orchard	18	28	42	26	4	1	119
Grass	3	23	40	21	14	2	103
Forest	11	44	206	571	2,106	3,847	6,425
Total	660	833	843	838	2,147	3,853	8,814
Ratio (%)	7.5	9.4	9.6	9.5	24.4	39.6	100.0

Source: ASI 1992.

The most intensive agricultural area of paddy and upland is concentrated on lowlands with a slope less than 7% and at an elevation below 100 meters above sea level.

Table 3 Distribution of paddy and upland by altitude ('000 ha).

Land Use	Total	Altitude (m)						
		<100	100-200	200-300	300-400	400-500	500-600	600<
Paddy	1,288	955	206	73	30	16	6	2
Upland	879	515	175	89	44	22	15	19
Total	2,167	1,470	381	162	74	38	21	88,821

Source: ASI 1992.

Topography greatly influences soil erosion and soil moisture, which are major constraints in sloping land utilization. Upland fields are predominantly distributed in local valleys, mountain foothills and hillsides within 100 meters above sea level.

Orchards are widely distributed in every physiographic zone and forests are mostly located on hilly to mountainous regions where grassland is generally managed under non-cultivated practices.

Table 4 Distribution of land use by topography ('000 ha).

Land Use	Alluvial Plain	Alluvial Fan	Local Valley	Dilluvial Terrace	Mt. Foot Slope	Hilly	Mountain
Paddy	507	40	591	51	89	2	(57)
Upland	74	66	285	19	215	145	34
Orchard	16	8	28	2	22	28	6
Grass	3	0.425	2	0.176	8	13	13
Forest	11	8	48	19	261	1,505	4,528

* Area excludes tidal flat, volcanic ash and others.
Source: ASI 1992.

The available soil depth of the slope land is generally shallow compared to optimum depth for crop cultivation. Soil hardness and bulk density are relatively high, and both porosity and clay content are low.

Table 5 Physical properties of sloping land soil.

	Av. Soil Depth (cm)	Slope (%)	Plow Depth (cm)	Hardness (mm)	Bulk Density (g/m3)	Porosity (%)	Clay Content (%)
Present	<50	15-60	11	24	1.4	48	16
Target	>50	7-15	20	18	1.3	51	20

Source: ASI 1992.

Evolution of sloping land development

Initial stage (1957-1961)

Slope land development, as the project for the settlement of landless households for 24 regions, has been carried out by the government since 1957. The United Nations Special Fund Supporting Agreement for Korea was granted to the Korean government in 1961. This enabled the formation of a demonstration field and development of technical training on reclamation.

Enforcement stage (1962-1966)

With the Reclamation Promoting Law in 1962, reclamation projects proceeded according to a 5-year plan supported by foreign aid.

Restructuring stage (1967-1971)

In 1967, the initial Reclamation Promoting Law was abolished, and the Farmland Development Law was established for sloping land development. Government grants for reclamation were discontinued and the government induced farmers to reclaim the land by themselves with a subsidy in terms of grain from foreign aid.

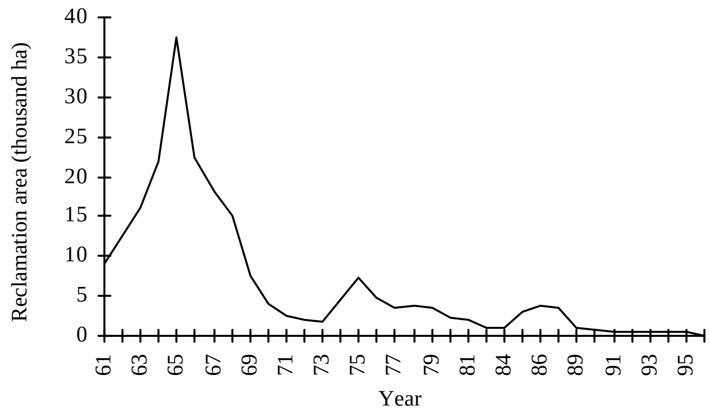
Trial period for a comprehensive plan (1972-1974)

Many unsuitable areas were developed, and management after development was poor. Small-scale development was initiated at four areas, Yeoju in Kyonggi-do, Taean in Chungchongnam-do, Igsan in Chollabug-do, and Sinan in ChoUanam-do were selected to demonstrate a large project of sloping land development under government supervision. The project was successful, and it was continued up to 1980.

Land consolidation and extension of farm scale development (1974-up to date)

A farmland expansion development group was established in the Agricultural Development Corporation. The group had a national base project for land consolidation and the extension of farm scale development in paddy fields and upland (Um 1986).

Figure 1 Yearly reclamation area of sloping land (1957 - 1996).



The area of arable mountain land can be calculated differently based upon the method, objective and organization of the field survey. A reconnaissance soil survey was conducted over the whole country by the Rural Development Administration (RDA). The results showed that the reclaimable hillside area was about 1,400,500 ha which included upland (159,000 ha), orchard and grassland. The total reclamation area of slope land consisted of 197,172 ha (Yearbook of ALWDS, 1997).

Evaluation of soil and water conservation

The magnitude of soil erosion on sloping land is determined by the interaction of four factors: climate, topography, vegetation and soil. Each has been refined by studies in different ways. The amount of soil loss according to soil texture, slope, cropping systems and conservation practices was demonstrated in Korea.

Table 6 Soil loss (ton/ha) by slope length and steepness.

Treatment	Steepness	10%			20%			30%		
	length (m)	5	10	15	5	10	15	5	10	15
Soybean-barley		1.14	1.48	1.81	2.37	3.06	3.77	3.69	5.16	6.31
Bare soil		6.55	8.54	10.63	11.80	15.83	22.20	17.85	28.01	43.90

Average from 1984 to 1988; Rainfall: 1,145 mm; R-factor: 550; Soil: sandy loam.
Source: ASI 1989.

Research information regarding the effects of slope length and steepness on soil loss and water runoff is required to estimate the soil loss. Soil erosion was affected more by slope steepness than slope length. The decline in productivity and the soil degradation were accelerated by erosion on steep slopes. Runoff per unit area decreased with increase in slope length and increased with increase in slope steepness.

Table 7 Runoff (ton/ha) with slope length and steepness.

Treatment	Steepness	10%			20%			30%		
	length (m)	5	10	15	5	10	15	5	10	15
Soybean-barley		175.9	134.0	117.2	196.8	169.0	159.7	222.1	199.9	189.0
Bare soil		381.7	326.3	288.5	427.1	377.7	325.0	478.9	407.2	381.1

Average from 1984 to 1988; Rainfall: 1,45 mm; R-factor: 550; Soil: sandy loam.
Source: ASI 1989.

The regression equations and correlation coefficients relating soil loss and runoff with slope length and steepness were analyzed on the basis of all years from 1984 to 1988. In general, slope length had a positive effect on soil loss and a negative effect on water runoff. But slope steepness had a positive effect on both of them. These results have many practical and agronomic implications in terms of slope length and steepness for soil and water conservation for sloping land.

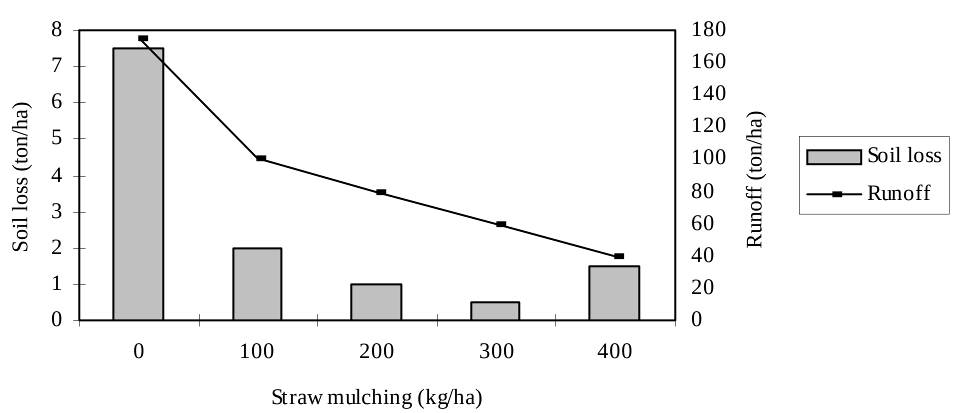
Table 8 Regression equations relating soil loss and runoff to slope length and steepness.

Items	Equations	r^2	Remarks
Soil loss	$S = 0.02 \; L^{0.459} \cdot G^{1.174}$	0.997**	Soybean-barley
(ton/ha/year)	$S = 0.145 \; L^{0.575} \cdot G^{1.106}$	0.974**	Bare soil
Runoff	$R = 179.38 \; L^{-0.380} \cdot G^{0.161}$	0.877**	Soybean-barley
(ton/ha/year)	$R = 292.99 \; L^{-0.181} \cdot G^{0.149}$	0.987**	Bare soil

L: slope length; G: slope steepness.
Source: ASI 1989.

The ideal amount of straw mulching for soil erosion control was tested over three years in small field plots with 15% slope. Increasing amounts of straw mulching greatly reduced soil erosion and runoff. The adequate level of straw mulching for the effective erosion control was 200 kg/ha in the barley-soybean cropping system.

Figure 2 Soil loss and runoff at different levels of straw mulching.



Alpine vegetables were cultivated in a monoculture system during the summer season. Summer vegetables consisted of mainly Chinese cabbage, radish and cabbage which are suitable for cool climate and height altitude. Mechanical conservation practices were employed to control the serious erosion problems in the alpine vegetable cultivated area of Jeongseon-gun, including hillside ditch, grass band and rock or stony barrier, drop spillway, terrace channels, farm roads, open and subsurface drainage systems, which are safer practices. This steep sloping land was reclaimed by a national project thirty years ago.

The land was reclaimed by applying the bench terracing method on steep slopes with an average of 30%. However, bench terracing was removed by farmers who used machines on the farms. As a result, soil erosion is severe.

When the land was first reclaimed, the black organic layer of soil measured more than one meter deep, now it is just a few centimeters. According to soil suitability classification, the areas should be used as grazing pasture or forest.

General soil characteristics of the representative alpine vegetable cultivated area at Jeongseon-gun located on 850 meters above sea level are shown in Table 9.

Table 9 Soil characteristics of alpine vegetable land at Jeongsem-gun.

Slope Length (m)	Soil Depth (cm)	Gravel (%)	Clay (%)	pH (1:1)	O.M. (%)	CEC (cmol/kg)	Avail. P_20_5 (ppm)	Permeability (mnvhr)
20	35	36.4	26.0	4.7	4.9	15.1	150	6.8
50	25	33.4	30.0	4.3	4.3	13.3	293	5.2
100	15	32.4	30.0	4.2	3.2	13.1	291	4.8
150	5	31.4	32.0	4.2	2.7	12.4	98	4.4

Source: Jung et al. 1995.

Soil is characterized by a shallow depth and about 30% of gravel and stones. Heavy rainfall and poor management accelerate soil erosion.

Table 10 Estimation of soil erosion by USLE in the alpine vegetable land.

Area	Factor					Soil Loss	Decrease of Soil
	R	K	LS	C	P	(ton/ha)	Depth (mrn/year)
Jeongseon	450	0.21	9.07	0.15	0.5	77.1	6.4
Pyongchang	450	0.21	4.45	0.15	0.5	33.1	2.7
Muju	464	0.21	6.60	0.15	0.5	48.2	4.0

R: rainfall factor; K: soil characteristic factor; LS: slope length and steepness factor;
C: crop factor; P: soil management factor.
Source: ASI 1995.

The estimation of soil erosion was calculated by the Universal Soil Loss Equation (USLE) in the alpine vegetable land. The land shows serious erosion problems. The rate of soil loss was 2.7-6.4 mm per year, which is a very rapid rate compared to the rate of soil formation.

Soil loss and runoff in the alpine vegetable area as affected by mechanical conservation practices are shown in Table 11. After adoption of the practices, soil loss and runoff decreased drastically compared to before. We could observe rills and gully erosion after heavy rainfall in this area.

Table 11 Soil loss and runoff at the alpine vegetable area as affected by mechanical conservation practices.

Item	Non-Conservation Practices (A)	Conservation Practices (B)	A / B
Soil loss (ton/ha)	102.5	12.3	8.3
Runoff (ton/ha)	1,614	892	1.8
Runoff ratio (%)	56.4	30.2	1.9

Rainfall: 295 mm (June 8 - July 10, 1994); Slope steepness: 25%;
Slope length: 200 m; Sea level: 800 meters; Soil: silt loam;
Source: Jung et al. 1995.

A lysimeter experiment was conducted to determine soil erosion and nutrient losses at different soil texture with 15% slope gradient and 5m slope length. The magnitude of soil and nutrient losses increased in order from sandy loam, loam to clay loam. Most NO_3-N and K_2O was found in the runoff water, but P_2O_5 was found in the eroded soil particles.

Table 12 Soil and nutrient losses (kg/ha) in different soil texture.

	Sandy Loam	Loam	Clay Loam
Soil erosion	27.4	40.0	51.2
Nutrient losses			
$N0_3$-N	30.0	31.6	33.2
P_2O_5	3.6	4.4	5.7
K_2O	28.9	31.5	32.0
Total	62.5	67.5	70.9

* Slope: 15%; Crop: red pepper;
Fertilizer level: N-P-K = 290-200-230 kg/ha.
* Source: 1997, NIAST Research Report.

Conclusion

Soil conservation and sloping land development were promoted in Korea about thirty years ago. Soil erosion from sloping land not only reduces soil fertility and crop productivity but also is associated with main sources of pollution. Chemicals and fertilizers carried with soils are the sources of water pollution. Sloping land management needs more care to manage soils in relation to their erosion and water deficit due to characteristics of steep slope, shallow soil depth and heavy rainfall. Thus, the potential productivity of marginal upland area decreases as a result of ongoing degenerative processes, and technology for soil and water conservation must be applied to the land.

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Agriculture in Areas with Unfavorable Farming Conditions in Korea

Gyu-Cheon Lee and Naewon Oh[*]

Issues concerning areas with unfavorable farming conditions

Although environmental philosophers have had little to say about agriculture, environmental critics have existed. These critics have concentrated on the choice between ecocentric (ecology-centered) and anthropocentric (human being-centered) ethics. Ecocentric ethics view environments with priority and anthropocentric ethics view human-being's satisfaction of food with priority. We have to choose a certain point, ranging from the ecocentric viewpoint to the anthropocentric viewpoint. The issue of areas with unfavorable farming conditions is in the center of these ethical viewpoints.

Judging either the development or the preservation of an area for future use is the government's choice. The recent history of agriculture in industrialized countries is a history of technological change such as farming with machines, chemical inputs, and genetic improvements. However, as a whole, this technological development has its own limits on increasing food supply with the current geographical conditions of agriculture. Even if each country differs in the size and productivity of farmlands, the solution of international food shortage, to some degree, depends on how to use the areas with unfavorable farming conditions. If we do not use the unfavorable lands for agriculture and leave them idle, problems will arise such as international food crises, destruction of the environment, and degradation of croplands.

Arable land is limited and the world population is growing. The population growth rate is higher than the production growth rate. The imbalance between food supply and demand worsens the food problem and threatens food security in many countries, especially in the underdeveloped and developing countries. Accordingly, concerns about the large portion of unfavorable areas in mountainous countries like Korea are prominent because the unfavorable areas, in one sense, are not only the prerequisite areas for growing crops to assure national food security, but they are also a key factor in national environmental issues.

The importance of marginal farmland management in national economic operations is recognized in the world. This is the reason why many European countries support farmers who live in less favored areas. In the international sense, there are reasons for the importance of those areas such as for solving the food problem and preserving environments. According to UN statistics and estimates, the world population growth rate was 1.74% in the 1980s and was estimated at 1.68% in the 1990s, l.41% in the 2000s, and 1.09% during the years of 2010 to 2025. Even if the population growth rate decreases, the world population will increase drastically, reaching 6.25 billion in the year of 2000, 7.19 billion in the year of 2010, and 10.0 billion in 2050. This growing population and most food come from land, but this is shrinking as the conversion of arable lands has accelerated due to industrialization and urbanization. The World Development Report shows that the urbanization rate was 28.8% in 1980, 43.4% in

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2000, 53% in 2010, and 61% in 2025. Urbanization boosts crop land price. The higher land price not only pushes up food production costs, but also increases the landowners' need for the conversion of land use. As a result of this phenomenon, the size of arable lands is reduced drastically. On the other hand, urbanization makes the farmers leave the rural areas and a lot of arable land is idle, usually in the areas with the unfavorable farming conditions.

Unfavorable farming conditions in Korea

Position of the agricultural sector in Korea's national economy

The agricultural issue in Korea cannot be separated from the international situation. The population has grown rapidly during the past half century in Korea. Population growth has inevitably resulted in two contradicting situations: the reduction of arable land and the need for more food production. The reduction of arable land is driven by industrialization and urbanization. The Korean government tried both to develop industries and to achieve self-sufficiency in food. In the process of industrialization, arable land has been converted to industrial uses. The Korean government fell into two sorts of dilemmas in harmonizing or choosing policy directions: first, the pursuit of industrialization and achieving food self-sufficiency; second, pursuing food production and preserving the environment.

In the process of industrialization, the position of the agricultural sector has decreased and the proportion of farmers has sharply decreased. Agriculture has traditionally played a major role and still plays at the present time a fundamental role in the Korean economy. However, the significance of agriculture in the national economy has decreased. Table 1 shows how much the agricultural sector has shrunk in terms of GDP, compared to other sectors. Between 1970 and 1996 the portion agriculture occupied in GDP decreased from 26.6% to 6.3%. As a result the general public is apt to believe that agriculture is not important in the national economy.

The population in the agricultural sector has decreased with the rapid urbanization process. The farm household population fell from 44.7% to 10.3% during the same period, which shows that Korean society has changed from an agrarian society to an industrialized one. At the same time the average size of the farm household decreased from 5.81 persons to 3.17 persons. This downsizing of farm households requires adjustments in farming like mechanization.

Table 1 Contribution of major sectors to GDP (%).

Sector	1970	1975	1980	1985	1990	1995	1996
Agriculture	26.6	24.9	14.7	12.5	8.7	6.5	6.3
Manufacturing	22.5	27.5	29.7	30.5	29.7	29.1	27.5
Construction	6.6	5.9	10.1	10.6	13.7	16.2	16.7
Services	44.3	41.7	45.5	46.5	47.9	49.4	49.5

Source: MAF, Major Statistics, 1997.

The reduction of arable land

Korea is still on the road to industrialization and urbanization. Industrialization needs a lot of land for factories and houses. Therefore, farmland has been converted into such uses. Table 2 shows the annual conversion of farmland. Five hundred and fifteen hectares of farmland were converted into other uses in 1975, increasing to 16,611 hectares in 1996.

On the other hand, a lot of farmland has been removed from cultivation due to lack of farmers. Now, a large proportion of farmers are aged, and young farmers have left their communities in order to seek jobs in urban areas. As a result, lots of arable land in disadvantaged areas is abandoned. As Table 2 shows, the idle area has increased from 1985 to 1995. However, the areas newly left idle in 1996 decreased in ratio, since the Korean government persuaded farmers to cultivate idle farmland for food security.

Table 2 Conversion of farmland ('000 ha).

	1975	1985	1990	1995	1996
Total arable land	2,240	2,144	2,109	1,985	1,945
Permitted area of conversion	0.5	2.1	10.6	16.3	16.6
Idle area	n.a.	20.2	40.4	64.6	34.3

Source: MAF, Major Statistics, 1997.

Self-sufficiency level of foods

As Table 3 shows, the total self-sufficiency rate of grains dropped from 80.5% in 1970 to 26.7% in 1996. The self-sufficiency level of rice, a major grain, has been maintained at over 90% from 1970 to 1995. However, in 1996 it decreased to 89.5%. The self-sufficiency level of grains excluding livestock feed also dropped from 86.2% in 1970 to 52.4% in 1996. This trend is expected to continue. On the other hand, the self-sufficiency level of wheat, maize, and beans is more serious. Because the self-sufficiency levels of wheat and maize are below 1%, any hope of self-sufficiency is lost. The situation for beans has dramatically declined.

Thus, policy is concerned with securing a stable supply of foodstuffs for the public. Korea has already given up hopes of self-sufficiency of agricultural products except rice. According to the UR agreement, even in case of rice, the Korean government must import the MMA and reduce public purchases.

Table 3 Self-sufficiency (%) of foods.

Year	Total Grains	Grains excluding Livestock Feed	Rice	Wheat	Maize	Beans
1970	80.5	86.2	93.1	15.4	18.9	86.1
1975	73.1	79.1	94.6	5.7	8.3	85.8
1980	56.0	69.6	95.1	4.8	5.9	35.1
1985	48.4	71.6	103.3	0.4	4.1	22.5
1990	43.1	70.3	108.3	0.05	1.9	20.1
1995	29.1	55.7	91.4	0.3	1.1	9.9
1996	26.7	52.4	89.5	0.38	0.8	9.9

Source: MAF, Major Statistics, 1997.

Environmental values of the areas of unfavorable farming conditions

The areas with unfavorable farming conditions are, in large, located in the mountainous areas with steep slopes. Those areas are not favorable to crop farming. They have unfavorable farming conditions such as poor soil potential, poor irrigation conditions, difficulty for mechanization of farming, and legal constraints socially imposed to preserve the natural landscape and protect water quality.

They, however, have a positive externality to the environment such as protection from landslides, from flooding, water reserves, the reduction of soil erosion from rainfall and strong winds, and providing landscape. If the inhabitants of those areas move into the city, not only will urban problems be accelerated in the city, but also destruction of environment will occur in the areas they leave. For these reasons, the government has various support policies for those who stay and cultivate the areas with unfavorable farming conditions.

The unfavorable farming areas: case study

The farming conditions can be considered unfavorable in two aspects. The first one is the natural conditions such as the unsuitable climate and topography, high altitude and steep slopes, which result in low land productivity. The second is the social condition since the living conditions are not comfortable and the opportunity to earn income is scarce. Economic development in Korea has been accomplished on growth poles centered on the metropolitan area of Seoul and the coastal regions of Kyungsangnam-Do Province. Accordingly, the social condition is an important factor in the unfavorable farming areas in Korea.

The rural area was classified according to the above two conditions, resulting in two hundred sixty-seven Eups and Myons (18.8%) out of 1,420 Eups and Myons being classified as unfavorable farming areas. These Eups and Myons are mainly located in the mountainous areas in Kangwon-Do Province and Kyungsangbuk-Do Province, but a few areas are located in metropolitan area of Seoul, including Kyunggi-Do Province, Choongchung-Do Province, and Pusan and Kyungsangnam-Do Province.

Population decrease due to the uncomfortable living conditions

Migration of the population because of the lack of non agricultural industries, the low level of income, and the poor medical and cultural are facilities are serious. As a result of depopulation, social investment is not practiced in the community. Local governments cannot provide social capital they need because of the low level of financial self-sufficiency. The unfavorable conditions result in a decrease of population and a reduction in industrial production in these areas. In short the vicious circle is repeated and the community becomes worse and worse. Some action is needed to maintain the community and the environment.

Agricultural conditions

The mountainous areas have unfavorable agricultural conditions such as the high altitude, fewer days without frost, farmland located in the valley, and steep slopes. Work efficiency is low in these areas due to the difficulties in using farm machinery. Even if mechanization is possible, it is expensive. Competitiveness in these areas will be lowered in the long run, because no increase of labor productivity is expected through the expansion of farming scale.

The productivity of island areas is low as well, because of the damage resulting from sea winds and salinity, the reduced hours of sunlight from occasional fogs and the weak irrigation systems. Because these areas are far from city markets and have bad transportation systems, farmers have difficulty in accessing market information and have to pay higher transportation costs. For example, it is hard to maintain vegetables fresh due to the unpaved roads. Table 5 shows a comparison of the mountainous and island areas with general rural areas.

Table 4 Agriculture and social conditions in favorable vs unfavorable areas.

Condition	Unfavorable Areas	General Rural Areas
Regional Conditions		
Population growth rate (1985-1995)	-6.2	-1.8
Population density (person/km^2)	38.6	2,763
Water service supply rate (%)	10.6	18.5
Number of medical doctors (per 10,000 population)	0.8	3.9
Ratio of poor households (%)	15.1	9.4
Mining and industrial employees (per 100 population)	2.5	13.0
Local tax per capita (won)	54,480	152,474
Agricultural Conditions		
Farmlands (%)	13.9	39.5
Farmland adjustment (%)	57,8	57.5
Irrigated farmlands (%)	50.8	68.3
Farm households (%)	70.5	52.2
Farm household, with more than two hectares (%)	13.0	16.8
Areas with greenhouse (%)	0.5	2.7

Note: Based on analysis of 141 Eups and Myons in 19 counties.
Source: MAF, 1980 and 1995 Total Agricultural Census. Yearly Statistics of Counties.

Government policy and prospects

Government investment has concentrated on adjustment of the agricultural production base, the establishment of crop production and marketing facilities, support for enlarging the scale of farmland. The measures aim to enforce competitiveness of agriculture in the WTO open market system. Therefore, the government has invested mainly in agricultural promotion of areas with favorable farming conditions. The level of government support for areas with unfavorable farming conditions has been lower. Accordingly, the disparity between the good and the poor areas is getting larger.

Thus, we can expect that the agricultural sector in unfavorable areas will shrink in the process of agricultural adjustment. In the short term, the idle farmlands will increase and farmers' income decrease. In the mid and long run, there are concerns about destruction of the agricultural sector because of the rapid decrease of the number of farm households.

Case study

A case study was conducted to investigate the substantive differences between the unfavorable areas and the favored areas, and the differences among the areas with unfavorable farming conditions in addition. We selected representative areas in three categories: mountainous paddy field regions (traditional grain), mountainous field regions (commercial crops such as vegetables), and island regions. We selected three villages in each area and nine villages in general areas.

Regional living conditions

The unfavorable areas are unable to take advantage of administrative, educational, medical, and cultural services. They are far from the cities and the transportation system is underdeveloped. Long distances and bad road conditions result in additional costs in delivering agricultural products to the cities. These difficulties are serious in island areas. The farmers there have to pay 30-40 US dollars additional for shipping a small truck loaded with their products. What is worse, occasionally the operations are cancelled due to high sea winds and heavy fog. In such cases they cannot deliver their fresh products in a timely manner.

Table 5 Road and transportation status.

	Unfavorable Areas				General
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	Region
Distance to cities (km)	26.0	21.1	32.0	26.4	14.9
Time (minute)	43.3	37.7	111.6	64.2	29.2
Mass transportation (bus: times/day)	8.3	0.0	5.0	4.4	23.6
Road pavement ratio (%)	69.3	57.7	22.4	49.8	86.8

In unfavorable areas, various facilities that enhance quality of life do not exist. Because the total population is small and population density is low, the operation of many facilities is not efficient. As Table 6 shows, there are no private medical centers except the government health care centers. There are only a few facilities such as beauty shops, public baths, restaurants, taverns, coffee chops, and bakeries. The educational condition is more serious, and most young couples leave for the sake of their children's education. As a result there are only a few children and 44.7% of the elementary schools closed during the past 10 years. The students of two grades are often taught in one classroom by one teacher due to low numbers of children.

Table 6 Medical, living and educational conditions in unfavorable areas.

	Unfavorable Areas				General
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average Region	Areas
No. of private medical centers	0	0	0	0	2.3
No. of restaurants and coffee shops	23	3.0	4.0	3.1	7.3
No. of public baths	0	0	0	0	0.9
No. of beauty shops	1.7	23	3.3	2.4	11.7
Elementary school closed during past 10 years (%)	62.5	29.2	42.3	44.7	6.4
Elementary school mixing two grades into one class (%)	0.0	76.5	20.0	45.7	14.7

Farmland conditions

The areas with unfavorable farming conditions are largely mountainous and the proportion of farmland is low (Table 7). These farmlands are located in the valleys and many are small and steep. However, in Mt. Taebak region, farmers use this land as dry fields and overcome the difficulties to some degree. On the other hand, the residents in Mt. Jiri region traditionally depend upon the rice industry. This land is very difficult to mechanize because the lots are small and adjustment of farmlands was not accomplished. In island regions, there are plain areas as well as mountainous areas, but the irrigation systems are very weak, so there is often salt damage especially in times of drought. After the 1980s, a lot of farmland was idle in these unfavorable areas.

Table 7 Farmland conditions in unfavorable areas.

	Unfavorable Areas				General Areas
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	
Proportion of paddy field (%)	66.3	4.2	41.7	37.4	74.3
Farmland adjusted to paddy field (%)	0	0	61.0	20.3	80.6
Ratio of water supply to paddy field (%)	77.4	0	54.7	44.0	89.0
Pyung per lot	621	1,029	278	643	980
Proportion of idle land	10.2	21.3	19.3	16.1	1.5

Demographic trends

The number of households and the population in the areas with unfavorable conditions has rapidly decreased in the process of industrialization. The number of households decreased by 35% from 1985 to 1997 and the population decreased by 45%. Because the productivity of rice cultivation was relatively high in the pre-industrial era, the impact of industrialization shows itself most strongly in these regions, where paddy field area was most prominent. In Mt. Taebak region where most farmland is dry fields, the decreasing rates are more mild. On the other hand, the decreasing rate in the island region is relatively low due to the higher income from fishery, seaweed culture and salt farming.

The average number of family members decreased from 3.72 persons to 3.16 (Table 8). As a result of this phenomenon, the common feeling of the community has been weakened.

Table 8 Number of households and population, 1985 and 1997.

	Unfavorable Areas				General Region
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	
No. of households in 1985	51.0	52.0	71.7	58.2	66.4
No. of households in 1997	31.7	31.7	49.3	37.6	58.1
Annual household change (%)	3.9	4.0	3.1	3.6	1.1
Population in 1985	206.7	186.7	256.3	216.6	255.8
Population in 1997	85.7	101.7	168.7	118.7	185.7
Annual population change (%)	7.1	4.9	3.4	4.9	2.6

The problems that confront Korean farm households are various, including the aging of farmers, the shortage of successors and the low level of motivation in enlarging farm size. These phenomena are more serious in the unfavorable areas. The youth have left their communities in the process of industrialization and only elderly farmers stay there. However, the elderly farmers did not ensure their successors, so a rapid decrease of farm households is expected in the long run.

As Table 9 shows, compared to the general region, the proportion of farmers with ensured successors is very low, and the number of farmers who intend to enlarge their farm size is also low. On the other hand, the number of farmers who intend to reduce or stop farming is two times that in general areas. The exception is Mt. Taebak where the ratio of young farmers is relatively high, but in this region commercial agriculture with greenhouse cultivation and large field size vegetable cultivation predominate. Even in the Mt. Taebak region, the number of farmers who intend to enlarge farm size is low and the proportion who have ensured successors is low. This means that even the commercial farmers are pessimistic about their communities.

Table 9 Characteristics of farm householders (%).

	Unfavorable Areas				General Areas
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	
Age of householder					
Below 39 years old	4.2	25.4	4.9	11.5	9.0
40 - 59 years old	29.1	44.4	38.2	37.2	43.2
Over 60 years old	66.7	30.2	56.9	51.3	47.8
Householders 60 years old who have ensured successor	12.5	15.8	8.6	11.2	21.1
Farmers intending to enlarge farm size	19.4	3.2	9.8	10.8	20.7
Farmers intending to reduce or stop farming	9.8	14.3	25.9	16.7	8.2

Although the Korean government has tried to adjust farmland size, the size of farmlands has not increased considerably. The average size of farmland increased from 1.11 hectares in 1985 to 1.32 hectares in 1996. The government's policy to enlarge the farm size has been practiced mainly in areas with favorable farming conditions. Thus, the adjustment of farmlands in the areas with unfavorable farming conditions is trivial. In two areas of this case study except Mt. Taebak region, the proportion of farmers who have less than 1 hectare of farmland is over two-thirds (Table 10).

Table 10 Ratio of farm household by farm size (%).

	Unfavorable Areas				General Areas
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	
Below 1 hectare	66.7	28.6	69.6	57.8	42.7
1 - 2 hectares	27.8	15.9	29.4	25.3	35.0
2 - 3 hectares	1.3	17.5	1.0	5.5	12.1
Over 3 hectare	4.2	38.1	0.0	11.4	10.2
Average farm size (ha)	0.89	2.89	0.80	1.38	1.49

Farming type

The ratio of paddy fields is the key element in deciding the kinds of crops cultivated in Korea. Even if some farmers put greenhouses in the paddy field or cultivate crops other than rice, most farmers cultivate rice in paddy fields. Some farmers cultivate vegetables in winter in paddy fields and rice in summer. Therefore, the cultivation of field crops differs among regions. The traditional dry field crops are, in general, beans, field vegetables, potato and sweet corn. The commercial farmers cultivate greenhouse vegetables, fruits, and oil seeds and special crops such as medicinal herbs. As Table 11 shows, the rice industry in Mt. Jiri region occupies over 80% and other crops are cultivated a little. On the other hand, in the island region, beans and vegetables are cultivated besides rice. In Mt. Taebak region, field vegetables (Napa) are the key crops and the special use crops are cultivated to a large extent. Fruits and household vegetables, which are highly productive but labor intensive, are rarely cultivated in unfavorable areas.

Table 11 Composition of crops (%).

Crop	Unfavorable Areas				General Region
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	
Rice	81.7	3.7	43.7	43.0	67.9
Barley, wheat	-	-	6.3	2.1	4.5
Beans	5.0	3.9	21.3	10.1	2.0
Field vegetables	9.9	40.2	23.7	24.6	11.3
House vegetables	-	-	0.2	0.1	2.1
Crops for a special use (medicinal)	3.0	27.0	2.1	10.7	0.4
Fruits	-	-	2.7	0.9	6.4
Others	0.4	25.2	-	8.7	5.4

Agricultural productivity and farm income

The productivity of agriculture is very low in the areas with unfavorable farming conditions, especially in the Mt. Taebak region. As Table 12 shows, the land productivity of rice is only two-thirds of that of general areas, but the average land productivity of total crops is only one-half of that of general areas. Agricultural income is low because of the low land productivity and the small farm size. Although the farm size is large in the Mt. Taebak region, the total income does not reach half of that in general areas. Total household income including non-agricultural income is only 60% of that in general areas. Lower income is the fundamental reason for farmers leaving their communities in unfavorable areas.

Table 12 Agricultural productivity and household income (10,000 won)

	Unfavorable Areas				General Region
	Mt. Jiri Region	Mt. Taebak Region	Island Region	Average	
Land productivity					
Revenue per ha (all crop)	51.1	36.0	65.9	51.0	102.5
Revenue per ha (rice)	42.5	34,8	41.5	39.6	60.0
Farm household income					
Farm gross income	424	854	526	601	1,759
Non-farm income	862	370	684	639	388
Total	1,286	1,224	1,210	1,240	2,147

Review of policies related to the unfavorable areas

As mentioned previously, the mountainous and island areas are undergoing dissolution of their communities due to naturally and socially disadvantaged conditions. Agriculture has also shrunk continuously. If these trends continue, we can expect that those areas will be destroyed. Unfortunately, the government policies dealing with those areas are not sufficient. Some policies have been practiced, but the effects are not successful.

Development programs in the hinterlands and islands have been practiced by the Ministry of Home Affairs. The program has concentrated on the improvement of living conditions such as water services, sewage facilities and road pavement. The hinterland development program planned to invest 2 billion won for every 403 Myons from 1990 to 1999. The island development program planned to invest 386.6 billion won for 449 islands from 1988 to 1997. However the amount budgeted for the hinterlands is lower than that of the settlement program for general areas. Thus, hinterland and island development programs cannot really be a development policy for undeveloped areas.

The development policy of "Development Promotion Regions" was launched in 1997 by the Ministry of Construction and Transportation to stimulate businesses such as manufacturing, tourism, and processing of agricultural products, and it is not related to the development of agriculture. Major policy tools are financial supports to the basic social structure, tax redemption, special treatment on permits and licenses, and land expropriation. The program is a kind of growth pole development. At the present time, 14 areas are designated. It will be a kind of development in the undeveloped areas. However, it is not easy to evaluate the performance of the program.

Government investment and loan projects have concentrated on the plains, the areas with favorable farming conditions (Table 13). Even if a differential support system for the unfavorable areas is needed for development with priority, it is not practiced yet

Table 13 Government investment and loans, 1995-1997 (10,000 won/ha).

	Ratio of Farmer with Specialty (%)	Aid	Loan	Total Support
Unfavorable Areas	2.1	115.1	357.4	472.5
General Areas	9.0	283.8	252.5	536.3

Note: Investment and loan projects include the direct payment scheme for the enlargement of farm size and other support projects such as farming machine purchase, farmland purchase, livestock facilities and purchase, greenhouse, house improvement and development of the settlement.

The policies to support the areas with unfavorable conditions are not sufficient as regional, industrial and income policies. The key causes are economic, social development with polarized growth, the under-development of local autonomy, public investment pursuing efficiency, and the partiality of development policies focused on the plains and the vicinity of cities.

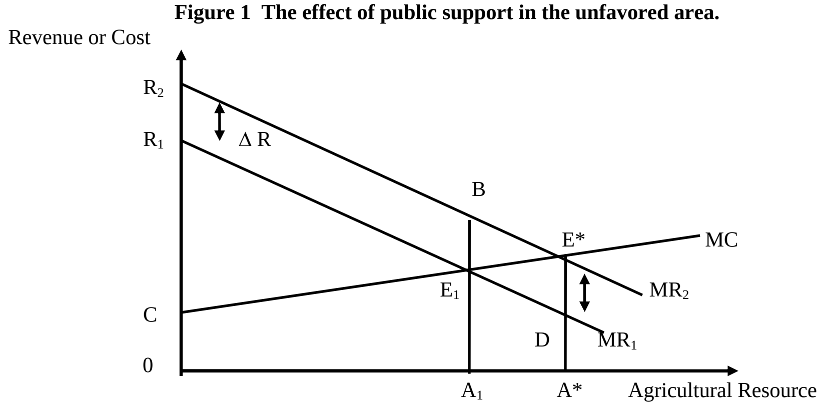
Conclusion and suggestions

A rapid decrease of population in the mountainous and island areas has occurred. Considering the trends of migration, residents' age structure, and the poor social overhead capital (SOC), there is concern that communities might be destroyed in the near future. Because the mountainous and island areas occupy a large portion of the whole national land, the destruction of these areas raises many problems in environment and land management. These areas occupy 14.8% of the whole national farmland and 27% of the whole national land. These areas play an important role publicly. Agriculture has important public functions such as the prevention of flooding and soil erosion, the maintenance and management of water services, and the provision of leisure and tourism sources for city dwellers. Public functions can be maintained thorough the maintenance of communities and agriculture in these areas.

However, the public functions of these areas are not evaluated in the market. Thus, if we leave them in the market, agricultural activities will shrink and they will not meet a socially desirable level. Government support to the unfavorable areas and their agriculture can ensure maintenance of the communities. Advanced countries such as European countries and Japan practice various policies to support such areas. The EU has practiced direct payment policies since 1975.

The necessity to support agriculture in the areas with the unfavorable conditions can be theoretically explained in Figure 1, where MR_1 is a marginal revenue curve and MC is a marginal cost curve about the use of agricultural resources. In the private market the level of agricultural products is determined at the point E_1. That is, only the amount of OA_1 can be utilized and the resource beyond OA_1 is left idle. Considering the public function of agriculture, the marginal revenue curve moves to MR_2 and the socially optimal level of production is the point, E*. In order to increase social benefits (ΔR), the government has to provide financial supports. The financial need equals $R_1R_2E^*D$ (ΔR x A*). The increase of farmers' income equals $R_1R_2E^*E_1$. The increase of social welfare equals E_1DE^*B. The social cost for increasing public functions of agriculture equals ΔE_lE^*D.

Figure 1 The effect of public support in the unfavored area.



The Korean government is concerned with the seriousness of the unfavorable areas and strives for various policy alternatives. The project of "Development Promotion Region" conducted by the Ministry of Construction and Transportation expresses this policy concern. In particular, a direct payment system to support the areas with the unfavorable farming conditions is seriously considered.

There are several policy alternatives for tackling the agricultural problems in under-developed areas. In the broad sense, the policies are classified into three types: the regional development policy, direct income support, and financial aid on agricultural investment. Because each policy tool has its own advantages and disadvantages, the government has to select policies with consideration of policy goals and conditions. Table 14 shows the advantages and disadvantages of each policy alternative.

Table 14 Advantages and disadvantage of policy alternatives.

Policy	Advantages	Disadvantages
Regional Development Policy	Long term and continuous	For short term effects Lots of investment
Direct Income Support	Immediate effects of the support	One time effect Conflict between beneficiaries and non-beneficiaries
Agricultural Investment	Related to the expansion of agricultural investment	Limits the rich farmer group

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Sustainable Highland Agriculture: Thailand's Experience

Vute Wangwacharakul[*]

Introduction

By topography, agriculture in Thailand can be divided into lowland, upland and highland. Lowland is area in the flat plains mainly found in the central region of the country. Rice in the main crop grown. Upland agriculture refers to areas with rapid drainage mainly in the Northeastern region and lower northern areas. Crops grown in these areas include field crops, rice, vegetables and fruit trees. Highland agriculture is mainly found in the high altitude areas, usually of more than 500 m. A large part of highland agriculture is found in the Upper North and Upper Northeastern areas. Many areas in the South are also considered highland agricultural areas. Most of the crops grown here are fruit trees, rubber, coffee, vegetables, upland rice and field crops.

Since this highland is located in the monsoon region, the high variation of climate conditions and rainfall between seasons creates vulnerable highland areas in Thailand. Inappropriate utilization of natural resources, especially land, forest and water, can have tremendous ecological effects on the highland environment as well as on the downstream areas.

Highland in Thailand has been utilized by subsistence hill tribes for centuries. In the early period, the hilltribes planted opium and food crops, mainly upland rice and maize, for their own consumption. Sustainable shifting agriculture was practiced for a very long time. However, due to population growth and gradual reduction of the rotation period this agriculture has become unsustainable.

Over the past few decades, there have been substantial efforts from the public sector to manage the fragile highland areas in Thailand. Various forest protection and agricultural development schemes have been implemented. Meanwhile, in certain areas in the country, a resource management system organized by local communities has effectively conserved the environment, although the pressure is increasing.

Due to mounting pressure on resources in the highland areas and serious deforestation, a new strategy has been introduced in Thailand to pursue sustainable land use in the areas. Integrated watershed resources management has been introduced to harmonize the resource demand and supply within watershed areas. Decentralization of resource management responsibility has also been developed. The local community is now playing the major role in resource management in its vicinity.

This paper provides an overview of highland agriculture in Thailand. It then discusses the management aspects of sustainable highland agriculture. Both existing management and proposed systems are discussed.

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Highland agriculture in Thailand

Sustainable agriculture can be defined as the use of natural resources for agricultural production such that the productivity can be sustained indefinitely. This definition means that the quality of natural resources must be maintained. Soil and water resources should be sustained. In economic terms, sustainable agriculture can be measured by sustainable real income generated by the natural resources. The net return generated by the use of resources should also take into account the existing externalities.

There are two aspects of sustainable highland agriculture to be considered simultaneously, the aggregate or macro level and the farm or micro level. Because of externalities and the imperfection of the market system, prices do not fully reflect resource scarcity and the environmental consequences of resource utilization. Activities which provide private maximum returns do not consistently provide the maximum welfare for society as a whole. Resources such as surface and underground freshwater are open access and there is no market to allocate their utilization efficiently. Water and air pollution from production and domestic sources are common externalities generated. In Thailand agricultural chemical residues from highland agriculture have increasingly threatened the downstream environment. Flash floods during the rainy season and erosion sedimentation in downstream have occurred more frequently in recent years. Deforestation and unsustained land resource uses are the main causes of such environmental effects.

Land and water resources are fundamental for highland agriculture. A balance between exploitation and preservation of these resources is important for sustainable agriculture in this area. Because forest and water, especially headwaters are closely related, management of highland areas must consider land and water resources simultaneously. The development status of the two resources is discussed below,

Land resources

Of the total land of 321 million rai[*] in Thailand, about one-half is suitable for agricultural crops such as field crops and paddy. About 30% of the total is not suitable for agriculture (Table 1). Land not suitable for agriculture is found mostly in the North. Of the total unsuitable land for agriculture, more than one-half is found in the North. Of the total land of 106 million rai in the region, more than 54 million rai are unsuitable for agriculture. This type of land covers mainly areas vulnerable for soil erosion, such as those at high altitude level, steep slopes, etc.

Because of its topographical conditions, the proportion of forest land in the North remains the highest of Thailand. Table 2 shows the land use structure of the country in 1992. Forest land in the North constitutes more than one-half of the total forest in the country. Note that most of land suitable for agriculture has been converted to other and unclassified land. Hence, despite fact that the statistics show that land use is within the land suitability, in fact, cultivated land in most of the region of the country has intruded into forest land, which is mostly unsuitable for agriculture.

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[*] 6.25 rai = 1 hectare; 2.5 rai = 1 acre

Table 1 Land suitability for agriculture by region in Thailand (million rai).

Land Suitability	North	Northeast	Central	East	South	Total
Field crop	20.02	30.69	11.46	5.31	0.16	67.66
Paddy	16.43	40.20	14.87	5.58	7.01	84.47
no problem	16.43	22.72	9.84	5.08	6.46	60.53
with acidity	-	-	4.73	0.51	0.59	5.83
with salinity	-	17.80	0.30	-	-	18.11
Fruit trees	-	-	0.70	0.96	14.70	16.36
For selected crops with appropriate measures	14.72	21.25	3.35	5.56	4.93	49.83
Not suitable for agriculture	54.21	12.09	12.85	3.99	16.71	99.90
Wetland	0.59	0.98	0.21	0.08	0.64	2.50
Total	106.03	105.53	43.45	21.49	44.17	320.70

Source: Daecha et al. no date.

Table 2 Land use structure in Thailand, 1992 (million rai).

Land Use	North	Northeast	Central	South	Total
Total land	106.03	105.53	64.94	44.20	320.70
Forestland	47.56	13.51	1.09	8.18	74.34
Housing	0.90	1.29	0.79	0.47	3.46
Paddy	15.14	37.96	12.36	3.37	68.84
Field crop	10.28	13.27	9.13	0.11	32.79
Fruit trees	1.93	1.92	4.45	12.54	20.85
Vegetables	0.29	0.20	0.32	0.07	0.88
Grassland	0.11	0.45	0.15	0.04	0.75
Idle land	0.32	2.15	0.38	0.46	3.32
Others	0.12	0.46	0.42	0.16	1.16
Unclassified	29.36	34.33	21.84	18.78	104.30

Note: Unclassified land includes public land, sanitary district area, swamp, municipal area, real estate, rail track, highways, etc.

Soil erosion is one of the main causes of unsustainable agriculture. Table 3 shows the different severity of soil erosion in Thailand. As can be seen, the most severe soil erosion usually occurs in field crop, deforested land and highland agriculture. Soil loss in this area is as high as 20 tons/hectare/year.

Table 3 Soil erosion in Thailand.

Group	Annual Soil Loss (tons/ha)	Area (mil. rai)	Land Use
Very slight	0.01-2.00	117.00	Paddy, forest, rubber
Slight	2.01-5.00	34.03	Paddy, forest
Moderate	5.01-20.00	131.59	Field crop, grassland
Severe	20.01 and above	20.13	Field crops, deforested land, highland agriculture,
Others	18.65		water resources, rocky mountain, mangroves, cities, mines, etc.

Source: Daecha et al. no date.

By region, it can be clearly seen how fragile the Northern region of Thailand is in maintaining sustainable agriculture. Table 4 shows soil erosion in different regions of Thailand. More than 60% of the land in the North has moderate or severe soil erosion while a relatively small proportion is observed in other regions. Note that the South of Thailand has relatively slight erosion rates compared to other regions. This mainly due to the concentration of rubber and oil palm plantations in the region. As most of the land is flat plain, soil erosion in the central region is mostly very slight or slight. In contrast, the high plan and hilly land in the Northeast has greater erosion severity, compared to the Central region (Table 4).

Table 4 Soil erosion at different levels of severity by region in Thailand (million rai).

Erosion	North	Northeast	Central	East	South
Very slight	26.08	48.75	20.27	8.14	13.76
Slight	8.25	9.27	7.51	2.09	6.91
Moderate	57.50	45.51	5.79	9.11	3.68
Severe	11.26	3.80	1.45	2.01	1.60
Others	0.96	0.92	0.40	0.11	0.26
Total	104.05	108.25	35.42	21.46	26.21
% of total					
Very slight	25.06	45.03	57.23	37.93	52.50
Slight	7.93	8.56	21.20	9.74	26.36
Moderate	55.26	42.04	16.35	42.45	14.04
Severe	10.82	3.51	4.09	9.37	6.10
Others	0.92	0.85	1.13	0.51	0.99
Total	100.00	100.00	100.00	100.00	100.00

Source: Daecha et al. no date.

Highland in Thailand is classified as land with average slope of 35% or greater. About one-third of the total land in the country is classified as highland. More than one-half of the land in the North is highland (Table 5).

Table 5 Land with average slope of 35% and above in Thailand.

	Land with 35% Slope	Total Land in the Region	Percent of Total Land
Northeast	14,828,037	105,533,963	14.05
East	3,639,217	21,487,812	16.94
Central	12,904,228	43,450,440	29.70
South	14,384,235	44,196,992	32.55
North	57,808,598	106,027,690	54.52

Source: Centre for Applied Economics 1996.

There are several constraints for agricultural land used in highland areas including:

- high soil erosion;
- thin layer of top soil; rocks and stones are commonly found;
- locational constraints; poor transport and inappropriate for mechanization;
- limited choices of agricultural production alternatives; and
- financially and environmentally costly for infrastructure development.

The hilltribes in Thailand have been using highland for food and shelter for a long time. Various hilltribe groups live in highland areas of 22 provinces, especially in the North of Thailand. Two main types of shifting agriculture are practiced - shifting and rotating land cultivation. The shifting land practice is found among the Maew, Yao, Muser and E-kor groups. They move the family and open new land when the productivity of the existing land is low. The main crop grown previously was opium. In contrast, land rotation is practiced by Karen and Lawa. Their settlements are more permanent. Cultivated land is rotated regularly to allow for the land to recover its fertility naturally.

To solve opium problems, the Thai government introduced alternative agricultural sources of income and provided infrastructure and social development. Promotion of permanent resettlement among this group is also implemented to enhance the control of drug trafficking. The increasing population pressure and the government policy of maintaining 40% of the land as forest (of which 25% is conserved forest) has resulted in shortening of the rotation period. The situation has been exacerbated by encroachment of lowland farmers to the highland, threatening environmental conditions in these areas.

In summary, the use of highland in Thailand is vulnerable to environmental effects. Sustainable agriculture can not be achieved without proper management of the land resources. The structure of land use and land suitability in Thailand indicate that the North of Thailand is the most vulnerable to soil erosion and hence unsustainable agriculture.

Water resources

Water is another highly important factor, not only for agricultural production, but also for others as well. "Water is life" has been clearly reflected by the culture of the hilltribes.

Agriculture has been and will continue to be the main freshwater user in Thailand. Water has increased land use intensity and hence agriculture productivity substantially. At present, partially and fully irrigated areas constitute roughly one-fourth of the total agricultural land in Thailand. A study of potential of water resource development in the 25 basins of the country indicates that agriculture consumes more than 90% of the total water supply, while domestic and industrial use are about 6 and 2.5% of total supply, respectively (Weeraphol 1996). The agricultural population will remain high and irrigated areas will be expanded by another one-half of the present level in 2006. As more than one-half of the population is in the agriculture sector, there is no doubt of the importance of water resources to the rural farmers in Thailand.

It is forecast that demand for water in Thailand will increase from 39 billion m^3 presently to not less than 45 billion m^3 by the year 2000 (Center for Applied Economic Research 1997). It is also estimated that by the year 2000, rural and urban domestic demand for water will increase from about 2.5 billion m^3 in 1995 to nearly 4 billion m^3; in contrast, demand for industrial water will increase gradually from about 1.9 billion to about 2.4 billion m^3 over the same period (ESCAP 1991, cited in Centre for Applied Economic Research 1997). Although water demand will increase in all sectors in absolute terms, development accompanied by structural change over the next decade will likely reduce agricultural consumption of water to about 88% of total supply, while domestic and industrial demand will increase by about 9.3 and 3.1%, respectively (Weeraphol 1996).

While increased demand for water in all sectors of the country threatens freshwater availability in the Thailand, fluctuation of seasonal supply has critically required more efficient management capability to balance between the two. Most of all, demand for water is peaking while availability of water is at its lowest in the summer. On the other hand, in the rainy season, water from rainfall is excessive, such that many areas are frequently flooded.

While demand is increasing, water supply has reached its limit. Thailand has an average rainfall of about 1,700 mm per year, ranging from 1,200 mm in the North and the central plain to 2,000-2,700 mm in the South and the East of the country. The total amount of rainfall in Thailand is approximately 800 billion m^3 per year. Of this, more than one-half is generated from the Northern and Northeastern regions of the country (Centre for Applied Economic Research 1996). Of the total rainfall, about 75% is evaporated and the remaining 25% is run-off in the 25 river basins of the country. Due to degradation of forest land, especially in the upper watershed areas, the amount of run-off is likely to have a declining trend.

Another important source of water supply is groundwater. Thailand's groundwater availability varies from more than 100-300 m^3 per hour in the central region of the country to less than 5 m^3 per hour in some areas in the Northeast. Use of groundwater resources in Thailand has grown over time. Thailand has imposed strict control of groundwater extraction in the environmental risk prone area of Bangkok and its vicinity.

The national flow of water supply has been partially controlled by dams and reservoirs constructed over the past. At present, there are 26 large reservoirs with total storage capacity of 66.1 billion m^3 and the effective storage capacity of 43 billion m^3. The actual usable water, however, varies greatly over time and across regions (Table 6).

Table 6 Actual usable water as percent of effective storage capacity, selected years.

	Effective	Actual Usable Water (billion m^3)			Actual/Effective (%)		
		1990	1993	1995	1990	1993	1995
North	16,934	8,603	5,629	13,220	50.80	33.24	78.07
Northeast	5,550	3,572	2,706	3,285	64.36	48.76	59.19
West	14,708	7,369	5,046	10,393	50.10	34.31	70.66
East	184	102	105	106	55.43	57.07	57.61
South	5,431	1,986	1,371	2,224	36.57	25.24	40.95
Total	42,807	21,632	14,857	29,228	50.53	34.71	68.28

Source: adapted from OEEP1997.

The trend of large dam and reservoir development in Thailand has been declining. This is partly due to physical limitations as well as social and environmental constraints. The environmental consciousness of the public and the requirement for preparation of an EIA and a public hearing for large water resource development have limited the expansion in recent years.

While large water resource development potential is increasingly limited, small and medium scale water resource development in increasing. Thailand has expanded farm pond development as part of the new concept of farming systems. Under the system, farmers diversity agricultural activities including crops, livestock and aquaculture. The farm ponds will be used as the main multi-purpose source of water supply to the farmers during the dry season. Medium-scale water resource development is emphasized in suitable areas to provide the main source of agricultural and domestic water supply for rural areas. This medium-scale development is more acceptable in terms of potential environmental impact, although the scale of the benefits is also relatively small.

The above phenomena reflect the increasingly serious situation Thailand is going to face by the beginning of the next century. Thailand is facing a continuous increase of water demand, while the ability to expand supply has reached its limits.

This overview of land and water resource development in Thailand reflects the fact that the areas which are highly vulnerable to degradation of land resources are also highly important as the main sources of water supply. The topographical and natural resource structure in Thailand suggests that sustainable highland agriculture in Thailand is not only important to the future of the communities in the region, but also vital to sustainable lowland agriculture in the country. Without sufficient and appropriate land conservation in the North, the main headwaters of the country, not only can highland agriculture not be sustained, but the water resource supply to the lowland areas will deteriorate affecting the main food producing region of the country.

Land management system at the aggregate level

There are two main types of land - public and private. The public land consists mainly of forests, crown estates, highways, etc. By law, Thai people can own private land and are free to trade. They have the right to cultivate and to obtain benefits from the use of their land. Public land is controlled by the government. For instance, forest land is under the responsibility of the Royal Forest Department, and irrigated land is managed by the Royal Irrigation Department. Although encroachment into forest land is against the law, intrusion into forest land has been common in Thailand. Only recently has strict control been imposed, but the enforcement is still not effective.

Land exploitation in Thailand has produced two types of land ownership - legal and illegal. The legal landowners generally take good care of their land and the public provide support for land conservation through various land conservation demonstration schemes. This type of land ownership will not be discussed here. The more critical point concerning sustainable agriculture is the illegally cultivated land. This type of land is mainly from either encroachment into forests, or the declaration of forest land as settlement area. Illegal ownership has accelerated over the past decade due to land speculation. Corrupt officials have issued land titles in prohibited areas (such as steep slopes, hilly areas, public land). The high economic growth over the past decade has also fueled forest encroachment. Farmers sold encroached forest (without documents) and further encroached into deeper forest areas.

Weak public enforcement of forest policies could not deal with the encroachment. Greater encroachment increases the social bargaining power of the farmers. Hence, the solution to forest encroachment frequently ends up influenced by politicians, and farmers are given the right to cultivate. Only in highly ecological sensitive areas are encroachers transferred to more suitable areas. These policies have involved the public in regulating land utilization by the encroachers. Land cultivation rights are provided, a basic infrastructure is set up and an appropriate land utilization system is promoted.

In contrast to the management of encroached areas by the public sector, highland agriculture in Thailand has existed for centuries. These hill tribes cultivate opium and other subsistence crops for that own consumption. They practiced sustainable shifting agriculture consistent with the highland ecological system. The long history of the hill tribe land management system has been studied extensively shedding light on the community-based land management system.

The community-based management system varies widely between different regions in Thailand. While the system had been effective in the past, high population growth and the influence of market-oriented agriculture threaten the system. Nevertheless, there is evidence to indicate that this community-initiated resource management system is still effective in certain areas. Meanwhile, the government has recently shifted the resource management policy from a centrally regulated system to decentralization of management responsibility. A public participatory approach has been emphasized and an integrated watershed management system introduced.

The centralized system

Due to the centralized administration system, public land management is practically a centrally regulated system. This has been used since the early period of development. Various resettlement programs were established to open up the forest land for agricultural production, such as self-support resettlement projects, and cooperative resettlement projects. Many of these areas are now urban centers in various parts of the country.

Conflicts over land use during the 1970s-1990s have resulted in the implementation of various land management programs to permanently settle the conflicts. The results are not satisfying however. To settle the encroachers, the Ministry of Agriculture and Cooperatives has emphasized two approaches - land reform and forest villages. Under the first approach, encroached forest land is excluded from the conserved forest area and land reform is introduced. In this scheme, the land is reallocated as far as possible to the existing farmers and other landless farmers. Each farmer is allocated 50 rai for cultivation rights. The land can be inherited within the family but is not tradable. Twenty percent of the land reform site must be devoted to reforestation. The land reform system is conceptually perfect but in practice ineffective. Land reform has been resisted by large land encroachers and influenced by local leaders.

The forest village program was implemented by the Royal Forest Department to control forest encroachment. Farmers were allocated a small area of land (15 rai) for cultivation. Where ecologically acceptable, farmers were allowed to continue the cultivation in the same area. If ecologically unacceptable, they were transferred to new areas. Limited basic infrastructure was provided. The forest village program was found insufficient for economic survival of farmers and difficult to control (Sopin 1997). Land allocated to farmers was small compared to land reform development. Social cohesion among community members is lacking and conflicts between the settlers and the hosts are more common.

The use of land reform as a spearhead to solve forest encroachment has also faced difficulties. Recently, the government has designated the Land Reform Office to play a greater role in land reform, including the encroached forest areas. The acceleration of the land reform system resulted in large land allocation but poor resource management. Land cultivation rights have been issued to achieve the target of 4 million rai per year. The political achievement of the programs has not been accompanied by economic or social success. Farmers still adopted conventional land practices without appropriate soil conservation. Also, in many cases, land quality was low resulting in poor harvests. At present, land reform by the public sector is still active, but more careful development programs have been laid out.

To control land use, a watershed classification system has been developed in Thailand. Six classes of watershed with different environment sensitivities have been established: 1 A, 1B, 2, 3, 4 and 5. Classes 1A and 1B are the most environmentally sensitive and no utilization is allowed. The lower classes (2, 3, 4 and 5) are cultivable with different conservation requirements (Faculty of Law, Thamasart University 1996). Table 7 shows the areas under different watershed categories by region in Thailand; the West and the North have relatively large proportions of 1A class compared with other regions of the country.

Table 7 Watershed areas (% of total area) in Thailand.

Category	North	Northeast	Central	East	West	South	Total
Total areas (km^2)	138,370	166,680	55,291	36,438	43,185	72,102	512,066
1A	30.20	6.10	5.80	6.40	34.40	13.34	16.40
1B	2.50	1.00	1.20	0.30	0.30	1.61	1.35
2	15.00	2.40	3.20	5.20	11.20	0.95	8.30
3	10.80	3.50	5.30	8.20	11.00	0.95	7.70
4	9.50	21.80	7.70	25.90	14.40	11.76	15.60
5	31.90	63.00	76.20	54.00	27.00	9.77	49.00
Forest area in 1988 (%)	47.60	14.00	12.40	19.70	49.88	16.30	28.00
Surface run-off (billion m^3)	40.96	37.18	9.45	21.13	16.61	44.95	201.18

Note: The class IAR and IBR are excluded here (1.6 % of total watershed areas in the country)
Source: Faculty of Law, Thamsart university 1996.

Together with watershed classification, the government aims at achieving a 40% forest covered area target. Protected forests have been declared, especially in highland areas. Migration of settlers in the highland areas to the lowland downstream was encouraged. Watershed classification and resource control policies of the government have faced various difficulties. Highland agriculture has long been practiced by the hill tribes, the lack of ground truth survey of actual land uses, the lack of manpower to control encroachment, etc. are common obstacles to the implementation of the policies. The separation between human and forest areas has consistently faced these constraints.

In summary, the public land management system has usually been implemented without sufficient sustainable agricultural development support. Poor quality of land resources and small land allotment are not sufficient for farmers to sustain their living. This forced them to further encroach when opportunity permits. In addition, there are cases of speculation motivated encroachment, generally done or supported by politicians and local influential persons. Acceleration of land reform is not adequately supported by agricultural development so it results in low income and further encroachment. The government has now toned down the political influence over land reform and adopted careful screening of participants and more comprehensive agricultural land development support is provided to the areas.

The integrated watershed resource management system

The integrated watershed resource management system in Thailand was emphasized in the 7th National Economic and Social Development Plan (1992-1996). In this approach, land resource management is emphasized to ensure appropriate allocation between protected watersheds and cultivated areas. The approach was introduced to enhance the management capability of the existing system. Public participation is used as an important mechanism to ensure that the management is transparent and open.

The integrated watershed management system is managed through the collective decision making process of a committee comprised of the stakeholders of the resources in the area. The committee members include the public sector, local community representatives, the private sector, NGOs and experts. This system requires regulation and institutional change especially decentralization of the administration power to local communities.

Actually, the integrated watershed management system was touched upon by government policy in the 1980s, when a watershed classification system was developed to identify environmentally vital areas. Soil conservation had long been promoted since the early period of agricultural development. Likewise, water resource development programs have been implemented. Unfortunately, these programs were not systematically integrated; land, forest and water resources were not viewed and developed as an integrated system. The watershed system has been used to define the boundary for integrated management. Several activities have been implemented, among them:

- Implementation of a pilot study on the watershed system approach in integrated resource and environmental development of three watershed areas in different regions, Northeast, North and South.
- Preparation of a new water law to address the institution and property rights issues.
- Preparation of a new forest law to address community rights in managing forest resources.
- Application of the watershed system approach to 25 watersheds throughout the country.
- Preparation of an integrated watershed development plan in the Chao Phraya basin.
- Establishment of grass-root institutions to support local communities.

The community based management system

The North of Thailand has a long history of community developed land management systems. This is partly due to the fact that most of the agricultural land in the North is located in highland areas where the environment is very sensitive. The hill tribes have long been living with the forests; their traditions and culture are deeply rooted in an ecologically sound agricultural system.

Rapid economic development and population growth have increased demand for land. Lowland people have moved to the upper watershed areas and they compete for land resource uses. The market-oriented economy has induced the highland people to move from subsistence farming to commercialized agriculture. Land resource demand has shifted from subsistence needs to profit maximization. While resources around the communities are still conserved, the villages exploit areas critical to other groups and conflict over land use occurs. The case of Mae Hong Son in the North of Thailand is used here to highlight this.

Table 8 shows distribution of hill tribes in different regions of Thailand. Most of the hill tribes are found in the upper North of the country. In 1987, there were about 550 thousand persons with an average growth rate of 3.6% per year. Of this, nearly 500 thousand of them were in the Northern region. A similar structure of hill tribes is observed in Mae Hong Son province (Centre for Applied Economic Research 1997).

Table 8 Distribution of hill tribes in Thailand by region, 1987 (%).

	Upper North	Lower North	Central	Northeast	Village	Population
Karen	48.2	11.7	99.4	-	59.2	48.9
Hmong	8.6	30.7	-	100	6.8	15.0
Muser	8.7	3.1	-	-	11.8	11.0
Yao	4.9	14.7	-	-	5.8	6.5
Lee Sor	4.0	5.5	-	-	3.7	4.6
E-Kor	5.7	0.5	-	-	5.8	5.9
Total (persons)	495,773	28,505	23,492	501	3,412	548.271

Source: Kanok Rerkasem et al 1989 cited in Arnant and Mingsarn 1995.

Studies of resource management systems in highland communities have found that the local communities, recognizing the importance of the ecological systems to their survival, have long developed appropriate land use systems in their communities (see 1995). The hill tribes in Mae Hong Son settle their communities, usually in areas with sufficient water supplies from the headwaters. Areas in their vicinities are zoned into three or four main uses:

- permanent forests (headwaters areas supplying water to the communities),
- worship forests (forests preserved from their religious belief, such as cemeteries, usually in the environmentally sensitive areas, no utilization is allowed),
- community forests (areas for limited wood cultivation, firewood, housing; no commercial uses are allowed),
- Cultivated land (areas for cultivation of agricultural crops).

There are rules and regulations established by the commodity committees to ensure the proper use of resources. Offenders are warned, fined and taken to law enforcers (see Appendix). it is observed that various ethnic groups of hill tribes have similar community based land management practices, including the Hmong, the most unconserving land exploiters. Unfortunately, these communities focused their conservation only within their vicinity. The further away from their watershed areas, the less were their concerns for the ecological effects of land utilization.

While land was abundant and the population density was low, limited conservation at the community level was still sufficient to sustain resource use. The shifting agriculture period remained a decade or more. Development over the past decade, however, changed the land rotation period substantially and the water resource stability is critical in villages in Mae Hong Son Province (Table 9).

Table 9 Average land rotation periods and sources of water supply in Mae Hong Son province.

District	Land Rotation Period (years)				Source of Domestic Water		
	<3	3-8	>8	don't know	village pipe water system	canals	others
Muang	22.73	52.27	7.95	5.68	47.73	46.59	5.68
Pai	47.37	49.12	0.00	3.51	80.70	15.79	3.51
Khun Yuam	11.11	74.00	12.70	1.59	68.25	28.57	3.17
Mae La Noi	12.73	79.09	7.27	10.00	74.55	13.64	11.82
Mae SeRiang	18.97	62.93	15.52	2.59	62.07	37.07	0.86
Sob Mei	11.00	87.00	2.00	0.00	35.00	56.00	9.00
Pang MaPha	60.94	37.74	0.00	11.32	56.60	30.19	13.21
Total	21.81	66.10	7.33	4.77	59.63	33.73	6.64

Source: Division of Land use Planning and Division of Soil Survey and Classification, 1994.

The introduction of commercial crops in recent years increased land expansion substantially. However, opening new land has been constrained by the aggressive protection of the government watershed area policy. Competitive uses of highland have increased and caused conflicts and tension between communities. With the support of development organizations such as NGOs, a community resource management network in the highland areas has been established. The community network is an important establishment to allocate land resources between communities and sub-watersheds. A three-dimensional watershed model is used as a medium to facilitate negotiation, agreement and monitoring of development between the stake-holders.

It is noted that such development of a community-based resource management system is normally found in the upper watershed areas in the North where local people reside. The system is not common in the Northeast region, where the upper watershed areas are occupied by villagers who migrated from other areas. Thus, the social structure of the communities is important for the establishment of a successful community-based management system. Also, the value of the resources to the communities can be an important inducement to conserve the resources.

Resource management at the farm level

In early times, farmers cultivated highland for subsistence only. Low population density allowed a long duration of land rotation in shifting agriculture. However, economic development has gradually changed their practice from subsistence to semi-subsistence and commercial agriculture.

Similar to lowland agriculture, highland agriculture is motivated by the market and the price system to maximize profits. They ignore externalities generated, but they are influenced by government policies. Economic development has changed the social structure and attitudes towards quality of life of the hilltribes gradually. Social development, especially infrastructure, has facilitated the adoption of market oriented agriculture. Highland agriculture development in Thailand reflects these points.

The rapid adapters

Over the past two decades, highland agriculture in the North has gone through substantial changes. Partly due to the security policy and partly to reduce narcotic production, the Thai government tried to control the mobility of the hilltribes (particularly Hmong) and promote agriculture, especially fruit trees, to replace opium production. Marketing development of the products has been strongly supported. The hilltribes have gradually adopted the practice and changed from subsistence to semi-subsistence and commercial agriculture. The changes vary between the ethnic groups. Hmong and Lee Sor can adapt to development rapidly. They have replaced opium by fruit trees and vegetables. The government assists the hill tribes in marketing their products.

Development of infrastructure, especially a road network, has expanded the market rapidly. Various commercial crops have been introduced to the highland areas by middlemen. These include bean, tomato, cabbage, garlic and ginger. Table 10 gives an example of the crop areas a village of Mae Hong Son province.

Commercial agriculture in the highland areas creates high risk to the highland ecological system. In the highland of the North of Thailand, the hilltribes, exploit their resources to increase production and to maximize profit. The introduction of cabbage in the areas has resulted in rapid conversion of highland forest to crop land. Farm mechanization and chemicals have further fueled the conversion of forest to vegetable land. Thousands of rai of forest were converted to cabbage areas. Now residues from chemical pesticides threaten the quality of the downstream water.

Ginger, the most recent crop introduced into the highland areas, is also harmful to the highland agricultural system. Ginger can not be continuously grown in the same land for more than 3 years. It prefers newly opened forest land. Despite the serious threat to the ecological system in highland areas, the agricultural policy to deal with this crop is not clear. While the earnings of the farmers increase dramatically, modern farming and living motivate further expansion for more income and hence deforestation and environmental effects. The sustainability of commercial highland agriculture in Thailand becomes questionable.

Table 10 Crop areas in Nam Rin village, Pang Mapha district, Mae Hong Son province, 1997.

Crop	Area		Total Production	Yield	Value
	(rai)	(%)	(kg)	(kg/rai)	(baht)
Upland rice	320	50.08	107,940	337	519,700
Lowland rice	64	10.02	14,640	229	21,960
Maize	20	3.13	7,424	371	37,120
Red bean	39	6.10	9,183	235	40,915
Soybean	38	5.95	9,490	250	56,940
Bean	2	0.31	850	425	7,650
Garlic	34.5	5.40	67,275	1,950	269,100
Cabbage	17.5	2.74	60,435	3,453	120,870
Ginger	66.5	10.41	200,210	3,011	3,003,150
White cabbage	0.5	0.08	na	-	na
Mango	12	1.88	-	-	-
Macadamia	25	3.91	-	-	-
Total	639	-	-	-	-

Source: Centre for Applied Economics 1998.

The conservative villagers

Adaptation to modern economic growth is slow in some hilltribes, e.g. the Karen. Their culture is closely related with forest and their way of life is simple subsistence farming. This group of hilltribes grows crops mainly for home consumption. They earn cash income from some field crops and vegetables. Forest products, especially mushrooms, bamboo shoots and honey, have been major sources of their cash income as well. It has been observed that in recent years this group of hilltribes has also been influenced by profit motivation. Environmentally sensitive crops such as cabbage and ginger have been grown (Table 11). In addition, increased accessibility to markets induces increased harvest of forest products and there is a potential to harvest more than what is renewable.

Table 11 Crop areas in Mae Spaetai village, Khun Yuam district, Mae Hong Son province, 1997.

Crop	Area		Total Product	Yield	Value
	(rai)	(%)	(kg)	(kg/rai)	(baht)
Upland rice	125.25	50.05	37,575	300	112,725
Lowland rice	6	2.40	1,800	300	5,400
Garlic	30	11.99	30,000	1,000	180,000
Soybean	83	33.17	20,750	250	166,000
Red bean	3	1.20	900	300	2,700
White Sesame	3	1.20	750	250	6,000
Total	250.25	-	-	-	-

Source: Centre for Applied Economics 1998.

This review of farm practices in highland agriculture indicates that rapid economic growth and infrastructure development have changed agricultural structure in the highland areas greatly. The hilltribes have changed from subsistence to commercialized farming, although the adaptation varies between ethnic groups. The profit maximization behavior of the farmers is not bound by the externalities generated. There is a potential to convert the forest in the upper watershed areas to cultivated land. There is also a tendency to over-harvest forest products for more income. This structural change of the highland economy is increasingly threatening its fragile ecological system. The existing community based resource management is put to the test.

Summary and conclusions

Highlands are the upper watershed areas where forest and water resources are environmentally significant not only to the villagers in the area but also to the downstream areas. Highland agriculture in Thailand was practiced mainly by the hilltribes of different ethnic groups in the early period of development. They practiced subsistence farming by shifting agriculture, which was sustainable because of the long rotation period of land use.

Population growth and economic and social development have gradually changed the structure of highland agriculture. Partly through government policies and partly due to market economic motivation, the hilltribes have gradually changed from subsistence to semi-subsistence and commercialized agriculture. The government has promoted permanent settlement of the hilltribes to control opium poppy cultivation. Permanent agriculture production has been promoted, and marketing of the products has been supported.

At the aggregate level, the Thai government is now introducing an integrated watershed resource management system to simultaneously manage the closely related land and water resources. A public participatory approach is emphasized and decentralization of administrative responsibility is in progress.

The system is close to the traditional community-based resource management system used by the hilltribes in the North of Thailand. Due to the importance of forest and water resources to the community, a land use management system has been established. The system has been expanded to a network at the watershed level.

Development over the past decades has changed the structure of agriculture in the highland areas as well as the way of life of the hilltribes. They have gradually changed their agricultural practices from subsistence to market oriented. Subsequently, monoculture and chemical application are increasing. Land expansion through conversion of forest land has increased. The fragile highland ecological system is increasingly threatened.

While the resource management system in the highland tries to optimize land use and ecological balance, the market-oriented economy induces increased use of resources. The existing public or community-based resource management systems seem insufficient to control the use of resources, so greater efforts are needed to ensure sustainable highland agriculture.

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Appendix

Some examples of rules in community-based land management in certain villages in Mae Hong Son Province are listed below:

- Planted Area
  - no encroachment on other persons' land
  - implement land rotation (three plots for 2 years)
  - no new clearing of forest land
  - no transfer of land to outsiders
  - punishment of offenders:
    - first offence - warn
    - second offence - fine 300 baht
    - third offence - negotiate with the owners with decision made by a committee
- Water Resources
  - for agriculture
  - for domestic consumption
  - rules of utilization:
    - no logging in headwater areas
    - for repair of waterpipe, at least a member per family must contribute their labor for the work
    - replacement of pipeline shall use the village fund
- Forest Land

- conserved forests
- headwaters forests
- community forests (for wood)
- areas for harvesting forest products (fuelwood)
- rules:
  - no encroachment into conserved forests, no hunting
  - if wood is needed, harvest from community forest is allowed and the village committee must be informed beforehand
  - harvesting forest products shall not cut or burn the trees
  - no wood be sold to outsiders
  - to burn a crop field, a fire buffer area must be developed around the plot
  - harvesting bamboo shoots must leave at last 3 stems for regeneration
  - no outsider is allowed to harvest bamboo shoots in the village
  - no trading of wild orchids is allowed
  - bamboo shoots harvested must be completely sold before new harvesting occurs
  - reforestation should be done annually
  - construct fire buffer zones in the conserved forests, headwater forests and reforestation areas.
- punishment:
  - first offence - the village committee warns
  - second offence - fine 300 baht
  - third offence - send to the police
  - harvesting wood log - replant to maintain the trees
- for selling wild orchids:
  - first offence - warn
  - second offence - submit to the police
- for livestock grazing areas:
  - establishing public grazing areas
  - fencing should be done for vegetable production areas
- punishment of offenders:
  - for vegetables produced in grazing land, if animals graze the land with fence, no fine is imposed
  - the owners of livestock are guilty if the livestock intrude into the fenced watershed

Discussion and Comments

Concerning Presentations

On the presentation of Dr Gour Chandra Munda and Dr N.D. Verma:

Mr Kiran Pyakuryal: Some of the key statistics given by Dr Munda, for example, chemical fertilizer use, are 1991 figures. I think more current statistics should be used.

Dr N.D. Verma: We have a different situation in the N.E.H. region and collecting data at the village level is sometimes difficult. It might be our local problem.

Dr Gour Chandra Munda: Basic data have been supplied by the local organizations in the N.E.H. region, but the Statistics Department sometimes lags behind giving the data.

Mr Kiran Pyakuryal: There are a number of policy recommendations in Dr Munda's report. I have a feeling that many of these recommendation are desirable, but how practical are they? Perhaps senior officials like you know better, but I think there should be a kind of prioritization of those which are most desirable and which can be implemented in a short term, because not all of them are possible to implement in the short term. For example, the agriculture sector is such that practices not only involve the government but also the decisions of millions of farmers. So, it has a greater inducement factor. Secondly, you have very nicely described marketing aspects. They may be relevant to those farmers who are closer to roads but to farmers living in the interior they may not be relevant. So I wish you could elaborate more practical policy options, so that this research will have more relevance to the policy planners. I don't think it will be that difficult.

Dr Gour Chandra Munda: Some of the projects given by the National Watershed Development are very important for the states of the N.E. region. Our scientists are participating in this project.

Dr R.L. Yadav: In India agriculture is a state subject, and then also it is a democratic institution where each individual farmer is free to choose his cropping system. It is very difficult to implement policy issues. For example, since the last five to six years we have come out with great recommendations that, if the rice-wheat system continues to grow like it has in the Punjab, the ground water table is going to go down and down and in 20-50 years we will be without water. But we are not able to convince farmers to stop growing rice. We have alternative crops there but we cannot force them. It is very difficult to convince the farmers. Government takes certain decisions, for example, subsidy schemes, but those have not worked well. Those worked initially when the subsidy was there, but when the subsidy was withdrawn, they did not work. So it is a complex issue; but slowly and surely, we are informing to them, it is penetrating their minds, and with more and more demonstrations, they are being convinced. It is a slow process.

Mr Kiran Pyakuryal: There are reasons for bringing up was this matter. On the one hand, at the macro-level, India has a vast network of agricultural researchers, 26 universities and scientists and also various outputs. On the other hand, if you examine the productivity of crops in different states, they do not match each other. So, somewhere a bridge is missing. The bridge between this full knowledge and farmer's practices is needed.

Dr R.L. Yadav: I agree. In the states where agricultural research, agricultural development and government policy are well integrated, agricultural productivity has increased.

But the states, where there is no harmony between the state department of agriculture and researchers, lag behind in that sense. But in another sense, because of climatic conditions, for example, in eastern India and west Bengal, even if farmers know how to apply fertilizers to increase their production, they do not apply it because they are not sure. If today they apply fertilizer in their field, tomorrow there will be heavy rain, and it will go to other fields; these are some of the climatic constraints. Unless he is sure that for 15 days there will be no rain, he will not apply fertilizer to the Kharif crops, so the fertilizer consumption is low there, although he is aware that he should apply fertilizer.

Dr Vute Wangwacharakul: Concerning the farmers growing rice differently and different crops in the hilly land, what is the adaptability of the farmers?

Dr N.D. Verma: Due to the local conditions, the farmers particularly in the N.E.H. region, don't use fertilizer, because they think that the soil will be spoiled. It will take time for the farmers to adopt new technology in this region.

Dr Gour Chandra Munda: It is a very difficult subject in the N.E. region. The extension network in the N.E. region is very poor. Whatever technology is developed it is very difficult to transfer to farmers.

On the presentation of Dr Gu Shuzhong and Dr. Cheng Shengkui:

Dr R.C. Maheshwari: I must complement the CGPRT Centre for choosing the backward areas in the two countries, the two most populous countries, India and China. The location of the project was excellent. These are the areas, which are neglected in both the countries and the farmers' problems have come to light. The experiences they have exchanged on these two project sites will benefit the two countries.

Indian Participants: In Guizhou province, when you make a terrace, you remove upper soil, so how does the fertility increase in the first year? It will increase in the third, fourth and fifth year, but not in the first and second year.

Dr Gu Shuzhong: Data were collected from the local terracing headquarters. Soil fertility increases because terracing can improve capacity for preserving water and soil nutrients.

Mr Kiran Pyakuryal: This is more of a general question. As you know, the Chinese agricultural sector started the new development since 1978 with a direction of responsibility system. The rural development started with a showing down of enterprise development linking this with agriculture and rural industries. As far as sustainability is concerned, the role of private citizens and private farmers, vis-a-vis the state, seems to be more and more difficult now, because with liberalization of the agricultural sector, state control over farming decisions is much less than it used to be in 1978 and before. My first question: how to reconcile this if there are any contradictions now. Previously, in China, the responsibility system was not there. All production brigades were there, communist systems were there, the state was controlling what to produce, why into produce, now it is not there, and it will also affect the productivity. Question number two: there was the very fundamental question from Dr Verma or Dr Singh which I do not know. He said, when you have a terrace, in the first year the productivity is likely to go down. Also Dr Yadav and someone else said the land area also may go down. On the one hand, scientists from India say that, if you protect the land by terracing, the productivity in the first year is likely to go down unless supplemented by chemical fertilizers and other means; on the other hand, we have heard from scientists from China that, with terracing we obtain at least 7% growth in the first year followed by 15%. Both scientists must have very good basis for these statements, but as a layman I am confused.

Dr Cheng Shengkui: I would like to answer your first question. In China, as you just mentioned, we previously had many problems, mainly from different prospects, particularly from the farmers and the government. In recent years, we have changed from a central economic planning system to a market economy system. The situation has changed. So, I think the proper policy for reconciliation may be developed out of the problems. The new technology can help farmers increase grain production and income. I think we can do better.

Dr Gu Shuzhong: I will answer the second question. Terracing in Guizhou province was done in the winter. Terraced lands are left for four months. That is one of the reasons for the fertility increase in the terraced land. The second is that terracing can improve the capacity for preserving water and nutrients in the soil. The third is that the soil layer or sowing layer is thickened from 15 to 40cm.

Dr R.C. Maheshwari: Does the terracing organization in China do the terracing on a commercial basis? Did the organization sell the terraced land to the farmers to make a profit? Will there be financial viability?

Dr Gu Shuzhong: No, terracing is not conducted on a commercial basis in China.

Mr Kiran Pyakuryal: In China, the land ownership is still very restricted. The family gets certain land; actually, this is a lease of 50 years. So the private sector’s operation in agricultural land is very restricted. This cannot be done under Chinese agrarian rules. The private sector cannot operate in rural households that freely. There are restrictions on agrarian land ownership, land transfer, and land cultivation. This has happened in India under the land reform act. This is not as free as in the non-agricultural sector.

On the presentation of Mr Ni Hongxing and Mr Li Weigou:

Dr R.C. Maheshwari: In tables one and two, are all these figures the cost invested per hectare or total project cost basis?

Mr Ni Hongxing: They are the total project cost.

Dr R.C. Maheshwari: What is the total project area?

Mr Ni Hongxing: It is about 1,283 ha.

Dr R.C. Maheshwari: Would you explain these figures in detail. How did you get these figures?

Mr Ni Hongxing: This is from my case study. Because this is just a presentation, I have not shown the figures in detail. Details are shown in my case study.

Dr Lee Gyucheon: I think it is very difficult to calculate the benefit and cost. Cost is easier to calculate but to calculate benefit is more difficult. How did you calculate the benefits from water and soil conservation? Because the cost benefit analysis technique is very tricky sometimes, we have to examine the method you have and other things.

Mr Ni Hongxing: In Qinghai, the local authority conducts a lot of research on the economic benefit of terracing. They calculated how much soil can be conserved annually.

Dr R.C. Maheshwari: I would like to have clarification as to what are the plans of the government promoting this, what are the targets in every five year plan. You don’t have any idea of the number of hectares? Are there any targets at the provincial level?

Mr Li Weigou: The terracing project is decided by the local government and there is a financial investment from the central government in terracing. We have terracing targets for the local government, but we can’t reach the targets. The plan is made by the Ministry of Water Conservation.

Dr R.C. Maheshwari: Are there property banks or agricultural banks financing this entire program?

Mr Ni Hongxing: As an incentive for terracing, the central government allocates the money through the financial system in the local governments. Then the terracing in different townships is done manually by the farmers.

Dr R.C. Maheshwari: A followup question could be how your study will be utilized by the local government or county or the provincial government; will they take up your recommendations for implementation?

Mr Ni Hongxing: Yes, of course. Terracing is planned by the community, because, in China, the land is owned by collectives. It is leased to individual farmers. They do the terracing work individually to get incentives from the government.

Dr R.C. Maheshwari: Do the farmers get 100% financing from the government? What is the percentage of loan?

Mr Ni Hongxing: There is no loan from the government.

On the presentation of Dr Lee Gyucheon:

Dr R.C. Maheshwari: He has brought up a very pertinent issue which we scientists who are in the world of technology development quite often miss. As Dr Munda explained yesterday, these technologies are good, but often we do not carry out the kind of social studies which would bring out the social constraints. We are more concerned with the technological constraints, but quite often miss the social part of it. Dr Lee has focused our attention to the social aspect of it and has allowed us to think about the social problems. I will say, in the second part of this project, we should carry out social studies. In Dr Munda's area, all the cost-benefit shows the advantage of terracing compared to jhum cultivation the government of India has been fighting for almost 40 years. Still, we are not able to solve it because socially the farmers are accustomed to it. So, probably whether supported by this program or some other program, I think it is better to carry out these kinds of social studies at our project sites. Similarly, in Dr Singh's area, there are several social problems coming up. While we carry out the technological development aspect, we should also study the social aspects. We must make it a part of our project development program. Side by side, we need to carry out such things as is done for South Korea. I am very thankful to Dr Lee for focusing our attention to this program, and I was so delighted to see that there is an analysis to social problems.

Dr Vute Wangwacharakul: I would like to comment on the graph. I think generally we expect that, when you help the farmers by supporting anything, by credit or direct kind, the marginal cost will drop. It is easier to understand because they can increase the production with increase of cost. It is just a suggestion. I have two questions: the first one is about indicators. I expect that the less the public bathe the better the development. The table clearly shows more development in unfavorable areas. Another one is, I wonder about your development promotion region. What will happen if you put industry in that unfavorable area? Will that induce the people to work in agriculture if you move the people off the land to work in the factories?

Dr Lee Gyucheon: Traditionally in the rural areas, houses are old and they don't have any kind of private bath. So they just go to the stream to take a shower. In the urban areas most houses have baths, so, in that sense, the fewer public baths the better. But in the rural areas, the less the public baths the worse. If government put an industrial complex in the rural areas, the arable land will decrease. But the government wants to find out some support systems to increase the opportunity for the farmers to get extra income from outside of agriculture. So, if the government establishes industry in the rural areas, then their income will increase, and they don't need to move into the cities. If they move into the cities, the cost to government will be greater.

Dr Vute Wangwacharakul: They don't move out. But they will not plant rice, because they work in industry. Everyday they have to go to the factory and work, and they don't want to go to the farm.

Dr Lee Gyucheon: But, in an economic sense, many dwellers in the rural areas want to develop their land in other ways, not just for agriculture, because the land price will go up.

Dr Vute Wangwacharakul: In the presentation, you talked about food support. We need to grow rice and everything. But you want to put factories there. The land is there, but they don't grow rice.

Dr Lee Gyucheon: That's why I told you we had a tragic choice. We need a harmony between them. It's very difficult.

Dr R.L. Yadav: In India, New Delhi, the capital city, was all surrounded by a rural mass with very fertile land. But when Delhi expanded, most of the rural villages came into the boundary of Delhi and the villagers sold their land. The government acquired the land. Those persons a few miles away from Delhi find that agriculture is not a profitable business. But still we say that agriculture is very good. It feeds the world but nobody takes care of it. Your study has very well pointed out, if you put fewer and fewer people in agriculture, your agriculture will develop. Take the example of the USA, only 2-3% people are in agriculture, and the rest are in other businesses. I fully support his view that, whether it is a favorable area or an unfavorable area, still the people do not get the opportunity to move out. They will continue to do agriculture whether you support them or don't support them. If you support them, and all goes well, they may produce more, but the moment they get the opportunity, they try to leave it. They enter another business. That is the common experience, which we are facing. The land under cultivation of a farmer who has a brother or a son who brings in a monthly income, is much more better than that of the farmer who has more land but doesn't have a monthly income. I think the economist should study these also. These are the facts and somebody should bring out these facts into such a forum.

Mr Kiran Pyakuryal: I have one issue which we have been talking about, namely the protection of environment vis-a-vis agricultural production and population. There are two schools of thought: one is very optimistic, which I am, another is alarmist, like World Watch, that everything is going down the drain. But let us see from the historical context. Malthus had predicted that we would not be able to raise production and we would not be able to feed the growing population. In fact, compared to the 18th century, our population is much higher in the 20th century. Historically, in India and China, very frequently there used to be famines in the 19th century. But in the latter half of the 20th century in both the countries, despite the two different political systems, they are successful in feeding their countries. At any time in the historical context in India and China, there is greater availability of food than in the past. So my first conclusion is that there is no need to be alarmist. We have to be positive that it can be done.

The second issue is protection of forests. Which among the developed countries can protect forest now? I will give two examples; one is Japan where 66.5% of the land is under forest. Another extreme is the Netherlands, which has hardly any forest. Both of them have done well environmentally. So there should not be only one indicator to say that developing countries are not doing well policy-wise. A third point concerns China. The land area under cultivation in China is declining actually. It is not because of any invaders from other areas but because of choice. The productivity has gone. If you look at land intensity or the cropping intensity, three countries of the world are in the best position: Egypt, Bangladesh and China, which have the highest. So, I think we should have more ingenuity as human beings. We may sound a little bit pessimistic at times, but human life has basically been sustained. Sustainable development was not brought by you alone. Otherwise, human civilization would have suffered and we should have disappeared from this world a long time back. The1996 food summit was to me more of a pessimistic outlook. If you read the literature of the 1960s, many so-called economists of the world had said that India would suffer a lot of famines. But India doubled food production. If you look at China, Chinese production between 1978 and 1985 jumped by 50%, just because of farmers' ingenuity and because of policy shifts. So, I don't think that natural resources will be exhausted as long as human beings' ingenuity is allowed to flourish.

Dr Lee Gyucheon: I agree that there are two viewpoints, optimistic and pessimistic, but we have to consider the situation. During the last two decades, technological development was so huge that we could produce more and more food even if the population grew rapidly. But, nowadays, the problem is that the rate of development in production technology is declining. In that case, we have to think about this kind of issue.

Mr Kiran Pyakuryal: Can I respond to that. There are two very positive developments in the world at the moment among developing countries. First of all, the population growth rate is also going down both in India and China. These two countries together produce every year twice Australia's population so a slowdown in these rates, 0.1% in India and 0.1% in China, is a big reduction. The second thing comes from the use of technology. If you see the per capita or per unit of use of technology in India and China, it is still far lower than potentially possible in the developed countries. So, there is a big gap between what is possible within the existing technology and what is being done. Let's take chemical fertilizer, inorganic fertilizer: China uses only 300kg per ha, India about 170kg. Now in any developed country, the use of chemical fertilizer per unit of land would be how much? I am not pessimistic.

On the presentation of Dr. Vute Wangwacharakul:

Dr Lee Gyucheon: I would like to know, after market forces or crop commercialization were introduced in the highland, what happened. I think there must be some changes, because the land was originally used by the community collectively, but because of commercialization, the land has become privately owned.

Dr Vute Wangwacharakul: First of all, the community-based management system is just a practice. They have no institutional backup. They don't own land. They utilize the land without the right by law actually. I think they have the right to use the land by tradition. When commercialized agriculture comes in, the people protect their community area, so they are free to utilize other areas. Now the government declared it as forest, so they have to encroach upon forest, because, if they go to another community boundary, they will have some conflict and argument. Regarding the policies, I would say that the basic principle is that, if we want to protect ecology, we have to convince those who stay there. I think one radical policy is not to disturb them. Let them subsist; in other words, don't build roads, don't provide electricity. You don't have to give them anything, just allow them to stay there. If you cannot pursue this policy, I think we have to convince them one way or another. For instance, they are the ones who stay in the watershed, and if you cannot control them, you have to make them your friends by giving them economic incentives. We may charge people down there for the water. We are not doing it in terms of pollution control. But unfortunately it's a little bit too late because we are suffering from an economic crisis now, so if we talk about payment, people will cry. It's not very good timing. But we will have to do it. The question is when and how.

Dr R.C. Maheshwari: I think your experiences are just the same as what we have in a joint management system in India, a forest management system. What you say about forests, electricity and water is the same in India. No politician will come and charge for it, they would rather announce one and after another no free electricity and free water. That is causing great harm to the resources. So, thank you very much indeed. In fact, I must thank all my esteemed experts from China, South Korea, and lastly Thailand, for giving excellent presentations. I personally learned a lot from these presentations and I am sure all of us have benefited.

General Discussion

Dr Haruo Inagaki: When we had some comments or questions from Dr Yadav this morning, I just remembered one of my experiences. When I was working for the Ministry of Agriculture in Tokyo, Japan, a group of the Congress people asked us to estimate the value of the function of farmland together with forest. This was more than 10 years ago. So, we tried to assess the real value of this function. For instance, for the water catchment capacity, we calculated the construction cost for the water dam in the mountain: how many dams we can construct from the value of the water catchment capacity of, for instance, in paddy fields. Actually, it has a very big capacity or availability to prevent floods in the rainy season in Japan. And for instance, generating oxygen by forest: we calculated the price of the oxygen bomb. It was very easy. The estimated value of the function of agricultural land and forest was almost 600 billion US dollars at that time. Then, someone was very much pleased to have this value. They praised us. The farmland and the forest had a very big value in their function. But other persons said: only that much? They were very disappointed. This kind of estimation of the function of, for instance, agricultural land, is very difficult and sometimes it is very easy. Still I doubt how much value that has. But, still at that time I felt that it was important to have some objective sense of economy in doing this kind of thing, because I was working at the Ministry. It was a quite important issue to the people, especially for making a plan at the Ministry or at the Congress. Even if this estimation value was very rough, still it had some value. Therefore, for estimating the value or cost or benefit of a land development or soil improvement, I think it is very important to have an economic sense to make a plan. In my personal understanding, a rural community, for instance, a group of farm villages has three kinds of functions. One function is the economic function in which they produce food and some other materials. The second one is that the village provides space for living, this is maybe called the social function of the village. The third one is the environmental function, which preserves or protects the natural environment, including the farmland. So, when we try to estimate the benefit of the investment to land management or soil management, soil development and land development, we must think about these three dimensions or three functions of the villages. So, under our project, we focused on the natural resources, the cost-benefit of a natural resource. But, even so, we must distinguish some direct effects and indirect effects. A direct effect is: once we develop some terraced farmland, the farmers can grow the crops and they can consume those crops by themselves. This is one function, which we cannot calculate in cash money. And if they can grow more products, they can sell these to increase their income, and then, in addition to this economic value, this investment or land development in making a terrace or bun has other value for the community or village. And prevention of soil erosion is protection of the environment. So, even if we cannot show this value in cash money, this aspect is very important.

A participant from RDA, Korea: Korea and Japan are going to work jointly for the OECD report about soil and water conservation. Generally, western countries say that paddy fields are a problem. There is a lot of methane gas from paddy fields. Thus we are going to evaluate or calculate the function of paddy soil and farmland.

Dr Haruo Inagaki: Maybe you know that some western countries are going to support the establishment of a so-called eco-regional initiative to improve the total agriculture in this region. This is a joint work by, at this moment, the French government, the Netherlands government and the International Rice Research Institute. They have already started the project, so, maybe this is related with the OECD work.

Dr Lee Dongphil: One of my colleagues tried to define the concept of marginal land. The KREI decided that about 20% of our administrative units in Korea belonged to marginal land or unfavorable agricultural areas. But the European countries identified more than 50% of their land belonged to the marginal land. So, I think it is time for us to try to define what the marginal land is, what the unfavorable or less favored areas are. As you know, the World Trade Organization is prohibiting price support policies. So, to avoid that, Korea and some other countries are trying to support certain regions in terms of regional development. In that sense, I think we need to define more clearly what marginal land is and what the less favored area is. I think that is one of our future tasks.

Dr Haruo Inagaki: This is a very important subject. That is a standardization of the term not only for researchers but also for administrative people. If we take other parameters or units, for instance, the unit of the land, length or temperature, we are using slightly different ones. If we say the 'marginal' as Dr Lee mentioned in the discussion, maybe, he used the terms 'unfavored land' or 'unfavorable land'. There are many words. So I think this is a very good subject for the UN body. Once Dr Kedi attended a small conference in Bangkok on the standardization of terms in agricultural development. But he found it was very difficult. Every country is using different units and different definitions. Therefore, as you mentioned right now, a definition is required. What is a marginal land?

Dr Kedi Suradisastra: I am going to contribute a little bit to this discussion particularly on the definition of marginal land. I think it should be connected to the objective of the definition itself. I am not a technical person. I am a sociologist. To me, there is no marginal land, because the technology itself is available for any kind of land, even in Israel. Israel produces the highest amount of milk per animal unit with a kind of land condition, which can be considered marginal from our point of view. The marginality has inter-sectoral connections, and should be very relative to the goal of an activity or discussion.

Closing Remarks

Sangwoo Park[*]

Over the last two days, we have extensively discussed the special issues regarding sustainable agriculture and resource management in marginal upland areas, particularly in Asia and the Pacific. Centered on management techniques and efficient use of soil, water and energy as well as sustainable agriculture, this seminar has brought about remarkable research results and valuable information. I believe they can serve as a solid foundation upon which proper agricultural policies and targeted environmental schemes will be drawn in the future.

In a sense, sustainable agriculture is a two-edged sword: it is to supply a stable food on the one hand and to maintain the environment and natural resources on the other hand. To deal with this difficult challenge in the present and future, we can not afford to stop our research for suitable solutions. For this reason, I believe, this regional seminar is highly significant and delivers important messages on the issues.

Finally, I deeply appreciate the great work done by Dr. Haruo Inagaki and the staff in the ESCAP/CGPRT Centre. Without their support, it would not be possible for KREI to hold the seminar in Seoul, Korea. In addition, I would like to give my special thanks to all participants who greatly contributed to the discussion with far-reaching insights and excellent ideas. Thank you all and have a nice field trip tomorrow.

[*] President, Korea Rural Economic Institute (KREI), Seoul, Korea.

Closing Remarks

Haruo Inagaki[*]

It is my pleasure to observe that the regional seminar on **Resource Management and Sustainable Agriculture in Marginal Upland Areas** was successfully carried out this time in Seoul in collaboration with the Korea Rural Economic Institute.

The seminar started with a comprehensive and keynote speech by Dr. Sang-Woo Park on "Sustainable Agriculture in Korea". The country reports from India and China discussed constraints and future possibilities in land and soil management for the improvement and stabilization of agriculture in the marginal upland areas in these countries. I would like to pay my respects to those national experts of India and China who accomplished this difficult research under the project. We really understood and were impressed by those enthusiastic efforts which have been made by governments, farmers and research people to maintain and to increase food production by giving better treatment to the land and soil in marginal areas. Also, we understand these treatments impact not only on economic aspects but also on the social community and environmental aspects.

In addition, discussions and comments presented by the distinguished guest speakers and participants certainly provided valuable information and new knowledge to the seminar. At the same time, they gave a large number of subjects to study in the related areas and they taught us it is important to have an objective sense of economy when planning and implementing land and soil development in farmland.

The reports and papers presented to this seminar will be published soon. I really hope that this outcome of the project and the seminar will be utilized effectively and further exploited by you and by other member countries in future study and policy planning for sustainable upland agriculture in marginal areas.

Now, I would like to express my sincere appreciation again to Dr. Sang-Woo Park, President of KREI, and the staff of KREI for their devoted cooperation and warm hospitality given to the seminar, and I thank you for your active participation.

[*] Director, CGPRT Centre.

Appendix 1 Program

Wednesday, 20 May 1998

Moderator:
Dr. Kedi Suradisastra

10.00-10.05	Explanation on time schedule and introduction of participants: *Dr. Kedi Suradisastra*
10.05-10.30	Opening Statements *Dr. Park Sangwoo* *Dr. Haruo Inagaki* *Mr. Kiran Pyakurya* *Mr. Suh Gyuyong*
10.30-10.45	Coffee break
10.45-11.45	Keynote address: Sustainable agriculture in Korea. *Dr Park Sangwoo*
11.45-12.00	Introduction of SUASA-2 and its progress. *Mr. Kim Minjae*
12.00-13.00	Lunch
13.00-14.00	Presentation: Economic assessment of selected management practices for efficient use of saline-sodic waters in arid and semi-arid sub-tropical India. *Dr. Mahander Singh* Commentator: *Dr. R.L. Yadav*
14.00-15.00	Presentation: Economic assessment of selected resource management techniques in marginal upland agriculture of Meghalaya (N.E. Region of India). *Dr. Gour Chandra Munda* Commentator: *Dr. N.D. Verma, Director*
15.00-15.15	Coffee break
15.15-16.15	Presentation: Energy audit and measurement of agricultural sustainability *Dr. R.C. Maheshwari*
16.15-17.15	Presentation: Soil and water resources conservation in marginal farmland *Dr. Jung Pilkyun*
18.00-20.00	Dinner party

Thursday, 21 May 1998

Moderator
Dr. R.C. Maheshwari

10.00-11.00	Presentation: Economic assessment of terracing technique in Guizhou Province of China. *Dr. Gu Shuzhong* Commentator: *Dr. Cheng Shengkui*
11.00-12.00	Presentation: Economic assessment of integrated agricultural development emphasized improving water efficiency on terracing in Qinghai Province of China. *Mr. Ni Hongxing* Commentator: *Mr. Li Weigou*
12.00-13.00	Lunch
13.00-14.00	Presentation: Agricultural situation in the areas of unfavourable farming condition in Korea. *Dr. Lee Gyucheon*
14.00-14.15	Coffee break
14.15-15.15	Presentation: Sustainable upland agriculture: The Thailand experiences. *Dr. Vute Wangwacharakul*
15.15-16.15	General discussion
16.15-16.30	Closing remarks *Dr. Park Sangwoo* *Dr. Haruo Inagaki*

Friday, 22 May 1998

10.00-16.00	Field trip

Appendix 2 List of Participants

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