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Evolving Sustainable Production Systems in Sloping Upland Areas
– Land Classification Issues and Options

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(02-AG-GE-STM-05) Report of the APO Study Meeting on Land Classification in Sloping Upland Areas for Sustainable Production Systems held in Japan, 10–17 July 2002

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Land Classification Issues and Options

2004
Asian Productivity Organization
Tokyo

Report of the APO Study Meeting on Land Classification in Sloping Upland Areas for Sustainable Production Systems held in Japan, 10-17 July 2002 (02-AG-GE-STM-05)

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FOREWORD

Slopelands provide food and livelihoods to millions of people in Asia and the Pacific. They are however facing growing problems of population pressure, poverty and environment degradation. Most slopelands have relatively shallow and less fertile soils. The steeper the gradient, the more severe such production problems tend to be. In many slopeland areas productivity is falling and there is decline in yields. An important reason of this resource degradation can be poor planning for development of slopelands for agricultural and other uses. This calls for proper development planning to reverse the above trend and to protect the prime agricultural slopelands.

Proper land-use planning can be supported by appropriate classification of slopelands into different zones for putting them to the right use. In many cases land classification at national level, however, has largely ignored the specific issues of agricultural development on sloping lands. Land classifications systems for lowlands could not be suitable for sloping uplands due to their high heterogeneity and complex terrain. Land classifications developed locally should be more meaningful for stakeholders and have higher relevance in addressing local agricultural production issues. Sustainable agricultural use of slopelands would require integrated use of different land classification tools like GIS, remote sensing and 3-D mapping which could provide comprehensive data and information of the rugged terrain. The active participation of the stakeholders in land-use planning would make the classification more relevant and applicable to the local conditions. Sustainable agricultural land use would require policy incentive to the farmers for their environment protection initiatives.

In view of the importance of promoting sustainable agriculture in upland areas to protect and improve their resource base, APO organized two projects on the subject in 1997 and 2001. As a follow-up this study meeting was organized to discuss land classification issues in evolving sustainable production systems in slopelands, as well as, issues and constraints affecting relevant policies, and formulate measures for improvement of their performance. The meeting was organized by the APO and hosted by Japan in July 2002. This volume contains papers and proceedings of the study meeting. We hope that it will prove useful to all those interested in agricultural development of slopelands.

I wish to express my appreciation to the Japanese Ministry of Agriculture, Forestry and Fisheries for hosting the study meeting, to the Association for International Cooperation of Agriculture and Forestry for implementing the program, and to the resource speakers and participants for their valuable contributions. Special thanks are due to Dr. Tej Partap for editing the present volume.

TAKASHI TAJIMA
Secretary-General

Tokyo
July 2004

SUMMARY OF FINDINGS

The Study Meeting on Land Classification in Sloping Upland Areas for Sustainable Production Systems which was organized by the Asian Productivity Organization (APO) and hosted by the Government of Japan was held in Tokyo from 10 to 17 July 2002. The program was implemented by the Association for International Cooperation of Agriculture and Forestry (AICAF) in cooperation with the Ministry of Agriculture, Forestry and Fisheries (MAFF). Seventeen participants from 15 member countries and five resource speakers from IRRI (International Rice Research Institute), India, Japan and U.S.A. attended the study meeting.

The objectives of the study meeting were: 1) to review the application of land classification in sloping upland areas for sustainable production systems; and 2) to identify issues and constraints affecting relevant policies and suggest measures for improvement of their performance.

The study meeting started with the presentation of resource papers by the selected experts. The resource papers focused on the following specific topics: 1) Land Classification for Sustainable Production Systems in Sloping Upland Areas of Asia and the Pacific: Issues and Strategies; 2) Methodologies for Land Classification for Optimizing Agricultural Use of Sloping Uplands of the Asia-Pacific Region; 3) Land Classification for Promoting Sustainable Agricultural Use of Sloping Uplands – A Case Study of Terraced Paddy Fields in Japan; 4) Spatial and Temporal Considerations Associated with Achieving Sustainable Steepland Agricultural Production; and 5) Direct Payment Policy for Sustainable Farming in Hills and Mountains of Japan. This was followed by presentation of country reports wherein the participants reviewed the recent developments in land classification in sloping upland areas for sustainable production systems in their respective countries, workshop (syndicate discussion) and the field studies in the Niigata prefecture, respectively.

The highlights of the study meeting are given below:

HIGHLIGHTS OF THE RESOURCE PAPERS

Land Classification for Sustainable Production Systems in Sloping Upland Areas of Asia and the Pacific: Issues and Strategies (Dr. Tej Partap)

Slope lands constitute an important segment of landmass. These are sensitive to disturbance and register marginal productivity with limiting soil conditions. However, slope lands can be made highly productive under appropriate land use systems. These lands can produce numerous high value cash crops like fruits and off-season vegetables. Since these are the habitats of wild animals and have beautiful landscapes, terraced fields and grasslands, they are ideal for eco-tourism. Further, because most of the flatland in the world have already been used, the additional land for feeding the rising population is being made available from the marginal slope lands. These lands have been classified differently in different countries in terms of the uses to which these have been put, degree of slope and other features. The importance of these areas varies across Asia-Pacific countries. For example, Japan has 30 percent of cropland as slope lands; in Korea 33 percent of the farmland consists of sloping land; in Taiwan 73 percent of the land is hilly and mountainous; and in Fiji slope lands account for 19 percent of the total farmlands. In terms of population, these inhabit as high as 35 million people in India followed by China and Nepal with 19.6 and 18.5 million, respectively. The farmers have been using these lands by following different methods like shifting cultivation, terracing, contour bunding, etc. Appropriate sloping land agricultural technologies have further contributed towards improving the productivity of these sloping lands.

The sustainable and productive use of slope lands has given rise to a number of issues. For instance, in countries like Nepal, Bangladesh, India, Pakistan and Bhutan these lands are facing serious problem of soil erosion and land degradation causing decline in productivity and food shortages of varying degree while in countries like Japan and Korea these lands face the problem of out-migration and depopulation because of, among others, decline in job opportunities, decline in social capital and infrastructural development, small plots of land making use of machinery difficult, intricate topography rendering farming non-viable, changing consumption pattern like decline in the importance of rice and increased importance of vegetables, fruits, etc. The gradual change in climate and fast evolving technologies are rapidly eroding natural niches these lands have traditionally enjoyed. The sweeping market and trade reforms have further compounded the problem. The undefined land tenure system, lack of infrastructural facilities, lack of agribusiness and agro-industries, inadequate market access, higher input prices, lower product prices and non-availability of credit also pose formidable constraints in improving upon the productivity of these lands in more remote areas.

The productive use of these lands requires the adoption of strategies compatible with their intricate topography and slope. Some of these could be the combination of agricultural and forestry activities emphasizing food security from planting to harvesting period, cultivating trees with higher commercial value and the cultivation of food crops using natural manure to reduce soil erosion. The adoption of these strategies has helped in the productive and sustainable use of these lands. For example, the success stories of sea-buckthorn in China, horticulture in Himachal Pradesh and large cardamom in Sikkim have many lessons to offer. The documentation of indigenous technologies for protecting these lands, their refinement and wider application also requires immediate attention. The participation of the local people in the natural resource management and conservation by adopting bottom-up planning approach is essential to promote sustainable production systems on sloping uplands.

Methodologies for Land Classification for Optimizing Agricultural Use of Sloping Uplands of the Asia-Pacific Region (Dr. Suan Pheng Kam)

Land classification at national level has largely ignored the specific issues of agricultural use and production on sloping lands. A *priori*, nationally standardized land cover/land use classifications often do not satisfactorily reflect the diversity, heterogeneity and dynamism of agricultural land use on sloping lands. On the other hand, a *posteriori* classifications are diverse, depending on purpose of classification and data source for mapping, arising in problems of reconciling these classifications. However, it may be argued that land classifications developed locally are more meaningful for stakeholders and have higher relevance in addressing local agricultural production issues. The distinctive physical characteristic of sloping uplands is the complex terrain, which poses difficulties in representing three-dimensionality in maps, and in interpolating climatic variables that are influenced by local relief. Also soil type and properties are greatly influenced by local relief, and this high heterogeneity is not sufficiently captured because of the difficulty posed by mapping soils in rugged terrain. To some extent remote sensing technology is able to provide comprehensive geographical data of inaccessible areas while GIS technology provides tools for spatial terrain analysis and modeling. At a lower technology level, 3-D mapping is not only a practical way of depicting three-dimensionality of sloping uplands but when done with community participation, it also offers a process and medium for social interactions in addressing spatial relationships of resource use and management. An additional dimension of land classification is evaluation of the land and water resources for suitability of agricultural use. The complex terrain of sloping lands again poses particular difficulties for evaluation and mapping suitability of the land for the very diverse and dynamic agricultural production systems commonly found in these areas. A case is made that the FAO approach of delineating land units and then evaluating their suitability for land use types is not so appropriate. An alternative way of defining land units based on suitability is suggested, and is demonstrated for a case study in Vietnam. This case study goes beyond land evaluation, using its outputs to explore optimal scenarios of land and resource use for agricultural production, and trade-offs between different development objectives.

Land Classification for Promoting Sustainable Agricultural Use of Sloping Uplands – A Case Study of Terraced Paddy Fields in Japan (Kazuko Endo)

In Japan, most of the farmland is used as paddy fields. Paddy fields are common in flat areas but have also been developed on hills and in small valleys surrounded by the mountains. A paddy field located in the sloping upland areas (SUA) is called terraced paddy field. Such paddy fields have multi-functions. However, after 1980s farmers started abandoning the cultivation of rice in the SUA due to unfavorable rice prices and labor shortage. Still such abandoning of rice cultivation continues due to increasing number of aged farmers and decreasing labor force. Japanese Government has been trying to conserve farmland in SUA keeping in mind its multi-functions. For this purpose an agricultural policy, a “direct payment system for farming in hilly and mountainous areas" called the Japanese-style decoupling was introduced in the year 2000. Such incentives would not prevent from agricultural labor force declining because of aggravating socio-economic conditions of SUA. Proper conservation of good farmland with declining agricultural labor force is a serious issue for agriculture in SUA of Japan.

The question is how to designate good farmland to be conserved as farmland for the future. For this purpose, land use planning is called for. Land classification is used as a basis for planning. Effectiveness of land use based on land classification can be secured through better coordination and shared financial responsibilities among farmland owners and users. However, in reality it is difficult to secure such effectiveness due to lack of proper information or vested interests of owners and users of land. Therefore, it is necessary to evaluate land objectivity and guide farmers to form a consensus based on the evaluation.

To secure effective land classification, a land classification method is proposed. Residents are the main body of land use planning with support from concerned organizations. They create a land classification model to decide land use by mapping each farmland parcel and apply it to create a consensus among the farm households on village land use planning.

The paper discusses procedure of development and application of land classification in Hosono village in Yasuzuka-machi, Higashi-kubiki-gun in Niigata prefecture. Also the results of land classification are discussed and an Independent Land Classification Method (ILCM) is proposed. Application of land classification in Hosono village involves land classification, community discussion, compiling basic information setting criteria for farmland to be conserved, and formulation of evaluation chart. Impact of land classification on their lives and conservation of farmland is also discussed by farm households themselves.

According to ILCM, discussion on land classification can lead to the introduction of specific measures to achieve goals by providing effective basic information and demonstration. In this method independent decision of farming household is respected but needs support from the municipal government, JA (Japan Agricultural Cooperatives) and extension centers, as well as participation of researchers and other experts. Clarification of objectives of land classification, sorting out elements to be examined and examination of data to be gathered are particularly important. Beauty of the ILCM is that it is not only based on active participation and empowerment of farm households in slope land but also bring in local government institutions, JA and researchers as well to provide help in the analysis of data using tools like GIS. This provides strong support to farm households in reaching at meaningful decision for an effective land use classification. It is a collective effort among various stakeholders.

Spatial and Temporal Considerations Associated with Achieving Sustainable Steepland Agricultural Production (Dr. Thomas L. Thurow)

Land with slopes over 30 percent occupies more than one billion ha, approximately 16 percent of the total land area of tropical regions. As population continues to increase there is a corresponding increase in converting steep forestlands to croplands. This pattern of vegetation cover change/land use is often accompanied by a dramatic increase in oil erosion and flooding. For example, during Hurricane Mitch in southern Honduras, the incidence of landslides was 31 times greater on recently harvested croplands than on forest. These data illustrate that it is important that the expansion of steepland cultivation must accompany investment in soil and water conservation.

There are several important spatial and temporal considerations that aid devising and implementing steepland conservation programs. Many development agencies have traditionally focused their planning rationale within the scope of the upland portion of the watershed, stressing the need to foster sustained productivity of steepland systems by preventing erosion and loss of fertility. Given the cost of steepland conservation investments, and the cash value of basic grains produced on these sites, the economic return-on-investment calculations put programs at a disadvantage that focus on upland agriculture alone. However, the economic rationale of steepland soil and water conservation programs is substantially strengthened if the project planning is done at a watershed level, with a strong emphasis on reducing downstream vulnerability to flooding and sedimentation hazards. An example is presented of how GIS analyses are very useful for targeting where investments in sustainable steepland agriculture will also pay the greatest dividends downstream. This duel objective of fostering both sustainable steepland agriculture and maximizing protection of downstream interests has proven to be a powerful tool for prioritizing where investment should be targeted. Indeed, this prioritization model has been adopted by the Inter-American Development Bank and the U.S. Agency for International Development to provide a rationale for funding and targeting soil and water conservation projects on steepland agriculture sites in Latin America.

Another spatial consideration is the scale of research plot designed to help guide decisions as to which conservation technologies should be used. Small research plots (<50 m^2) are best suited for assessing the effectiveness of conservation technologies targeted at reducing inter-rill erosion. Conservation technology decisions made on research plots of this size are, however, not able to be scaled up to field-level applications if larger-scale processes (e.g., landslides) are an important concern in the region. Data that illustrate these dichotomies are discussed.

Temporal considerations that are discussed include the necessity to accommodate adoption psychology by having a stepwise approach to introduction of conservation technologies. Data are also presented to illustrate that the length of the project evaluation period is an important consideration associated with assessment of technologies.

Direct Payment Policy for Sustainable Farming in Hills and Mountains of Japan
(Dr. Masayuki Kashiwagi)

Under the WTO system and the amended Staple Food Law, the perspective of Japanese agriculture has gone from bad to worse. It is a principle of the Japanese agricultural policy to try to improve productivity and raise the international competitiveness in line with the New Agricultural Policy, which was established by Japanese MAFF in 1992. However, agriculture in the hilly and mountainous areas in Japan (the Japanese LFAs) faces great difficulties to follow such policy lines. Rural dwellers hardly resort to stable part-time farmers because such areas are far from the main labor market. In some regions, it is becoming increasingly difficult for ancestral farm households to be succeeded by their heirs. They feel that their farmland cannot be maintained because population has been decreasing. Furthermore, a retreat of price support policy measures, including even rice, is rapidly deteriorating the perspective of agriculture in the Japanese LFAs.

Under such situation, the problem of how to deal with terraced paddy-field farming and how to prevent an increase in abandoned cultivated land, is getting increasing attention because such abandoning of farmland is bound to deteriorate the rural environment and “multiple functions” of paddy-field farming.

Against such background, the Government of Japan; namely, MAFF has decided to introduce direct payment to farmers in the Japanese LFAs from the fiscal year 2000, in order to prevent abandonment of farmland and to preserve its precious multiple functions in those areas. This is the first attempt for direct payment in Japan. In formulating their policy, the direct payments to farmers in the LFAs in the EU studied. The Japanese new policy measures should be consistent with the paragraph 13 of Annex II in the WTO Agreement on Agriculture. However, many people including researchers have serious doubt about its practical effect. Continuation of this new policy depends on just its practical effect, or how it meets people’s expectation, because “transparency of the results” must be an important issue in such kind of policy measures.

After explaining multiple functions of farming and farmland the paper gives a detailed account of meaning and limitations of direct payment to farmers in the Japanese LFAs under the following subtitles:

i. Background of direct payment system in Japan
ii. Meaning and limitations of the system
iii. How should the system be operated?

Thereafter, the paper makes following specific suggestions for the creation of successor system through community agreement:

i. Need to induce creation of a new successor system for community agriculture
ii. Need for community agreements that guarantee formation of new cultivation maintenance system
iii. Need for measures to ease dynamic disadvantageous conditions
iv. Importance of creating ‘core’ receivers of community agriculture
v. Response to the problem of excessively small communities in mountainous areas.

Meaning and limitations of direct payment system in hilly and mountainous areas in Japan are discussed. Although the system still has serious limitations in term of settlement effects and food policy, giving importance to the role of communities in maintaining agriculture and natural resource management. It has certain significance and maybe called as "Japanese-style decoupling". It is, however, essential to operate the system in such a way that will induce the formation of a new successor system for farmland management to ensure its effectiveness. For such operations, the ability of the management body of local agriculture becomes crucial. It is necessary to discuss who should be expected to be the body or how to create an effective body? The system has a serious limitation as a policy for hilly and mountainous areas. Even though local industry policy needs to be established promptly, what the local management body should be like will be a big issue.

HIGHLIGHTS OF COUNTRY REPORTS

Bangladesh

The geographical area of Bangladesh is 147,570 km^2, of which 20 percent is the sloping upland. Out of 22 recognized physiographic units in Bangladesh, four major ones are: a) alluvial plain, 75 percent; b) mangrove forest, 5 percent; c) terrace, 8 percent; and d) hills, 12 percent. Alluvial plain soils are highly fertile, and suitable for rice, jute and wheat production, but extremely vulnerable to flood and drought. Since alluvial plains offer little scope for expansion of command area for alternative crops due to already high cropping intensity, only alternative is expansion of farming to the sloping upland areas, i.e., northern and eastern hills, and the terrace areas comprising Barind, Madhupur and Akhaura tracts. Such sloping upland areas are free from seasonal flooding and thus suitable for growing diversified field crops, horticultural crops, spices, rubber, tea and forest species.

Most of the hills have steep to very steep slopes. Terrace areas are dissected by valleys to varying extent, giving some level of sloping upland areas and other areas with broken relief. Both hill and terrace areas have diverse soil types. Human intrusion in the sloping areas, traditional shifting cultivation (locally called '*Jhum*'), reckless felling of trees, cultivation of annual and perennial crops on steep and very steep slopes are causing severe soil erosion, runoff, landslides and eventually siltation of local stream beds, low lying areas, natural drainage lines and lakes. Shortened fallow period in the shifting cultivation and monocropping on slopping uplands without appropriate soil and water conservation measures are further accentuating the problems of soil loss, nutrient depletion and land degradation.

Several types of classification of land are used in Bangladesh, which require some modifications for upland areas. Use of modern techniques like sloping agricultural land technology (SALT), contour terracing, bench terracing, hedgerows, gabion check dams, etc. in the hills is still limited. To protect the sloping uplands, the paper suggests immediate abandoning of the *Jhum* practice, afforesting the fallow sloping uplands, ensuring land ownership, expanding adoption of SALT, using modern land classification systems for more rationale upland classification and thereby optimizing their agricultural use and promoting multipurpose use of excess rainwater to minimize runoff losses and land degradation.

Republic of China

Taiwan (ROC) is a small island with a broad range of environments. Almost three-fourth of the main island consists of sloping land (i.e., land with elevation above 100 m and 5 percent slope). And nearly half of the total area is above 1,000 m. Taiwan is dominated by forests covering 58.5 percent of the total island. The vast majority of above forests are on steep and rugged slope land. Therefore, sound forestry practices are vital for soil, water and nature conservation. Currently three laws (i.e., the Cultural Heritage Preservation Law, Wildlife Conservation Law, and National Parks Law) and a new scheme of a 'central mountain eco-corridor' are being used to enforce forest management, soil and water conservation, and environmental protection.

Recently a consensus has been growing that forest resources should be managed according to ecosystem management practices. However, the prerequisite process for forest ecosystem management is forestland classification using ecosystem principles. In Taiwan, there is no particular forestland classification system. Therefore, island-wide forestland classification is underway in concert with ecosystem management.

A case study using the Liukuei Experimental Forest of the Taiwan Forestry Research Institute (TFRI) is presented for the use of forestland classification in Taiwan's sustainable forest management. The methods include: (1) developing a forestland classification system including ecosystem delineation using digital terrain model (DTM) and development of hierarchical ecosystem classification using GIS and multivariate statistical analysis; and (2) establishing a forestland classification decision support system (DSS) using an Ecosystem Management Decision Support (EMDS) system for forestland suitability analysis and site selection.

Before the approaches and the results obtained from the case study can be used in Taiwan's forestland classification, some issues and problems encountered in the case study have to be resolved. Such issues and problems are related to: (1) ecosystem delineation using DTM; (2) type of the hierarchical ecosystem classification scheme; and (3) forestland classification DSS. It is suggested that Taiwan's forestland classification should focus on finding solutions to the above problems, particularly for analysis units, the concept of common units is recommended.

To meet the demands of management hierarchies, forest managers should focus on forest management at various scales in addition to using techniques such as DTM, GIS and DSS. Therefore, further challenges to Taiwan's forestland classification are not only to adopt a common ecosystem unit, but also to integrate ecosystem and management hierarchies into GIS and DSS.

Fiji

Land is the main source of livelihood to the people of Fiji. The land is classified according to physical limitations of the land. Based on USDA (U.S. Department of Agriculture) Land Classification System of suitability for agricultural use land is divided into eight categories. About 85 percent of Fiji's area is sloping land. With increasing population number of people living on land as their main source of livelihood is also increasing. This has led to expansion of cultivation to hilly marginal land. The agriculture sector includes cropping, livestock farming, fishing and forestry. To help the people living in rural areas, Commodity Development Frameworks have carried out diversification efforts with an investment of US$69.1 million.

Main issues and problems in classification of sloping upland areas for sustainable agricultural production systems in Fiji are rapid demographic changes, pressure on the production base, over-dependence on the sugar industry, inadequate use of appropriate technologies, lack of physical infrastructure, weak institutional land use in watersheds, inappropriate land use in the coastal margins, lack of information/poor communication, and inappropriate land tenure. The strategy so far adopted for proper land use to enhance land protection is a treatment-oriented land classification system using vegetable barriers. Technical and financial assistance from international donors is needed to address above issues and problems.

India

The sloping uplands are located in the regions of Himalayas, Western Ghats, Eastern Ghats and Vidhya Satpura Hills. There is no systematic survey to delineate these uplands. In India about 93 million ha land is mountainous, of which 51 million ha lies in the Himalayan region. Himalayas are youngest chain of mountains in the world extending over a length of 2,500 km and width of 250-300 km. Broadly the hills of Himalayan region are classified into three longitudinal zones, i.e., i) Great Himalayas (above 3,000 m elevation); ii) Middle Himalayas (with elevation ranging from 900 to 3000 m); and iii) lower Himalayas (Shivaliks with elevation less than 900 m). The sloping lands of hills are sensitive to agricultural encroachments and suffer from soil erosion. The small and marginal farmers have traditionally used sloping lands for subsistence farming despite low yields/farm productivity. The shifting cultivation is being practiced on uplands even with slopes more than 30 percent. In the Himalayan region, about 11 percent of the total area is being used for cropping to support livelihood of most rural households. The key issues are shrinking size of landholdings, erosion from sloping farmlands and decline in soil fertility.

A case study of watershed development in the Doon Valley of lower Himalayas (Shivaliks) supports that scientific farming on hill slopes after developing appropriate site-specific soil and water conservation measures with full people participation is the answer for sustainable use of sloping uplands.

Indonesia

Agriculture remains a key sector to the economy of Indonesia and contributes 20 percent of GDP. Among 55.8 million ha of arable land, upland accounts for 22.3 million ha. So far, upland development has received less attention of the government. During the last 30 years development was focused on wetland, therefore, significant gap exists between upland and wetland productivity.

Several land classification systems have been used in Indonesia. However, only three systems; namely, land classification based on physical characteristics, land use and agro-ecological zoning are discussed. According to the land classification based on physical characteristic, land is categorized into 11 types. Classification based on land use divides the land into five categories depending on degree of slope. Each slope determines the allowable land use. Third classification based on agro-ecological zoning also divides the land into five main categories.

In Indonesia upland development is quite challenging. Most upland is not irrigated, and 65 percent of poor people live in upland areas. Typical climate of Indonesia characterized by intense and heavy rainfall threatens land fertility due to heavy soil erosion and soil degradation particularly in sloping areas. Upland farming is generally dependent on rainfall that restricts cropping option, and shortens safe growing season. Increasing population has also led to resource degradation mainly due to deforestation and disruption of land tenure system.

The Government of Indonesia is promoting sustainable land use by considering watershed as the basic physio-biological and socio-economic unit for planning and management. A participatory approach is followed for the decision-making process. Under this policy a national program for re-greening and reforestation with full participation of people is in progress.

Some of the sustainable farming practices in sloping uplands of Indonesia include alley cropping and agro-forestry. These farming practices involve use of organic matter for fertilizer, recycling of organic matter and minerals, minimizing the use of inorganic matter, and application of soil and water conservation measures. In conclusion, key to sustainable farming on sloping uplands is in learning from nature and evolving specific location strategies for poverty alleviation.

Islamic Republic of Iran

About 30 percent of Iran's 1.6 million km^2 area is sloping uplands. It is mostly dry. Average annual precipitation throughout the country is about 250 mm. Only 8 percent of the country receives between 500 and 1,000 mm of precipitation and only a small part of the country is humid. Increasing soil erosion in steeplands is causing sedimentation in water reservoirs/dams. Another serious problem of upland areas is the migration of poor villagers to the big cities. This paper discusses the issue of upland development citing the example of watershed management strategies in Iran.

Main issues and problems in utilizing sloping upland areas for sustainable agricultural production are subdivision of land into small units, very slow agriculture development, lack of suitable infrastructure such as access roads, lack of suitable irrigation systems in sloping areas, and limited government funds for sloping land development. A multidisciplinary and participatory approach involving all stakeholders is suggested for sustainable agriculture on sloping upland areas in Iran.

Republic of Korea

Soils in the sloping uplands in Korea are subject to intensive land use with high input of agrochemicals and are vulnerable to soil erosion. Development of the environmentally sound land management strategy is essential for sustainable production system in the sloping upland. This paper reports the status of upland agriculture, land use classification system, the best management practices and the government policies and programs.

Soils of Korea are classified into seven soil orders, 19 suborders, 29 great groups, 390 soil series, 501 soil types, and 1,288 soil phases. The dominant orders for upland and paddy are inceptisols and entisols. About 65 percent of Korean lands are occupied by forest and only 21 percent by arable crops. The latter is mostly paddy land and upland. Upland is about 7 percent of the total land. About 62 percent of the upland has slopes higher than 7 percent.

In Korea, land recommendation and classifications are made on the basis of soil properties and other factors limiting crop productivity, such as slope degree, etc. The categories of land use recommendation are upland, paddy, orchard, grassland, and forest. Land in each category is classified into five suitability classes (I to V). The majority of the uplands are in classes II-IV.

The government has developed many policies for sustainable agriculture. 'The Environmental Policy in Agriculture, Forestry and Fisheries for the 21st Century (1996)' and 'the Sustainable Agriculture Promotion Law (1998)' have been the major policies. The main emphasis is placed on reducing pollution and other environmentally harmful effects of agriculture, conserving the agro-environmental resources, and encouraging environment-friendly farming systems. Major policy instruments and activities to promote sustainable management include promotion of model projects for environment-friendly agriculture, designation of promotion areas and model villages, integrated nutrient and pest management (INM, IPM), and subsidies on water quality preservation and nature protection. Compensation for reduction in farmers' income due to the environment-friendly farming such as organic farming and low input sustainable agriculture (LISA) will be subsidized through direct payment policies. The government initiated construction of the computerized soil environment information system in 1998, by employing the GIS tool. However, a specific policy and program on sustainable development of agriculture on sloping uplands and related land classification exercise is underway.

Alpine uplands are located at elevations higher than 600 m. More than 70 percent of the alpine lands have slopes greater than 7 percent. Due to the site-specificity, many managerial and environmental problems are occurring, such as severe erosion, shallow surface soils with rocky fragments, and loading of non-point source (NPS) contaminants into the watershed. A series of field research studies have been conducted to develop the best management practices (BMP) for the sloping alpine uplands. The results reported conclude that the proper management practice is a key element of land classification.

Malaysia

Malaysia consists of three geographical regions; namely, Peninsular Malaysia, Sarawak and Sabah. Each region is made up of coastal plains, river floodplains and uplands. The plains are largely considered suitable for agriculture, but they constitute only small percentage of the total land area. Some of the uplands where the slope is not too steep fall into the 'suitable' category. However, more than 80 percent of land that is considered unsuitable for agriculture is the sloping upland. The uplands at low elevations are being cultivated with tree crops such as oil palm, rubber, cocoa and tropical fruits.

'Highlands' constitute an important part of the sloping uplands where cultivation of tea, several species of vegetables and a range of flowers is expanding. Cameron Highlands, situated at 900-1,800 m above sea level, provide many examples of highland farming practices and problems related to soil erosion, runoff, and the transport of nutrients and chemicals.

Land classification systems in the sloping uplands are based on topography, slope gradient and elevation. In Peninsular Malaysia, the 20º slope gradient is used to separate 'agriculture land' from 'steepland'. Where the gradient exceeds 20º, the topography becomes rugged and slopes tend to be long. 'Steepland' is considered as unsuitable for agriculture. In Sarawak, the 33º gradient is used to separate 'agriculture land' from 'steepland', while in Sabah, the relevant slope gradient is 25º.

Peninsular Malaysia and Sarawak have also adopted land classification according to physiographic units. This system is used in broad land use planning and in providing information on the location and extent of various types of land. There are five broad regions in Peninsular Malaysia, ranging from coastal plains to hills and mountains. In Sarawak, three broad physiographic regions are recognized, but each region is subdivided into several agro-ecological zones.

Sloping uplands that are deemed suitable for agriculture may be further subdivided into different classes based on degree of slope. This classification system was used in a comprehensive set of recommendations on land clearing methods, soil conservation measures and agronomic practices. A more refined classification system is based on land qualities that include soil properties and microclimate needs to be developed in future to help land use planning for upland agriculture.

Mongolia

Mongolia has about 1.565 million km^2 of land where agriculture is limited due to long cold periods. Land use includes farming (5.7 percent), permanent pastures (81 percent), forests and woodland (11.4 percent), and others (1.9 percent). A large part of the agricultural land of Mongolia is the sloping land. About 62 million ha (50 percent) active pastureland is on mountainous area. There is no special or distinct land capability classification (LCC) for sloping lands. The challenges to sustainable agriculture in Mongolia have a different dimension than in other parts of the region. The difficulties of cultivating terrain are made worse by continental harsh climate and the nomadic livestock. Mongolia has 70 million livestock, more than the grazing capacity of the pastures.

The report explains results of a 40-year study on mapping of the Mongolian pasture lands. Issues and problems in sustainable production systems for sloping upland areas of Mongolia include harsh climate, steep sloping lands with shallow soil depth, allocation of 80 percent agricultural funds for pasture land only, reduction in pasture land, reduction in pasture yield by 2-3 times due to erosion of more than 70 percent of soil cover because of high grazing pressure, deterioration of pasture quality, high population pressure on sloping lands especially around urban centers, over-dependence on livestock industry and pastoral farming, lack of awareness about appropriate agricultural practices, low income and nomadic lifestyle of herders, absence of land ownership, poor access to market, and high transport costs. Progress toward sustainable agriculture in sloping lands of Mongolia would require addressing host of above issues.

Nepal

Nepal, a landlocked country is situated in between two great countries; China and India. The elevation of the country varies from 60 m to 8,848 m that creates a range of agro-climatic regimes. Out of a total geographical area of 14.75 million ha, 77 percent is mountainous and out of the total land only 2.97 million ha is cropland. More than 80 percent people depend on agriculture for their livelihood. About 60 percent Nepalese live in the mountain areas, which have 48.5 percent of the total cultivated land. The main crops grown in the mountain areas are maize, wheat, paddy, potato, finger millet, soybean, mustard, barley and buckwheat. Paddy is grown in the terraces. The mountain climate is also suitable for growing different fruit crops such as citrus, apple, banana as well as vegetables, spices and medicinal plants and herbs. Livestock rearing is an important component of mountain farming systems.

The land is basically classified into two categories, i.e., 1) taxational classification (which deals with agricultural land only) and 2) the land system approach (which deals with various agro-climatic zoning). The land system-mapping framework is divided into four regions, i.e., physiographic regions, land system, land units, and land types. There are five physiographic regions; namely, Terai, Siwalik, Mid-mountain, High Mountain and High Himalayas. Furthermore, the land system-mapping framework is divided into 17 land systems, which deals in detail with the land forms and land units.

Major issues in sustainable use of sloping uplands are soil erosion, landslides, less accessibility to market, low literacy, less input supply, poorly managed irrigation system, high population pressure, increasing number of unproductive domestic livestock and non-availability of credit. The paper suggests strategies to address some of the above issues.

Pakistan

Pakistan has 79.61 million ha of geographical area in which sloping uplands constitute about 25.5 percent. Of the total geographical area, 21.49 million ha is cropland, 3.66 million ha is under forest, 24.5 million ha is not available for cultivation and 9.13 million ha is culturable waste. Of the cultivated area 17.32 million ha are irrigated, and 4.67 million ha is rainfed. Wheat, cotton, rice, sugarcane are major crops grown on the irrigated land while wheat, peanut, chick pea, millets and pulses are mainly cultivated on the rainfed land. The crop yields in general are low especially in the rainfed areas.

Much work has been done on land classification in Pakistan including soil taxonomic classification and land capability classification. Reconnaissance soil survey of almost entire reported area of Pakistan has been completed and detailed soil survey of some of the selected areas has also been carried out. According to taxonomic classification, more than 130 soil series have been identified in Pakistan. While according to land capability, there are eight classes. The classes I-IV are arable lands while classes V-VIII are non-arable lands. Unfavorable soil texture, erosion hazard, climatic limitations, salinity/sodicity, hardpan, wetness, water-logging and snow cover are major limiting factors in land use. Soil erosion effects are more predominant in the sloping upland areas. There is more heterogeneity in soil, geomorphologic and climatic conditions of sloping areas that are mainly rainfed.

Small and fragmented holdings, poor economic conditions of the farmers, migration of the farming communities to urban areas and inadequate institutional support are some of the issues and problems being faced by farming in sloping upland areas. Several government and NGOs are assisting the farming communities in their socio-economic development in the form of advisory service, extension service, subsidized activities, human resource development (HRD) and institutional development.

Philippines

Upland agriculture contributes significantly to the socio-economic development of the Philippines. Apparently agricultural production is concentrated in the highland region of the Cordillera Administrative Region (CAR). The CAR is situated at the northern part of the Philippine archipelago and it consists of six provinces; namely, Abra, Apayao, Benguet, Ifugao, Kalinga and Mountain.

The region's population has reached 1,525,000 with a growth rate of 63.82 percent from the year 1985-2000. The region has a total land area of 1,829,368 ha, of which only 18.6 percent is certified arable and rest 81.4 percent is still forestland and unclassified public forest. Because of faulty forest policy, declaring large areas as unclassified public forest most of the inhabitants are legally 'squatters on their own land'. Based on existing vegetation cover, lands are categorized into agricultural lands, brush lands, grasslands, built-up areas, mossy and old growth forests, pine forests, river beds/water bodies and others.

Predominantly very steep slopes to nearly level slopes towards the lowland areas characterize the region. More than half of the total land area has a slope of 50 percent and above. Elevation ranges from 5 m to around 3,000 m. The Cordillera is considered as the locus of vegetable production in the Philippines. It is capable of producing millions of tons of vegetables and crops. It supplies around 70 percent of the domestic market needs and remaining is exported to other countries.

Government interventions are very significant to develop this part of the country. Some of the major policies and programs for sustainable development of sloping uplands include the establishment and management of integrated protected areas, community-based forest management, modernization of agriculture and fisheries, agrarian reforms for rural development, and various donor-assisted projects.

Nevertheless, these upland areas are beset with complicated problems, issues, and concerns that need to be addressed to move Cordillera in achieving its goals. Among others are low productivity and income, inadequate infrastructure, defective marketing system, insecurity of land tenure, continuous forest denudation and environmental stress, and lack of funds for planned development programs.

Sri Lanka

Steep highlands (slope gradient more than 30 percent) account for about 22 percent (1.45 million ha) of the total land area in Sri Lanka. In steep hilly areas the per capita availability of arable land is considerably lower than 0.13 ha. As arable lands become scarce, the farmers in the hilly areas move up steep slopes into marginal lands. Intensive use of these lands for annual crop cultivation without any soil conservation measures has exacerbated problem of soil erosion in the uplands and silt load in the downstream reservoirs. Thus, there is an urgent need for land suitability assessment so that appropriate land uses/crops can be established in these marginal areas.

Since 1940s land selection for various irrigation projects in the dry zone has been based on land classification assessment. However, collection and analysis of data for classification of steep hilly lands are extremely complex due to diverse nature of their physical environment and socio-economic conditions. Therefore, more emphasis should be given on the use of GIS technology in future land classification programs.

The most important single policy document, which is directly related to protection and development of sloping areas in the country, is the Soil Conservation Act of 1951. The commonly used land suitability classification system in Sri Lanka is that of the FAO.

To avoid unnecessary wastage of money, time and human resources, land classification in the hilly areas should be concentrated only where land use changes are immediately needed. It is recommended that annual crops on lands highly vulnerable to soil erosion be replaced with more stable perennial tree-based cropping systems. To realize such a goal, farmers should be given incentives in the form of alternate lands or money.

Some of the other issues and problems are lack of regulation on allocation of land for diverse uses, inadequate coordination among institutions concerned with land use planning, lack of readily available information on land suitability as well as on social, cultural and political constraints, overexploitation of land resources due to lack of land ownership, and lack of awareness and understanding of terminology for land classification. Also the paper suggests strategies to address such issues.

Thailand

Agricultural production in Thailand is generally low and unstable due to erratic rainfall and poor natural resource endowment. Soil degradation, in particular, is a serious problem. Moreover, as population pressure increases, farming is expanding into less fertile areas of low agricultural potential. Also farmland is cropped more intensively without appropriate management practices that has led to lower average yields than those in previous decades. Shifting cultivation in mountainous areas has also led to resource degradation. Cultivation of lands unsuitable for agriculture, such as steeply sloped lands and forestlands, is common.

Since 1963 Land Development Department (LDD) has carried out systematic soil surveys in Thailand. The general approach to soil survey is based on the methods and techniques described in the USDA Soil Survey Manual and Soil Taxonomy with some modifications. The official soil classification system adopted is currently the USDA Soil Taxonomy System. The detailed reconnaissance soil survey of all provinces was completed in 1979. Sloping lands have been defined as lands with a slope of 2 percent and greater.

Thailand has adopted many systems for land classification: the modified USDA land capability classification, soil suitability classification, U.S. Bureau of Reclamation (USBR) economic irrigable land classification, and FAO guidelines for land evaluation. All are used by LDD. The Royal Forest Department (RFD) uses watershed classification to classify sloping upland areas. Thai LDD has found that the modified land capability classification is not appropriate for land use in Thailand, due to different kinds of crops and land use patterns. Therefore, they have developed guidelines for soil suitability classification for 29 specific crops or groups of crops, including paddy rice, upland crops, rubber, pasture, and woodland. According to their potential and degree of limitation for each crop, soils are classified into five classes. Other similar approaches include a modified USBR system, and a modified FAO framework for qualitative land evaluation.

The report discusses evolution and application of watershed classification system in Thailand. The system divides watershed lands into five classes: i) protected or conservation forest and stream headwater areas; ii) commercial forest areas; iii) fruit tree plantation areas; iv) upland farming areas; and v) lowland farming areas.

In the past four decades, much of Thailand's economic growth has been based on a continual opening up of new agricultural land frontiers, particularly in the steep highlands. This has had a major impact, contributing to the deterioration of the natural resource base, and the degradation of the environment. Therefore, issues regarding agriculture, natural resources, and the environment have been included in the National Economic and Social Development Plans, since the Seventh Plan (1992-96), and the emphasis is on sustainability. The goal of the above land use and watershed classification systems is to help those concerned with resource use and planning to make decisions that will lead to better and more sustainable agricultural production and resource management.

Vietnam

Total land area of Vietnam is about 33 million ha, of which 75 percent is the mountainous area with mainly sloping upland. More than 10 years ago, the Vietnam Government set up a specific strategy of the socio-economic development for the resource management of watershed regions. Since 1994 the national project of land evaluation for land use planning of the sloping upland areas has applied land classification methods based on FAO guidelines at different levels to identify suitable land use systems. Agro-ecological zoning is one of the most important factors for the assessment of agro-forestry production systems in sloping upland areas. The key strategy of the development of agricultural production on the sloping upland is to ensure sustainable farming for food security of all mountain people set as a goal under the project on 'Hunger Eradication and Poverty Production for Ethnic Minority'. In addition aim is to increase household income, soil conservation, crop diversification on sloping lands, application of new technologies and land and water management. The paper discusses land suitability classification at national, provincial and district level.

The government has requested Ministry of Agriculture and Rural Development (MARD) to prepare a National Program for Rural Development in Vietnam over the period 1996-2000 with long-term projections up to the year 2010 for whole country and for the sustainable agricultural production in the mountainous regions until 2005. As follow-up to the National Program 327 for re-greening barren hills, a new program named ‘Five Million Hectares of Agro-forestry’ for sloping upland areas has been launched. Main issue is the lack of knowledge of GIS and LIS (Land Information System) technology for land classification and strategy to enhance such technological capacities through international collaboration is desired.

FIELD VISITS

To observe current status of agricultural production systems in sloping upland areas of Japan, participants got an opportunity to undertake a field visit to Yasuzuka Town Office (YTO) and to meet farmers of Hosono village in the Niigata prefecture. A brief account of the visit is as follows:

Yasuzuka Town Office

Mr. Shin Maruyama (Vice Governor), Mr. Eiichi Yokoo (Chief, Village Agriculture Promotion Unit) and Mr. Kinichi Iwasaki (Officer, Village Agriculture Promotion Unit) welcomed the participants. They briefed the participants on different activities of YTO. Yasuzuka-machi is located in the southwest part of Niigata prefecture, adjacent to Nagano prefecture. It occupies an area of 70.23 km^2 and has a population of 3,754 people with 1,220 households and 29 villages. Yasuzuka-machi is surrounded by farmland devoted to rice cultivation. Being a mountainous area the environmental conditions are rough here. It receives an annual snowfall of 2-4 m with lowest winter temperatures hovering between 2ºC and -5ºC. The biggest challenge facing the Yasuzuka-machi is drastic reduction in its population from 11,000 in 1955 to 3,754 in 2002 in spite of all out efforts by YTO to regain the vitality and confidence of the residents.

For this purpose, YTO has established many social welfare, educational, and recreational facilities such as Cupid Valley Ski Resort to refresh people’s minds, Yukidaruma Foundation as a regional consultant for public services, Yasuzuka Jiyu Gakuen (Yasuzuka Free School) to provide education in a cheerful and congenial environment, and Rokuyasan Inn for social exchanges, among others. YTO is promoting the scheme that aims to make Yasuzuka “Japan’s number one welfare township”. The township has also created certain attractions for the urban youth of Japan to encourage them to visit the Yasuzuka. Such attractions include experiencing rice seeding transplantation, supplying quality food products, and experiencing overall rural life. About 200,000 people visit hot springs of Yasuzuka-machi each year.

The mountain agriculture of Yasuzuka-machi is in general characterized by small-scale farming on terraced sloping lands. Major issues in sustaining mountain agricultural production include desertions from villages and migration of people to urban areas, increasing number of aged farmers (70 percent are 65-year old or more), and abandoning of farming activities as more people continue to quit agriculture. The mission of the Yasuzuka-machi Office is to promote agricultural land conservation, develop production strategies, and promote multi-functionality of agriculture. In general, income from agricultural activities is low and unstable except for rice. Future success of Yasuzuka-machi will depend on how they enhance people’s confidence in staying in the township and in continuing farming as well as how to make their agricultural products more competitive through value addition, etc. Participants expressed keen interest in the farming-related activities of the Yasuzuka-machi office by asking very interesting and thought provoking questions.

Hosono Village

Mr. Ohkinata, a farmer and Village Director welcomed the participants. Hosono is a very small village with only 30 households and a population of 90 people. Hosono is a typical sloping mountain village and has long history of cultivating rice on terraced fields. Landslides are common. Since some farmers have been abandoning farming since long and their holdings were fragmented, land consolidation was undertaken for better land use planning. In view of the proposal made by Yasuzuka Township, Hosono-mura has conducted land classification as a model village. Work on land classification in Hosono is regarded as a model-working plan for land use planning of a municipality.

Hosono villagers worked on creating a village by establishing the “Natural Kingdom of Hosono” and through exchanges with urban citizens, which include invitibg applications for ownership of *Koshihikari* rice when it built a facility to make rice cakes, under a prefectural project in 1994, to realize the women’s ideas. Although a woodwork facility and inexpensive inns opened later, residents had a sense of increase in farmers quitting farming and shortage of successors of agricultural production. Due to above factors, Hosono village has undertaken land classification for land use planning to utilize local resources and conserve farmland. Such land classification has been done by the farmers themselves but with assistance from staff of local government, JA, extension center and researchers.

According to Village Director, they are introducing different interventions to enhance farmers' confidence in farming but income from agriculture in general is very low. The village leadership is facing the challenge of sustainable farming and is trying its best to attract people from urban centers through U-turns and I-turns with a hope to increase or at least maintain the number of farm households of the village. For this purpose they have established off-farm activities such as small-scale food processing and woodworks to engage the aged farmers and increase their income through value-addition and establishing small market for purchase of locally produced vegetables. Besides Rokuyasan Inn at the Nature Kingdom of Hosono village is the site of various festivals and events that provide opportunity to local people for social exchange.

WORKSHOP

Objectives

A workshop was conducted: 1) to identify major issues and constraints in land classification for sustainable production systems in sloping upland areas of the APO member countries; and 2) to suggest strategies and action plans (specific activities) to address such issues and constraints. To enhance the discussion and achieve a better sharing of views and experiences, the participants were divided into two groups as follows:

Group I: Bangladesh, Fiji, India, Islamic Republic of Iran, Mongolia, Nepal, Pakistan and Sri Lanka.
Chairperson: Mr. Badri Prasad Bimoli
Rapporteur: Mr. T. M. J. Bandara
Facilitator: Dr. Tej Partap

Group II: Republic of China, Indonesia, Republic of Korea, Malaysia, Philippines, Thailand (2) and Vietnam (2)
Chairperson: Dr. Jae E. Yang
Rapporteur: Dr. Jane D. Toribio
Facilitator: Dr. Thomas L. Thurow

Outputs of Discussion

The outputs of two groups were presented in a plenary session for further deliberations. These thoroughly deliberated outputs are summarized as follows:

Group I

Issues and Constraints	Strategies	Action Plans
1. Policies/approaches		
C Traditional land classification systems not effective for evolving sustainable production systems C Lack of comprehensive integrated sustainable land use policies for improving upland production systems C Absence of policy providing compensation/incentives to upland farmers for maintaining ecological/environmental/ecosystem services through their production systems	C Evolving better systems for delineating production systems using new technologies such as GIS-RS, etc. C Advocate modifications in land use planning approaches to better land use management approaches for existing upland production systems C National policies for providing incentives to upland farmers for maintaining sustainable production systems	C Supporting creation of facilities and trained manpower C Facilitate creation of sustainable upland production system approaches relevant to respective areas and disseminate them C For informed decision-making, ask for area-based studies to find out the nitty-gritty of likely incentive systems to be given

... To be continued

Group I. Continuation

Issues and Constraints	Strategies	Action Plans
2. Access to appropriate technologies for sustainable upland production system		
C Lack of technologies relevant for fragile and marginal upland production systems C Lack of water conservation and management technologies C Lack of NRM (Natural Resource Management)-based production technologies C Need for technologies promoting high value-low volume-non-perishable value-added produce (produce with comparative advantage)	C Focus on generating range of new technologies relevant to fragile and marginal upland production systems C Focus on NRM-oriented production technologies C Focus on generating technologies that give high value-low volume-non-perishable produce to up-land farmers	C Identify institutions for remandating and/or strengthening for generating relevant technologies C Enhance support for technological research in this area C Enhance support for technological research in this area (HRD component included)
3. Institutional infrastructure		
C Absence of research system for generating technologies relevant to upland farming and NRM C Lack of market access to upland produce C How to reduce overhead costs	C Strengthening/setting research systems to address the appropriate upland technology gaps C Create enabling policy/institutional/infrastructure environment for market access to upland produce	C Identify institutions in upland areas for strengthening and provide support for necessary changes C Commission studies for evolving right policies to provide access to markets with comparative advan-tage and encourage policy for-mulation
4. Socio-economic aspects		
C Prevalent poverty of upland farmers because of marginal and limited land resources C Landless poor farming communities C Insecure land tenure C Communal land ownership largely in shifting cultivation and pastoral areas C Traditional systems/practices of NRM and niche production ignored by interventions C Inadequate people participation in production system management	C Evolve strategies that create wider opportunities for upland farmers both on-farm and off-farm C Strategies for on-farm and off-farm livelihood opportunities to landless C Recognizing the value of traditional land ownership systems and find ways to provide protection and user rights to stakeholders C Encouraging people participation through incentives and enforcing regulations about resource use. C Area or community-based development programs and or approaches should have concurrence of local people.	C Developing time bound development projects/programs focusing on widening opportunities for uplanders C Focused development plan/program for the landless C To encourage countries re-examine these sensitive issues, create awareness about advocating the need for such actions through policy studies C Prepare a blueprint for enhancing awareness about the absolute need for people participation for upland production system and the methodologies of people participation. People participation should incorporate cultural considerations too.
5. Access to information		
C Lack of global access to information about appropriate technologies C Lack of access of appropriate technological information to extensionists, NGOs and farmers	C Evolve strategies that facilitate exchange of knowledge and experience about technologies and their impacts C Improve access to appropriate technologies to all stakeholders using various approaches	C Some international organization (e.g., APO) should take the lead in providing support. C Countries need to revisit their extension approaches and modify them accordingly.

Group II

Issues and Constraints	Strategies	Action Plans
1. Social		
C Poverty C Indigenous knowledge/low adaptability of technology/no recognition of the merits of indigenous knowledge C Inaccessibility to basic services such as health, education, communication, etc. C Subsistence living C Traditional life/culture/land tenure issue C Disenfranchise from political process C Population pressure	C Promote the appropriate land use/suitability of land to the sloping uplands/land use planning C Internalization of sound plans in the uplands C Policy enforcement through downstreaming the people C Rural credit systems	C Information and education on sustainable land use systems C Preparation/formulation of implementable investment plans C Watershed as a planning unit in land classification
2. Economic		
C Poverty C Limited investment/lack of capital C Inaccessibility to credit C Poor marketing/trade barrier C Poor transportation/infrastructure C Lack of off-farm opportunities C Ecological considerations of upland are not valued properly in economic terms.	C Downstream people should pay the upstream for conservation. C Land use planning and management should be based on the land classification. C Synchronization of land classification methodologies	C Policy formulation and immediate implementation C Establishment of land classification networking immediately (APO)
3. Political		
C Insecure land tenure C Land use policies are unfavorable. C Policies are for uplands but not for people. C No compensation/incentives for upland farmers	C Land classification be done in context of land tenure security C Carrying capacity should be incorporated in land classification	C Promotion of appropriate/ suitable land use to farmers C Target investment to create options to live within the carrying capacity: building schools and health facilities, etc.
4. Environmental/ecological		
C Environmental degradation C Illegal harvest of forest products C Climatic changes C Pollution	C Transportation/infrastructure should be included as part of land classification criteria (this will affect the type of land use that will be practical).	C Infrastructure investment should be prioritized based on helping area achieve appropriate production strategy, e.g., food production area
C Excessive/inappropriate exploita-tion of resources C Land classification system focus on production but not on risk assessment. C Limitations in database	C Downstream risk associated with steepland use should be an important criteria in land classification C Downstream beneficiaries of steepland management should help cover the cost of the steepland management	C Link downstream sector develop-ment with sustainable upland management (does downstream investment make sense within the context of sustainable water-shed management?)

CONCLUSION

The study meeting afforded the participants an opportunity to discuss the present situation of land classification systems used in sloping upland areas across the APO member countries. It emerged that although different land classification systems were followed, not only among countries but also among different authoritative agencies within a country, common feature of these land classification schemes was that they were based on biophysical traits (e.g., climate, soil, slope, etc.) only.

The purpose of land classification is to serve as a decision-making tool to foster sustainable land use. Current land use classification schemes mainly focus on biophysical aspects of land classification and pay little attention to other multifunctional aspects of steeplands. They have not fully achieved the desired objective of influencing implementation of planning for sustainable production systems in sloping upland areas of the region as a whole. For example, upland drainage could be classified in terms of the water they produce for downstream users or in terms of downstream risk associated with flooding or erosion originating from different types of cover (e.g., annual crops vs. forest). These dimensions of land classification are policy relevant to downstream residents and can help provide a rationale for why it is in the interest of downstream residents to invest in upland systems. In short, steepland classification should have some components that are relevant to downstream interests. Downstream interests should not be artificially separated from their direct connection to steepland classification and its ramifications.

In the current land classification systems there is no connection between the biophysical emphasis on land use and the people-centered definition of sustainable development (meeting the needs of the current generation without harming the ability of future generations to provide for their needs). To reconcile these two concepts, land classification must improve the capacity to integrate the needs of the people with the characteristics of the land. Most land classification systems presume that no investment will be made in making steepland agriculture sustainable (e.g., terracing), therefore they deem that only forests should occupy lands that have a slope over -30 percent. For example, the people of Japan wanted to/needed to produce rice on very steep slopes. It would not be relevant for a land classification system to indicate that rice production on these steep slopes is ‘inappropriate’. Both the USDA and FAO classification systems would indicate these lands should be reserved for forests, but the Japanese farmers have proven that they could install sustainable rice terrace systems on such steeplands. Rather it would be useful to have a component of the classification scheme that would reflect the degree of effort it would take to make the cropping system on such a steep slope stable, i.e., this could be expressed in terms of the amount of energy necessary to stabilize a particular land unit if cover is changed from forest to farming.

Developing a land classification system for sustainable agriculture in the sloping uplands poses several challenges. For example, it is difficult to take an inventory and map sloping lands because of the rough terrain and inaccessibility. Highly diversified agricultural production systems in the sloping uplands and the fragmented nature of many steepland farming systems often result in land classification units that are smaller than the measuring scale of wide-area surveys. Use of alternative technological options to land classification, such as GIS, GPS (Global Positioning System), etc. can facilitate better delineation of upland production systems and better natural resource management planning for each production system. There are several spatial and temporal considerations that can aid devising and implementing steepland conservation programs provided planning is done at a watershed level, with a strong emphasis on reducing downstream vulnerability to flooding and sedimentation hazard.

People are being pushed on to steeplands because of limited opportunities elsewhere to earn their livelihoods. It is hoped that technologically very steep lands can be sustainably farmed if there is a land tenure system that allows for the investment to install and maintain conservation structures. There is a danger however, that steeplands can become a poverty trap (poverty-accelerated intensification-reduced sustainability-poverty) because of their limited potentials. Only outside investment can break the cycle of degradation (e.g., investment in soil and water conservation; investment in creating opportunities for people to leave the steeplands – education and off-steepland opportunity). Participants were impressed by the innovative policies and programs designed to maintain upland farming in Japan for the sake of its multifunctional role including ecological services, agro-biodiversity conservation and intergenerational equity. It provided new direction of thinking to participants, in relation to their respective countries.

Just as understanding a forest requires more than studying individual trees, steepland agro-ecosystems must be recognized based on their inherent potentials. The multi-functionality of steeplands has much potential beyond agricultural production on the fields that must be considered as part of land classification (e.g., watershed protection, food security, population dispersal, aesthetics, etc.)

The study meeting was used as a platform to come to a broad understanding that whole set of new policies, technological tools and institutional support will be needed for evolving sustainable production systems in sloping upland areas of the world in general, and the Asia-Pacific region in particular. Further, the study meeting was able to catalyze a process of fresh thinking on the subject, which would help policymakers, planners and implementing officials to readjust their focus and revise their strategies for sustainable development of sloping upland farming systems.

1. LAND CLASSIFICATION FOR SUSTAINABLE PRODUCTION SYSTEMS IN SLOPING UPLAND AREAS OF THE ASIA AND THE PACIFIC: ISSUES AND STRATEGIES

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THE SLOPING LANDS

The main feature of uplands is the slope. Sloping conditions are generally unsuitable for cultivation without implementation of other measures. These lands are generally considered fit for forests. Based on degree of fragility, resilience and productive capacity as basic factors, Scherr, *et al*. (1995) classified uplands into three categories viz. sensitive to disturbance, marginal but productive with some limiting soil conditions and highly productive under appropriate land use approaches.

Upland farming is broadly defined to include all activities such as cropping, horticulture, animal husbandry, forestry and their inter-linkages and is a prime source of livelihoods of mountain farmers. The sloping lands by virtue of intricate topography and rich biological resource have the potential of producing a variety of produce in variety of farming niches. Slope lands should not only be viewed purely from agricultural production point of view. They contribute towards development and sustaining livelihoods in a variety of ways. These areas are reservoirs of biodiversity and have huge potential for eco-tourism because of being habitats of wild animals, beautiful landscapes, terraced fields and grasslands. The importance of sustainable management of these lands also arises from the fact that in many countries of the developing world, flatlands have become scarce and additional land for feeding the increasing population shall come from the sloping uplands.

The traditional ways of sloping land use include farming, fruit farming, rangelands, pastures and forests and accordingly different kinds of systems have evolved in different regions. However, Asia region also has a history of institutional interventions to promote use of sloping lands according to technically classified categories based on slope degree. The region has mixed experience in this regard. This paper looks at sloping land classification from different angles; traditional ways, technical recommendations and ecological principles. Discussion points in the paper are covered under different sections as follows:

- People, livelihoods and sloping lands of Asia Pacific
- Traditional systems/practices of sloping land use in the uplands of Asia-Pacific
- Official land use classification systems – of how much value to people?
- Can sloping lands have sustainable production systems?
- Guiding principles for evolving sustainable production systems on sloping lands
- Issues and strategies.

SLOPING LANDS OF ASIA-PACIFIC AND LIVELIHOODS

Sloping uplands are dominant feature across Asia-Pacific region. In almost all countries sloping uplands are also home to farming communities, which have been instrumental in evolving a variety of upland farming systems to sustain their livelihoods. Croplands on sloping lands, rangelands and forests, all are used in different ways to eke out a living. Table 1 reflects extent of sloping land in Asia-Pacific and the number of people dependent on these lands for their livelihoods. Such as, Japan has 30 percent of cropland on sloping lands. In Korea, 33 percent of the farmland consists of sloping land while in Taiwan, 73 percent of the land is hilly and mountainous. In Fiji, 19 percent of farmland is sloping land.

Table 1 shows that a significant proportion of the total population depends on slope lands for their livelihoods; in different Asian countries the upland population varies; it is 35 millions in India followed by China and Nepal 19.6 millions and 18.5 millions, respectively. While in other countries such as Philippines, India and Bangladesh there is a significant percentage of sloping land between 8-30 percent. In others like Bhutan, Nepal, China, Papua New Guinea, high percentage of the sloping land is beyond 30 percent. The population density on the sloping land is as high as 126 persons per km^2 in Nepal and as low as 20 persons in Myanmar.

PURPOSE-SPECIFIC TRADITIONAL WAYS OF CLASSIFYING SLOPING LANDS

For centuries, the folk classification or categorization of sloping lands by the farming communities was largely based on their perception of most appropriate and sustainable use of these land resources. The major indicators of traditional classification or categorization of sloping lands are available to us today in the forms of widely known farming practices on the sloping lands such as terracing, shifting cultivation and grasslands, rangelands, etc. Forests in uplands were invariably managed on sloping lands of all kinds from gentle slopes to very steep slopes. The latter practice also formed part of the formal institutional interventions in almost all countries and therefore, today, we find that most forests are on sloping lands.

Terracing

Terracing is an important widely known indigenous technology devised by upland farmers to manage sloping lands of different categories for sustainable use. Terracing is that crucial process which helps develop sloping lands of various degrees as cropland for farming. It helps reduce soil erosion and maintain fertility. The scale of terracing can be gauged from the fact that 30 percent of the cropland in Nepal (Land Resources Mapping Project [LRMP], 1986) and 30 percent in Bhutan (Thinly, 1991), almost equal percentage in India, Pakistan and Chinese Himalayas is under various forms of terracing (Das and Mahajan, 1988).

Sloping farmlands are managed by forming a variety of terraces, each reflecting the physical and social attributes of the village lands where they occur. For example, irrigated rice terraces are flat and rainfed terraces tend to be gently sloping so as to join terraces at different levels. Therefore, each region has devised its own system of terracing depending upon its climate and other factors like local soil conditions, regional climatic conditions, cropping preferences, local productivity, profitability, etc. Measures like hillside ditches, bench terraces built along the contour line, grass barriers, i.e., planting grass on strips along contour lines at suitable distance, cover and mulches, applying live vegetation and vegetation residues, and stonewalling are the most common measures adopted for soil conservation.

A prerequisite for a sound terracing systems on sloping lands was that the farmer should be able to maintain the fertility of the soils. It is here that the system is no longer functioning in many places. The lack of management of the traditional terracing system is due to decline in productivity of the marginal sloping lands. Therefore, the improvement in the productivity of these lands is essential to realize the positive impact of the terracing system (Carson, 1992).

Shifting Cultivation

Shifting cultivation is a popular sloping upland farming system practiced by indigenous ethnic farming communities living in humid tropical and subtropical parts in several countries of Asia-Pacific. A large proportion of the cultivated land with varying degree of slopes is under the shifting cultivation in many countries. In Bhutan 32 percent of the total cultivated land is under shifting cultivation. In northeastern Himalayas, shifting cultivation or *jhuming* is predominant land use system providing livelihoods to 1.6 million tribal people over an area of 426 million ha. In south Yunan province of Chinese Himalayas, the shifting cultivation covered about 90 percent of the farmland, supporting 48 percent of its population (Pei, 1985). Likewise, shifting cultivation is practiced in Chittagong Hill Tracts of Bangladesh, in the hill states of Kachin, Karen, Chin and Shan of Myanmar, parts of northeast India and Bhutan.

Table 1. Sloping Lands and People in the Uplands of Asia-Pacific Region

S. No.	Country	Hilly/Mountain Area (km^2)	8-30% Slope Land Area (percent value)	>30% Slope Land (percent)	Percent of Slope Land Area Above 8% Slope	Population Density ($/km^2$)	Population Inhabiting Slope Land (million)
1.	Bhutan	46,500	12.7	85.3	98	30	1.2
2.	Nepal	147,181	12.7	66.3	79	126	18.5
3.	India	482,920	30.7	21.3	52	73	35
4.	Taiwan	1,647,725	10.0	50.7	61	20	19.6
5.	Indonesia	-	14.5	30.8	45	-	-
6.	Philippines	-	45.6	12.1	58	-	12.1
7.	Papua New Guinea	-	8.6	62.1	70	-	1.4
8.	Afghanistan	390,475	35.1	41.9	77	35	13.8
9.	Bangladesh	13,189	60.5	12.2	72	57	1.2
10.	Myanmar	280,862	37.4	29.1	67	20	5.8
11.	Pakistan	404,195	29.3	35.6	65	56	22.7

Source: T. Partap, 1998a.

Under shifting cultivation both gentle and steep slopes are cultivated for a shorter period of time and then left fallow for several years so that they regain soil productivity/health. This system of agriculture represents a response to the difficulties of establishing settled agriculture in the tropical regions. It is an example of extremely successful human adaptation mechanism to the rigors and constraints of the humid tropics (FAO, 1991). The system functioned well at times when the population pressure on land was low and the swiddeners were leading subsistent lifestyles.

However, today due to increase in population pressure and mainstreaming of the farming communities this sloping land use system is no longer sustainable. The cycle of shifting cultivation has declined from 15-20 years to just 3-4 years, thus becoming environmentally and ecologically unsustainable. It has led to food shortages and increased food insecurity among the inhabitants.

The primary reasons for shortening fallow periods are the classification of fallow lands into forest reserves, or logging concession areas, population growth, immigration and the impact of cash cropping (FAO, 1991). Some countries like Vietnam have initiated programs for the settlement of those engaged in shifting cultivation by providing infrastructure facilities, social welfare programs, institutional finance and necessary technical know-how. Most countries are still far away from finding reasonable alternatives to the use of humid tropical sloping lands for shifting cultivation.

Sloping Lands Use as Rangelands and Pastures

It is centuries old practice of upland communities to make use of marginal sloping lands as grasslands, rangelands and pastures. There are countless examples in every country about private and community owned well-managed sloping grasslands. Prevalence of grasslands has strongly supported evolution of crop-livestock systems in such regions. Using sloping lands as grasslands is also one of the ecologically appropriate options.

In recent decades, a trend has been unfolding about converting grasslands into grasslands-cum-fruit farming areas. In such cases it enhanced economic productivity of these sloping lands besides providing them further ecological stability. There also has been increasing evidence of conversion of these lands into croplands – both, sloping and terraced. Nepal, India, Bangladesh, Sri Lanka, and several other countries of Asia-Pacific are witness to such trends. However, this conversion of sloping marginal lands into cropland and then intensive use of these croplands for agricultural diversification has not been a success story of sustainable farming.

SLOPING LAND ISSUES LINKED TO OFFICIAL LAND USE CLASSIFICATION SYSTEMS

Whatever information is available about the official/technical land use classification systems, it indicates that the fundamentals of all official/technical land use classification, adopted by several Asian countries were based on the suitable use of land without damage. Much of the technicalities in this classification were derived from the land use classification adopted by the U.S.A. and also that this classification system was largely promoted by the departments of forests, soil conservation and watershed development. Even though the classification systems may have been followed by research systems, they were never implemented in agriculture/farming systems development – the main user of land resources in Asia and the Pacific. Table 2 presents the standard land use-cum-land capability classification that most national soil survey and land use departments have been following.

Table 3 is extracted from the general guidelines recommended by land use departments about sustainable use of sloping lands. These broad guidelines are quoted across countries of Asia-Pacific for land use development. How far these guidelines are followed by farmers, will be discussed elsewhere under other section of this paper. The bizarre part is that in many countries most of the agriculture is being done beyond the slope degrees not recommended for farming. It is not to say that it should have been stopped but to put forth the point that the ground realities have never been accommodated/incorporated in this classification system. That also is the major cause why it has not been widely followed in practice. Being far away from ground realities it also meant that research guided by these principles was of no value to farming communities who were using their sloping lands employing traditional ways of land use categorization for farming on their land resources.

Table 2. Land Capability Classification for Sloping Lands: Widely Used by Soil Survey and Land Use Departments of Provincial and National Governments

Class of Land	Percent Slope	Recommended Use of Sloping Land
A. Land Suitable for Cultivation		
Class I	0-1 degree slope	Any crop with proper crop rotation and green manuring to maintain soil fertility
Class II	1-3 degree slope	Contour farming, contour strip cropping and cover cropping
Class III	3-5 degree slope	Intensive agronomical measures such as contour cropping, contour strip cropping and cover cropping
Class IV	5-8 degree slope	Contour bunds and intense agronomic measures. Mostly soil building and soil maintaining crops are able to grow.
B. Land Not Suitable for Cultivation		
Class V	8-12 degree slope	Permanent pasture with controlled grazing
Class VI	12-18 degree slope	Pasture, grasses, and forestry. Grazing should be restricted
Class VII	18-25 degree slope	Forest with restricted felling. Contour trenching as conservation measure
Class VIII	Greater than 20 degree slope	Forests with complete closure to grazing and felling of trees

Source: Michael, A.M. and T.P. Ojha, 1978.

Table 3. Official Land Use Classification for Sloping Lands

Slope (percent)	Recommended Land Use by National Soil Survey/Land Use/ Land Development Departments
1-2	Agriculture with field bunding, land smoothening
2-6	Agriculture but supplemented by graded contour bunding
7-15	Agriculture on terracing and sloping lands
15-33	Agriculture on sloping and terraced land
34-50	Horticulture and silviculture
Above 50	Forests, grasslands

The land use classification given in Table 4 has remained a theoretical concept and is rarely followed. For example, in Hindu-Kush Himalayan (HKH) region countries, sloping lands more than 5 degrees account for 35 percent of the cropland of which 14.2 percent is on the slopes having above 25 degrees. In the tropical regions, land area with slopes greater than 30 percent occupy slightly more than one billion ha, accounting for 16 percent of the total land area. These areas are characterized by low nutrient availability, low level of organic matter in the soils, shallow topsoils, etc.

If the guidelines in Table 4 were to be followed *in toto*, that will imply that most of the slope lands in Asia-Pacific countries will come under forestry. But as reported, in actual practice, much of these lands are under farming systems of different kinds. These guidelines, however, influenced research agenda of National Agriculture Research Systems, which did not give adequate attention to agriculture on sloping lands. Consequently, there has been general lack of suitable technologies for developing sustainable agricultural production systems on sloping lands (Partap, 1998).

Table 4. Example Case of Administrative/Political Area Classification by Land Department: Himachal Pradesh, India

Class	Definition	Area (km^2)*
1. Forestland	All actually forested area of land classed or administered as FOREST under any legal enactment dealing with forests-state or private-owned. Even if not actually wooded, all agricultural encroachments in forest area are also to be treated as forests only.	10,490
2. Barren and uncultivable land	All barren and uncultivable land like mountains, deserts, etc. Land, which cannot be brought under cultivation without very high management costs whether isolated or lies within the cultivated holdings.	1,493
3. Area under non-agricultural uses	All land under buildings, roads, railway, or under water-dams, lakes, rivers, canals, and other non-agricultural uses.	1,986
4. Permanent pastures and other grazing lands	All grazing lands whether they are permanent pastures and meadows or not, including village commons and grazing lands.	11,936
5. Land under miscellaneous tree crops and groves not included in net area sown	All cultivated lands not included under "net area sown" but put to some other agricultural use. Includes land under casuarinas trees, thatching grasses, bamboo bushes and other groves for fuel, etc. that are not included under orchards.	486
6. Cultivable waste land	All lands available for cultivation whether uncultivated or not or taken up for cultivation once but not cultivated during the current year and the last five years or more in succession for any reason. Maybe fallow or covered with jungles and shrubs not put to any use. Called *Banjar Kadim* in revenue records.	1,181
7. Fallow land other than current fallows	All lands that were taken up for cultivation but are temporarily out of cultivation for a period of not less than one year but not more than five years due to poverty, being non-remunerative, water shortage or siltation. Called *Banjar Jadid* or *Deegar Banjar* in revenue records.	207
8. Current fallows	Cropped areas kept fallow during the current year.	559
9. Net area sown	Areas sown with crops and orchards counting areas sown more than once in the same year as one only. Net geographical area under crops and orchards.	5,683

Note: * The total figures are much less than the total geographical area of 55,673 km^2.

CLASSIFICATION OF GEOGRAPHICAL LAND AREA BY THE LAND DEPARTMENT: EXAMPLE OF HIMACHAL PRADESH PROVINCE IN INDIA

During the British times, South Asia region was given a land classification system by the British and it is continuing even today. The countries that follow it are India, Pakistan, Bangladesh, Bhutan, Myanmar and may be several others.

The system is based on ninefold classes of land for easy comparability and management. These 1-9 categories are matched to the cadastrally surveyed area, i.e., the area according to village papers. The data presented in Table 4 for Himachal are as reported in official papers in 1994-95.

In some areas like this example of Himachal, there is, however, one issue and that emerges in several other upland areas – it is about the disparity in quantitative data of reporting areas/classes.

By comparing data in Table 4 and 5 one finds that there is considerable gap. For discussion on sloping land use classification, this means that even if efforts have been made to develop classification systems for sloping lands, their use value for planning diminished because of lack of efforts to gather correct quantitative information.

Table 5. Geographical Area of Himachal Pradesh: Broad Categories and Discrepancies in Quantitative Data

Total area of province (km^2)	55,673 (Surveyor General of India)
Under Forest Department	65 percent (remote sensing reports put it 22.4 percent)
In agricultural use (under Revenue Department)	10 percent (remote sensing reports put it 18 percent)
Other land area	25 percent

CAN SLOPING LANDS SUPPORT SUSTAINABLE PRODUCTION SYSTEMS?

Before discussing sustainable use of any category of sloping uplands, it is necessary to know answers to following two questions: **One**, are the sloping uplands capable of supporting productive agricultural production systems?; **Two**, how much of a threat is the prevailing land use to the sustainable management of sloping lands and for securing sustainable livelihoods to the inhabitants living there in?

Let us analyze the issue, whether sloping lands in general can support productive and sustainable land use systems? Because of the widely held view that cropping is unsustainable beyond 15-degree slope, agriculture research and development (R&D) holds such areas as unsuitable for agriculture development. General principle has been to promote forestry on lands beyond slopes of 18 percent or forbid annual cropping on these lands. For example, in the Philippines, government controls much of the sloping upland areas beyond 18 percent slopes for maintaining forests. That means research will ignore finding solutions to evolving sustainable production systems in these areas. Despite the fact that people do cultivation in these areas and look for technological assistance the most. A large part of the Himalayan region is under sloping land classes ranging from 8 to 30 percent, where most of the people live. Consequently, these upland communities are deprived of the necessary technological support to adopt sustainable production options.

Interestingly, humid sloping lands experience unique meteorological conditions, specifically intense precipitation and high levels of solar radiation. These conditions certainly create high potential for agricultural productivity, even though it may be at the cost of depleting soil moisture reserves and intensify drought effects. Soil characters of different classes of sloping lands also vary widely.

Although initial soil conditions – depth, nutrient content and structure may determine the relative impact of land use and erosion effects, a combination of features ultimately determines the productive potentials and unsustainability status of these soils. For example, much of the highland soils in the HKH region are acidic and are a limiting factor for enhancing productivity of agricultural productions systems.

One also finds that series of misconceptions have evolved around the role of forests in sustainable use and management of sloping lands. Although forests play important ecological role for maintaining the hydrology and soil movement from the sloping uplands, but forests do not help in alleviating poverty of inhabitants of sloping uplands.

Unfortunately, the development planners and government bureaucracy have nurtured misconceptions about the role of forests to the extent that they block adoption of alternative options that can be both ecologically and economically sustainable. Implications of such lost opportunities can be far reaching. This restrictive role of institutions is partly blocking access to opportunities for developing sustainable production systems on sloping uplands.

The development of sustainable production systems on most classes of the sloping uplands is possible. However, it will require that the strategy follows certain guiding principles (Partap, 1998b). The ecological philosophy is that, "Any approach to use a category/class of sloping uplands will be sustainable if it is designed to mimic the control mechanisms that occur naturally in the ecosystems covering such a sloping land category or class". Because of sloping land classes, there are great scopes for searching and adopting structurally diverse land use systems. Agro-ecology and agro-biodiversity associated with diversity of sloping upland habitats further enhance the variety of available opportunities (Table 6).

Table 6. USDA Land Capability Classification for Sloping Lands

Land Classes	Slope (percent)	Slope Description and Use Value
Class I	0-1	Nearly level – suitable for cultivation
Class II	1-3	Almost level plain or gentle slope – suitable for cultivation
Class III	3-8	Almost level plain or moderate slope – suitable for cultivation
Class IV	8-15	Almost level plain or moderately steep – suitable for cultivation
Class V	<3	Stony rocky or marshy land – unsuitable for farming
Class VI	15-35	Steep slope – unsuitable for farming
Class VII	35-50	Very steep slope – unsuitable for farming
Class VIII	>50	Very steep slope, rocky mountains – unsuitable for farming

Source: U.S. Department of Agriculture (USDA), *USDA Handbook*, 1961.

GUIDING PRINCIPLES FOR MANAGING SLOPING UPLANDS SUSTAINABLY

The basic principles of sloping lands use are presented in Table 7 and a brief narrative of these guiding principles is presented as follows:

Identifying and Harnessing Location Specific Niches

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

Recognizing Diversity of Sloping Lands

Developing structurally diverse sloping land use systems erosion impacts can be contained. Varying the shape and size of the disturbances will create islands of cultivation dependent production systems surrounded by natural ecosystems. This can help trap soil from slopes. Agro-ecological diversity also offers potential for developing diverse production systems. Numerous examples have been quoted by Partap (1998b).

Counter Measures for Managing Marginality of Sloping Lands

Sustainable use of sloping lands rests on maintaining soil cover to ensure diffusion of erosive potential of rain. Thus, the production system management techniques will need to focus on maintaining ground cover. The greater the vegetative cover of a farming system on a sloping land, the less the erosion, less nutrient loss and water runoff and more stable the production. Land use principles for sloping areas need to promote multiple solutions rather than uni-dimensional solutions.

Table 7. Sloping Land Categories and Options for Sustainable Production Systems

Ecological Groups	Physical Characteristics	Low Density (<30 persons/km^2)	Medium Density (30-100 persons/km^2)	High Density (>100 persons/km^2)
Sensitive steep fragile land	– Prone to mass movement – Unique biodiversity – Very shallow soils	Steeper Himalayan slopes C Direct population away	Engage population in conser-vation and non-farm activities	Mid-Hills (Nepal/India)
Lower production potential – Sloping – Marginal land	– Limiting soil (e.g., acidic, shallow, erosive, low fer-tility) – Climatic limitations (e.g., altitude, drought-prone)	Frontier of Thailand and the Philippines C Contain/reduce forest clear-ing process	C Southeast Asian acid hill-sides C Increase fertility and main-tain soil cover	C Low potential soils (Nepalese highlands) C Increase fertility produc-tivity farming systems
High production potential – Gentle landscapes with deep soil	– Deep, fertile subsoil – Less erosive soils	– Develop low cost ero-sion barriers	– Develop low cost erosion barriers	C Deep volcanic soils of Java as valley areas in HKH region C Increase productivity C Encourage off-farm income diversification

Source: Partap, 1998b.

Table 8. Sloping Land Use Principles: Some Examples

Principle	Objective	Examples	Practices
Manage diversity and draw benefits from it	While containing soil erosion and degradation maintain vegetation and biodiversity on the landscapes	Promoting wider use of shelter belts, windbreaks and hedge systems	Promoting small plots inter-spaced with natural vegetation
Harness niches of sloping lands	Evolve niches specific production systems	Intensive horticulture farming	Agro-forestry systems
Manage marginality and fragility of sloping lands	Diffuse erosive potential of rain through maintaining vegetation cover	Using ways to add bio-mass to build organic matter	Increase density of planting
Promote minimum soil disturbance and maintain organic matter in soil	Decrease potential for runoff and replenish nutrients lost through harvests	Forest type production systems Farm yard manure (FYM) use, composting	Use of nitrogen fixing species Green manuring
Manage limiting factors to sustainable production on sloping lands	Provide mechanisms for non-erosive runoff, and percolation of water into soil	Stone check dams	Micro basins
Facilitate slope modification	Trap water to reduce erosive runoff and use it for farming	Terraced fields Contour hedgerows	Passive terracing Contour hedgerows

Source: Partap, 1998b.

Ensuring a Balanced Relationship between People and Sloping Lands

To some extent population growth supported by needed technological and institutional tools can lead to better conservation and use of sloping lands (Partap, 1998b). Factors that can influence evolution of practically useful classification of sloping lands for sustainable production systems include land tenure relations, market access, access to technological and institutional innovations and local ecological conditions. Studies have shown that factors, which contribute to unsustainable use of sloping lands and poverty, can also encourage farmers employ sustainable farming practices on sloping lands (Scherr, *et al*., 1995).

Table 7 shows the land production capacities in terms of ecological characteristics and their production potential. In terms of ecological groups, the slope land can be divided into three categories viz. sensitive land which is very steep and fragile and prone to mass movement had unique biodiversity but with very shallow soils. The land with lower production potential is characterized by acidic, shallow, erosive soils with climatic limitations. The high production potential land is characterized by gentle landscapes with deep soils, which are fertile. Such lands have potential to be developed into high productive lands given the suitable technology. Some areas in HKH and Java valley having volcanic soils are examples of these types of lands.

ISSUES AND STRATEGIES

Sloping lands constitute an important segment of landmass in Asia-Pacific. A considerable number of people are dependent for their livelihoods on sloping lands across the region. Even if these are known for their marginality and fragility, there is adequate evidence to show that these lands can support productive productions systems.

Classifying sloping lands for developing sustainable production systems, raises number of issues. On the one hand, in countries like Nepal, Bangladesh, India, Pakistan and Bhutan these lands are facing serious problem of soil erosion and land degradation causing decline in productivity and food shortages of varying degree. On the other hand, in countries like Japan and Korea these lands face the problem of out-migration and depopulation because of, among other things, decline in job opportunities, decline in social capital and infrastructure development.

Sloping uplands have been classified differently by people and by the institutions. One also finds that technical classification of sloping lands is not user-friendly and therefore not widely used. On the other hand folk categorization of sloping lands is done according to their appropriateness. That has helped evolve diversity of farming cultures on the sloping landscapes.

In the technical classification, slope angle is the major consideration and a uniform rule is applied in slope angle-based classification, whatever the landscape diversity. It is general knowledge that physical diversity and diversity of marginality conditions (largely linked to slopes) is so great in the uplands that it will be wrong to use only one parameter – slope angle – for classifying the sloping lands. In this regard, government policies have also not been very helpful. By using standard yardstick of sloping land classification for land capability and land use planning, development of sustainable production systems was harmed in the sense that it blocked much needed technological research investments for improving the sloping land-based production systems.

The potential of sloping lands for evolving particular production systems is very much site-specific and traditional resource management information can provide plenty of leads (ITK) about what kind of sustainable production system can be developed under a particular ecological setting.

Gradual change in climate and fast evolving technologies are rapidly eroding niches potential of sloping lands. The sweeping market and trade reforms have further compounded the problem. The undefined land tenure system, lack of infrastructural facilities, lack of agro-business, etc. are additional externalities that act as influencing factors of sustainability of sloping land production systems.

But do we need classification of sloping lands for evolving sustainable production systems? It is an issue, which needs debate between conservation lobby and development lobby on the one hand; and farming communities and concerned institutions on the other hand.

Strategies

Sloping upland areas have a huge potential, given their natural niches. Sloping lands already support a range of production systems in the uplands. Sloping lands are home to subsistent societies as well as well off-livelihoods operating on commercial production systems. Numerous types of high value, low volume, non-perishable produce, largely come from the sloping uplands. Sloping uplands are also home to many specialty items of agricultural enterprise be it, fruit crops, vegetables, medicinal and aromatic plants.

There are numerous examples to substantiate the fact that different classes of sloping uplands have supported different types of production systems and sustainable livelihoods. In general broad approaches/models that have been suggested for sloping lands include: first, the combination of agricultural and forestry activities emphasizing food security from planting to harvesting period; second, cultivating trees with higher commercial value; and third, the cultivation of food crops using natural manure to reduce soil erosion.

The productive use of the sloping lands requires the adoption of strategies that are compatible with the intricate topography of sloping lands. Some of these could be the combination of agricultural and forestry activities emphasizing food security. The application of indigenous technologies for protecting these lands, their refinement and wider application also requires attention.

Analysis of the various success stories of sustainable production systems on sloping uplands (Partap, 1998b) reveals that it may be irrelevant to classify sloping uplands using single dimension of slope degree and then decide on its capability for sustainable production system. Production and sustainability on sloping lands is very much dependent on several other factors – among them most notable is the type of production systems being promoted.

General scenario of sloping uplands of Asia-Pacific (APO, 1998) indicates that for planning sustainable use of sloping uplands will benefit much by giving due consideration to indigenous knowledge and resource management practices. Success of evolving a farmer-friendly land classification for harnessing potentials of sloping lands will very much depend on how much consideration is given to incorporating this aspect.

In the past, development planners largely adopted conservation-oriented land use classification for the sloping upland areas. Obviously focus was not on developing viable production systems on sloping lands. However, situation is changing today. Land pressure indicators predict that in coming times more and more sloping upland areas will need to be used for supporting increasing hungry people. The sloping upland classification strategy can therefore be designed to facilitate use of more sloping lands – that are suitable for farming and other types of production systems on which people can depend for their livelihoods sustainably.

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2. METHODOLOGIES FOR LAND CLASSIFICATION FOR OPTIMIZING AGRICULTURAL USE OF SLOPING UPLANDS OF THE ASIA-PACIFIC REGION

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WHY IS LAND CLASSIFICATION IMPORTANT FOR OPTIMAL AND SUSTAINABLE AGRICULTURAL USE OF SLOPING UPLANDS?

For various reasons, national-level land classification systems have largely ignored the complex nature of sloping uplands and the diverse way in which these fragile lands are actually being used for agricultural production in many countries in the Asia-Pacific region. From a land use policy viewpoint, the mountainous areas are meant to remain forested. From a national economy viewpoint, the main economic value associated with these areas is forestry rather than agriculture. Traditionally agriculture in the sloping uplands is associated with subsistence-level production systems, commonly of indigenous people and ethnic minorities that are often not included in the mainstream of the national economy.

More recently, the issue of land and resource use in the mountainous areas has increasingly become one of major concern for a number of reasons:

i. There has been increasing pressure of human activities in exploiting the natural resources of sloping uplands, not only by the traditional agriculturalists but also by expanding forestry industry and the movement of lowland populations into upland and marginal areas as good agricultural land in the lowlands are used up.
ii. As the uplands are increasingly exposed to the market economy, the production systems are changing from subsistence to semi-subsistence to commercial mode, resulting in greater agricultural intensification and diversification.
iii. Allover the Asia-Pacific region, there is increasing evidence of unsustainable use of uplands resources resulting in environmental degradation, particularly soil erosion, with severe downstream effects. For example, the disastrous floods in southern Thailand in the early 1990s due to indiscriminate timber extraction prompted the government to take the drastic step of banning logging.
iv. There is mounting international pressure to develop national policies, strategies and actions for more sustainable development that ensure the attainment and continued satisfaction of human needs for present and future generations, under Agenda 21. The growing concern over the environmental degradation of fragile mountainous ecosystems places mountain issues in the environmental and political agenda (Heywood, *et al*., 1994).

Policy decisions relating to agriculture would be taken at more local level by looking at people, institutions and the ecosystem in smaller units that are relatively more homogeneous, e.g., within agro-ecological zones, river basins, watersheds. The policies would need to address different areas of concern, keeping in view the land and water resources and the people who depend on these resources. There is a need for a systematic way of grouping together pieces of land based on similar characteristics for identifying and understanding their utilities – hence some land classification system.

LAND CLASSIFICATION: FOR WHAT PURPOSES?

A classification comprises a systematic framework for putting objects into distinct groups or classes based on certain diagnostic criteria (Kuechler and Zonneveld, 1988). A land classification would therefore be based on criteria that characterize pieces of land, such as physical properties of the land (e.g., elevation, slope); features that are found on the land (e.g., vegetation, water features); and functions of the land (e.g., existing use, planned use). Class boundaries in a classification should be non-overlapping, unambiguous and quantitative where possible.

The main land classifications that are relevant and important for optimizing agricultural use of sloping uplands include land cover/land use classification, classification of land characteristics such as climate, terrain and soil; of tenure and of legal/protection status. These basic characterizations, in turn, may form the basis for derived classifications for specific purposes related to planning and management of sloping uplands for sustainable agriculture, such as land suitability/capability assessment, environmental risk assessment, e.g., soil erosion risk, or disaster mitigation, e.g., earthquake mitigation (Wakamatsu, *et al*., 2001).

Countries and governments develop land classification systems for various purposes:

i. To inventory resource status and value
ii. To provide the basis for taxation
iii. To provide legal protection to land resources, e.g., forests, biodiversity
iv. To facilitate land use planning and natural resource management
v. To guide policy.

It is not surprising that different land classification systems are developed, not only among countries but also among different agencies within a country to serve different purposes, e.g., the forestry sector would use forestry-biased classifications that emphasize forest type, use and zoning categories, while the agriculture sector places more emphasis on agricultural use categories. It is not surprising that some land classification systems designed for multiple purposes reflect a mixture of land cover, use and zoning (i.e., intended or legal use, as opposed to actual use) categories.

PROBLEMS AND ISSUES IN LAND CLASSIFICATION FOR AGRICULTURE IN THE SLOPING UPLANDS

National land classification and mapping efforts often overgeneralize the properties and use of land resources in the sloping uplands. Developing land classification system for sustainable agriculture in the sloping uplands poses several problems and challenges:

i. There are particular difficulties in carrying out land inventory and mapping of sloping lands because of the rough terrain and inaccessibility. This problem is alleviated to some extent by using modern satellite-based technologies like remote sensing and global positioning systems (GPS) for collecting geographically referenced data. However, other kinds of information that require on-location data collection, such as climatic records, are still very sparse and unreliable.
ii. Agricultural production systems in the sloping uplands are highly diversified, transient and dynamic. Different crops may be planted together in the same piece of land, or in different combinations at different seasons in a year, or in different years.
iii. Spatially, planting of crops on slopes is patchy and highly fragmented, often occurring in small pockets that are smaller than the measuring or mapping scale of wide-area surveys.

Besides these practical problems, there are sometimes also sensitive political issues regarding land use by indigenous people and ethnic minorities who lack political voice and may fall outside the official framework of land ownership in government systems where customary rights are not legally recognized. Often their use of land for transient or even permanent agricultural production is not accounted for, thus giving rise to discrepancies between what is officially documented or mapped and what happens in reality. Official land classifications that do not recognize the reality of present land use in mountainous areas would fail to address crucial issues of sustainable land use in these areas.

LAND COVER/LAND USE CLASSIFICATION

Land cover/land use is one of the basic attributes of land. It is important to distinguish between land cover and land use classification. Land cover is the observed biophysical cover of the earth's surface, which is typically vegetation types or other earth surface features where no vegetation occurs, e.g., water bodies, exposed soils, built-up areas. Land use has an additional functional dimension. It describes what and how people make use of the land cover and may, in doing so, alter or maintain it. For example, "grassland" is a cover term, while "pasture" and "golf course" describe different uses of pieces of land observed to have grass cover. Corollary to this, "recreation" may make use of very different land cover types including sandy stretches of beach, patches of grass cover, lakes, and forested areas.

A Priori and *A Posteriori* Land Cover/Land Use Classification

Efforts have been made to develop more "standardized" land cover/land use classification systems. These include "universal" and national systems, e.g., the Land Cover Classification System (LCCS) developed by the Food and Agriculture Organization (FAO) (Di Gregorio and Jansen, 2000), and the Economic Commission for European Standard Statistical Classification of Land Use; and the national systems, e.g., the United States Geological Survey (USGS) Land Use/Land Cover System of the U.S.A. (Anderson, *et al*., 1976).

The "standardized" land cover/land use classification systems are *a priori* systems, i.e., the classes are predefined, covering all possible combinations of the diagnostic criteria, and are independent of the area to be covered and the means used. The advantage of standardization is obvious for national policy, taxation and other land administration purposes. The disadvantage is that a single classification scheme may be too general for some purposes. One solution is to develop a hierarchical classification system whereby increasingly detailed categories are nested within more general categories (Anderson, *et al*., 1976). The appropriate level of detail may be selected to suit specific purposes. Even so, when such *a priori* systems are applied to particular areas or situations, it is sometimes difficult to assign observations, whether made in the field or interpreted from remotely sensed data, to one of the predefined classes.

An *a posteriori* classification system is not based on preconceived ideas of diagnostic criteria and classes, but instead defines classes based on similarity or dissimilarity of observations samples. In being more location-specific, it has greater local relevance, flexibility and adaptability to suit the problem or issue at hand, but at the expense of not being generalizable over larger areas.

Mapping Land Cover/Land Use

Land use/land cover classification systems are not necessarily designed for mapping; non-spatial statistical reporting of many countries routinely use land classifications. However, given the highly spatial nature of land cover and land use, it is inevitable that land classification systems should be amenable for mapping purposes. Mapping may be considered as the application of a land classification in a specific area using a selected map scale. All or a subset of the defined classes constitute the map legend. The legend is scale-dependent, e.g., at smaller mapping scales certain classes that occur in only very small and fragmented areas will be subsumed into mapping units depicting mixed classes.

The map legend is also dependent on the information content of the source data and mapping methodology. The information content of radiometric-based satellite imagery is different from that of an aerial photograph, hence leading to different interpretation about the land cover, even for the same area at the same point in time. For example, the good visual clues of shape and texture from aerial photographs allow better interpretation of forest types based on species composition (through shape of crown and general texture and tones of the canopy), while the good spectral resolution of radiometric satellite data can better distinguish deciduous from evergreen vegetation if taken at an appropriate time in the year. Maps derived from digital classification of radiometric-based remote sensing systems tend to reflect land cover rather than land use. Mapping of land use requires additional human interpretation of how the land cover types are utilized. Alternately, digital satellite data can be enhanced and converted to photographic products for visual interpretation.

Case Example

A case example of land cover/land use studies to capture rapid changes in agricultural land use and development in the mountainous province of Bac Kan in Vietnam illustrates several of the issues mentioned above.

Table 1 lists the standardized Vietnamese land use classification, which is hierarchical. The General Department of Land Administration (GDLA), which is the authoritative government agency for land use inventorying, estimates land use statistics and produces land use maps using this classification. For example, the 1:100.000 scale land use map of Bac Kan province for 1998 has as its legend the lowest hierarchical level of this classification (GDLA, 1998). Although reasonably comprehensive, it is still inadequate for land use classification and mapping to address issues of sustainable agriculture in the sloping uplands of this province. In particular, it does not satisfactorily capture the extensive slash-and-burn cultivation systems that are prevalent in the province. These areas would appear as mosaics of upland crops (including rice), grass, shrubs and scattered trees. On the other hand, the forest classes indicate intended use, e.g., production, protection and special use forests, but do not reflect the reality on the ground.

Table 1. Hierarchical Land Use Classification for Vietnam

1. Agricultural Land

- 1.1 Annual Crops
  - 1.1.1 Rice Land
    - 1.1.1.1 Three crops
    - 1.1.1.2 Two crops
    - 1.1.1.3 One crop
    - 1.1.1.4 Rice nursery
  - 1.1.2 Upland field
    - 1.1.2.1 Upland rice
    - 1.1.2.2 Upland annual crop
  - 1.1.3 Other Annual Crops (flat land)
    - 1.1.3.1 Industrial Crops
    - 1.1.3.2 Only vegetable
    - 1.1.3.3 Only Rush
    - 1.1.3.4 Remaining annual crops
- 1.2 Assorted garden
- 1.3 Perennial crops
  - 1.3.1 Perennial industrial crops
  - 1.3.2 Fruit trees
  - 1.3.3 Other perennial crops
  - 1.3.4 Nursery garden
- 1.4 Grazing
  - 1.4.1 Planted grass
  - 1.4.2 Natural grass
- 1.5 Water bodies for aquaculture
  - 1.5.1 Fish pond
  - 1.5.2 Shrimp pond
  - 1.5.3 Other aquatic animals

2. Forestry Land

- 2.1 Natural forest land
  - 2.1.1 Exploitable natural forest (Productive forest)
  - 2.1.2 Protection Natural forest
  - 2.1.3 Special Natural forest
- 2.2 Planted forest land
  - 2.2.1 Exploitable planted forest (Productive forest)
  - 2.2.2 Protection planted forest
  - 2.2.3 Special planted forest
- 2.3 Forestry Nursery garden

3. Land for Special Purpose

- 3.1 Construction
- 3.2 Transportation
- 3.3 Irrigation
- 3.4 Historic-cultural heritage
- 3.5 Military use

3.6 Mining
3.7 Construction material land
3.8 Cemetery land
3.9 Other special land

4. Residential Land

4.1 Urban residential
4.2 Rural residential

5. Non-use Land

5.1 Non-use flat land
5.2 Non-use sloping land
5.3 Non-use water surface
5.4 Rivers, streamline
5.5 Barren mountain land
5.6 Other non-use land

Source: GDLA, 1998.

Table 2 is a cross-tabulation of the area under these land use categories of the GDLA map with a map using an *a posteriori* land use classification created using manual interpretation of Syst-me Pour l'Observation de la Terre (SPOT) multi-spectral satellite imagery acquired in 1998. The total agricultural area constitutes 46,700 ha, or less than 10 percent of the land area of Bac Kan province based on the GDLA map, while it accounts for 104,000 ha, or over 20 percent, in the other map. The GDLA map grossly underestimates the area under upland crop.

It is noteworthy that extensive areas mapped as the two forest classes in the GDLA map are actually being used for agriculture – 28,000 ha under upland crop and 6,000 ha under the "mosaic" or mixed class. The GDLA classification ignores the fact that vast areas – 17 percent of the total "forest" area – are already under agricultural use. As these areas do not appear in the official land use statistics, the extent of agriculture on sloping lands is likely to be grossly under-represented.

Figure 1 compares the various land cover/land use features that are discernable and interpreted using different data sources at different levels of detail and for different purposes in Bac Kan province, and attempts to harmonize the map legends from the various maps (Castella, 2000). This figure illustrates a common problem faced in trying to reconcile the land cover/land use classifications adopted by different agencies for different purposes, or changes in classification over a time period, largely to accommodate changing or evolving land use types.

CLASSIFICATION OF OTHER LAND ATTRIBUTES

In the context of agricultural development in sloping uplands, the purpose of land classification is to be able to identify the constraints and opportunities for using and managing natural resources in a sustainable manner. Hence besides land cover/land use, other land attributes and their classification are pertinent for natural resource evaluation. Specifically for the sloping uplands, the multiple land attributes should capture the high degree of heterogeneity resulting from the complex terrain, and the dynamism in use. The spatial dimension, and hence mapping heterogeneity and variability in land attributes, is particularly important given the complex terrain of sloping uplands. These needs have not been adequately addressed in land classifications developed for broader use at national level. The important attributes of sloping land and issues relating to their classification are discussed below.

Terrain Classification and Analysis

Sloping uplands have high relief, thus distinct terrain features such as elevation, slope and aspect are important land characteristics influencing agricultural use. Current state of art digital terrain modeling can extend the utility of elevation data for terrain analysis, e.g., deriving slope steepness, slope aspect, watershed delineation and surface drainage modeling. Gridded surfaces of these terrain features generated using GIS (geographical information systems) techniques provide useful representations of the complex terrain for spatial analysis. These surfaces represent continuous values that provide flexibility in setting classification thresholds for specific purposes (e.g., slope steepness thresholds are different for different crop types), rather than the rigidity of *a priori* thresholds associated with contour lines or slope class maps.

Table 2. Cross Tabulated Area of Land Use Classes between Two Different Sources of Land Use Maps for Bac Kan Province, Vietnam

(Unit: ha)

GDLA Map / SAM[a] Map	Lowland Rice and Annual Crop	Upland Crop	Annual Crop	Fruit Tree	Grass	Productive Natural Forest	Productive Planted Forest	Non-cultivated Area	Total (GDLA)
Lowland rice	5,438	56	588	350	200	3,813	2,738	5,788	18,971
Rice on terrace	381	6	63	6	125	131	375	488	1,575
Upland crop	5,213	138	506	544	1,125	17,494	10,856	30,719	66,595
Mosaic[b]	906	150	150	125	25	3,250	2,638	9,806	17,050
Grass	706	44	13	56	2,356	2,063	2,738	5,681	13,657
Medium forest	63	-	-	-	-	1,063	881	2,550	4,557
Poor forest	1,444	294	325	94	200	19,881	5,513	32,044	59,795
Shrub	19,575	794	2,113	3,250	4,700	77,981	45,044	138,650	292,107
Residential area	2,169	63	281	181	181	1,881	1,438	3,244	9,438
Water body	594	-	13	31	-	444	175	975	2,232
Other	-	-	-	-	-	-	38	50	88
SAM Total	36,489	1,545	4,052	4,637	8,912	128,001	72,434	229,995	486,065

Notes: Columns are land use classes from the 1:100,000-scale land use map of Bac Kan province produced by GDLA (1998). Rows are land use classes from interpretation of 1998 SPOT satellite data carried out by the IRRI-Institut de Recherche pour le D-veloppment (IRD) Mountain Agrarian Systems Project for Bac Kan province.

[a] SAM = Mountain Agrarian System Project in Bac Kan province of Vietnam; and [b] refers to a category in the land use map representing mixed and not easily separable land use/land cover types including scrub land and miscellaneous planting of upland crops.

<table>
<tr><td>VTGEO Legend (based on air-photos)</td><td colspan="4">Homogenous dense forest slightly disturbed</td><td colspan="3">Non-homogenous forest disturbed</td><td colspan="3">Non-homogenous forest disturbed to strongly disturbed</td><td colspan="3">Non-homogenous area of shrubs mixed with growing trees</td><td>Bare soil surfaces</td><td>Terraces</td><td>Lowland rice</td><td>Residen-tial area</td><td>Sedimen -tation zone</td><td>Open water surface</td></tr>
<tr><td>SAM_R Legend (based on air-photos)</td><td>Dense forest</td><td colspan="2">Medium forest</td><td>Poor forest</td><td>Young forest</td><td>Bamboo forest</td><td colspan="2">Scattered trees</td><td>Shrub lands</td><td colspan="2">Mosaic (scattered trees +shrub+upland crops+grass lands)</td><td>Upland crops</td><td colspan="2">Grass lands</td><td>Terraces</td><td>Lowland rice</td><td>Residen-tial area</td><td>Others</td><td>Water body</td></tr>
<tr><td>SAM_R Legend (based on SPOT image) (provincial level)</td><td colspan="2">Forest</td><td colspan="2">Forest</td><td colspan="5">Shrubs</td><td colspan="2">Mosaic (scattered trees +shrub+upland crops+grass lands)</td><td>Upland crops</td><td colspan="2">Grass lands</td><td colspan="2">Paddy field</td><td>Residen-tial area</td><td>No infor-mation</td><td>Water body</td></tr>
<tr><td>SAM_R Legend (based on SPOT image) (commune level)</td><td colspan="4">Dense forest</td><td colspan="2">Secondary forest</td><td colspan="3">Shrub lands</td><td colspan="2">Mosaic (scattered trees +shrub+upland crops+grass lands)</td><td>Upland crops</td><td colspan="2">Grass lands</td><td colspan="2">Paddy field</td><td>Residen-tial area</td><td>No infor-mation</td><td>Water body</td></tr>
<tr><td>CRES Legend (based on air-photos)</td><td colspan="4">Closed canopy forest</td><td colspan="2">Open canopy forest</td><td colspan="5">Shrub lands/bare soil</td><td>Upland crops</td><td colspan="2">Shrub lands/ bare soil</td><td colspan="2">Paddy field</td><td>Residen-tial area</td><td>No infor-mation</td><td>Water body</td></tr>
</table>

Figure 1. Comparison of Legends from Different Land Use Maps Produced for Bac Kan Province, Vietnam

Note: Thanks to the air-photos, the forest can be divided into two kinds. Hence, there are two toness for “Forest” object in the legend of SAM_R Project (based on SPOT image).

The physical characteristic that is distinct about sloping uplands is their three-dimensionality (3-D). Graphical representations of terrain in two dimensions, i.e., maps, do not convey this 3-D satisfactorily. Digital terrain modeling provides tools for improved visualization of these terrain attributes, e.g., 3-D perspectives in 2.5-D representations draped with other information layers such as land use, and animation of simulated "flying over" the landscape.

True 3-D mapping can be done by making physical scaled-down models of the terrain. It is found that people who are not familiar with map reading can relate better with 3-D models, particularly people living in mountainous areas as they are familiar with the complex terrain. This is the basis for developing 3-D participatory mapping approach for community-oriented resource inventorying (Rambaldi and Callosa-Tarr, 2000). In such an approach, communities are engaged in constructing 3-D terrain models of where they live, and in defining land classifications that are meaningful to them. The physical 3-D terrain model acts as a geo-referenced and scaled spatial integrator for the communities to map the relevant land attributes. Spatial relationships among various land cover/land use and the status of the natural resources are explicit and easy to discern. The process of 3-D participatory mapping itself facilitates collective discussion and negotiation in managing the natural resources within communities (Castella, *et al*., 2001).

Climatic Analysis and Mapping

Spatial complexity of the terrain makes interpolation of climatic variables difficult. While the influence of elevation on air temperature is relatively straightforward (Figure 2 is an example of a gridded temperature surface for Vietnam), more could be done to model thermal differences arising from aspect, using terrain analysis tools that model solar illumination. These thermal differences caused by complex terrain affects plant and animal life and distribution. Terrain effects on rainfall are even more complex, giving rise to rain-receiving and rain shadow areas, and here again there is need for better modeling, quantification and classification of terrain-weather interactions.

Soil Classification and Mapping

Another land attribute of the sloping uplands that has been poorly classified is the soil. Soils of the uplands, which are actually very heterogeneous because of the complex terrain, are often classed as "slope complex" or "steepland soils". This seemingly monolithic category does not reflect the variety of soil characteristics, and corresponding implications of suitability for agriculture, ranging from the fertile valley bottoms to the fragile and thin soils of very steep ground. There is need for developing practical soil classifications that are amenable to simple and low-cost mapping of important soil agronomic properties and are meaningful for agricultural and land use management.

GIS and related technologies can facilitate characterization of the various attributes mentioned above (Oberthur and Kam, 2000) and provide flexibility for multidimensional land classification to be used in resource evaluation (Kam, *et al*., 2000). The latter is discussed in greater detail in the next section.

FROM LAND CLASSIFICATION TO LAND EVALUATION

Classifications of basic land attributes mentioned above would be used in evaluating the capability and capacity of the land and its resources to support agriculture and other uses. Land evaluation involves matching the qualities of the land with its use or intended use.

The FAO Land Evaluation Framework

The FAO framework for land evaluation (FAO, 1976 and 1993) offers a systematic way of classifying land according to its suitability for some intended use. In this framework, land evaluation is carried out on a land unit (LU). The land qualities (LQ) of the LU, which are interpreted from its land characteristics (LC), are matched with the land use requirements (LUR) for particular land use types (LUT) to determine the suitability of the land unit for the intended use. The result of land evaluation itself can be considered a form of land classification, in that it characterizes and classifies the land in terms of suitability, which is derived from basic land classifications of climate, terrain, soil types, etc.

The FAO framework can be implemented with an explicit geographical dimension whereby the LUs are spatially delineated, using GIS techniques. A spatial LU would be a contiguous piece of land that is relatively homogeneous in a number of biophysical characteristics that determine its potential or suitability for particular uses.

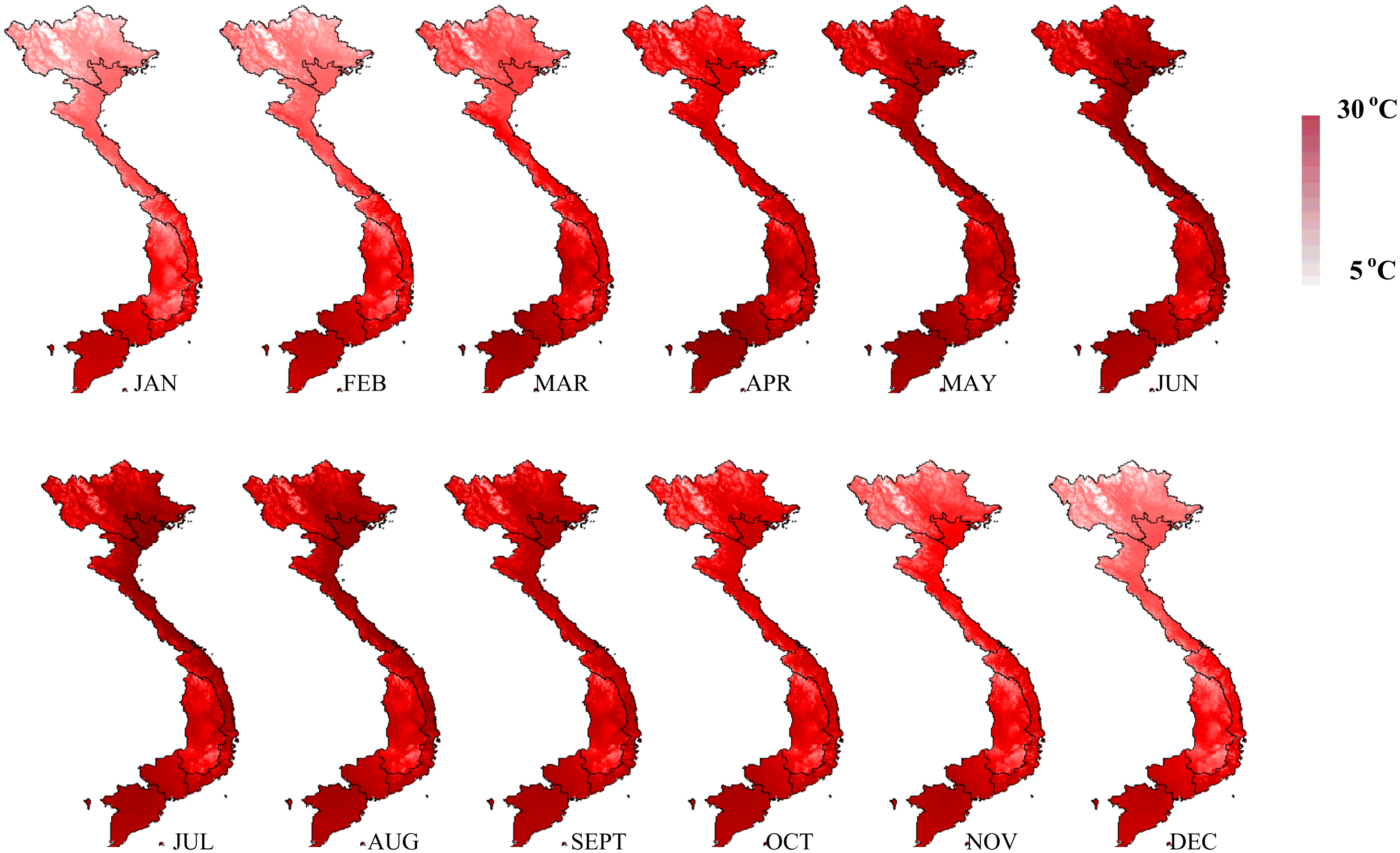

Figure 2. Gridded Average Monthly Temperature Surfaces for Vietnam

The delineation of LUs in the GIS is most commonly carried out in the vector mode by overlaying input maps of various themes, each thematic layer constituting a key biophysical or socio-economic factor determining land suitability, and comprising polygons representing discrete classes or categories of that factor. For example rainfall zones are defined by thresholds of annual rainfall amounts, while temperature regimes are classes of temperature ranges or interpreted as length of growing period that have influence on crop growth. Similarly terrain may be represented by a map of slope classes, while soil maps are inherently drawn with discrete boundaries. The resulting LU map consists of polygons that are intersections of the polygons from the input map layers. Each LU thus formed is considered homogenous with respect to all the characteristics that define it.

Case Example

Again here, Bac Kan province in north Vietnam is used as an example of land evaluation and classification of sloping uplands for agriculture and other uses. Bac Kan province, covering 480,000 ha, has complex relief and arable land is limited and highly fragmented. A methodology and decision support system – the Land Use Planning and Analysis System, LUPAS in short (Hoanh, et al., 2000) – was developed for exploring scenarios of optimizing land use for sustainable agriculture in this mountainous province, which is also among the poorest in Vietnam.

Land evaluation is fundamental to the LUPAS methodology. It is carried out to assess if the existing or intended use is appropriate or can be supported by the resource base, or conversely for what kinds of uses the land is suited or has potential for. In the case of Bac Kan province where agriculture is largely subsistence or semi-subsistence in nature, farmers grow a variety of crops in a variety of combinations of different crops grown indifferent seasons of a year. Each combination of crop seasons is considered a LUT. A LUT may consist of only one crop (e.g., summer upland rice only, or a perennial crop), or have combinations of two or three crops grown in different seasons of the year. For example a two-crop LUT may comprise summer rice followed by winter vegetables; a three-crop LUT may be spring rice followed by summer maize and winter potato. Each LUT would have specific biophysical requirements of slope, soil and climatic conditions (Kam, et al., 2000). For Bac Kan province, 42 LUTs comprising combinations of 18 different crop types were determined to represent the most common cropping systems adopted by farmers. The qualitative phase of land evaluation is done by determining the suitability of the land for each LUT.

If the FAO land evaluation approach is followed, one would start by delineating LUs for the province. Figure 3 is the LU map for the province, generated in the vector mode using thematic layers of soil properties, slope and climate. The Figure shows the complexity of the resulting LU map for areas of high relief and heterogeneity. Starting with 24 soil classes, seven soil texture classes, three slope classes, three climatic (rainfall) zones and 122 communes, we obtained 2,713 polygons of 47 LUs. In the interest of keeping the number of LUs manageable, there is a tendency to restrict the number of input map classes for each thematic layer, at the expense of overgeneralizing the value ranges of the variables concerned. The map also illustrates the limitations of representing continuous variables like terrain and climatic variables in vector mode. Discretization of continuous variables such as rainfall, temperature and terrain into predefined zones imposes rigidity on the thresholds in evaluating the specific suitability of the LU for a range of crops and LUTs. For example, the slope thresholds for determining crop suitability differ

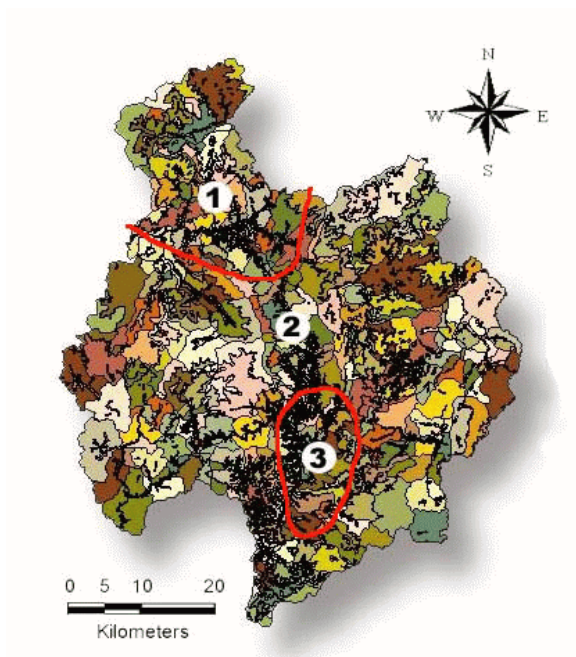

Figure 3. Land Units Delineated Using Vector Mode; Bac Kan Province, Vietnam

with the kind of crop. Similarly, climatic requirements (e.g., temperature thresholds) differ among crops and cultivars depending on the physiological range of adaptation. Even for the same crop the suitability for cultivation is season-dependent. Once categorized into discrete zones based on time-aggregated values, e.g., annual rainfall, average temperature, length of growing period, the climatic characteristics are assumed to be uniform geographically throughout each zone, and does not reflect seasonal variations. This does not allow for crop- and season-specific evaluation of suitability for each LU. This example shows the disadvantages of vector approach to delineate LUs first and then carry out land evaluation for the LUs, particularly in areas of high relief.

Kam, *et al*. (2000) developed an alternative strategy for land evaluation of complex cropping systems in a heterogeneous environment using the raster GIS approach, whereby the area of the province is divided up into a regular grid of squares, each being 250 m on a side. We first considered the time-invariant factors, i.e., match the terrain and soil conditions against the requirements of particular crop types (e.g., maize, rice, potato, etc.) Thus the slope-soil-crop suitability was determined for selected crop types at each cell in the raster representation of the province. Grid cells having similar slope-soil-crop suitability for the selected crop types were then clustered into LUs.

In the next steps of the qualitative evaluation, the dynamic factors are taken into account by:

a) matching, for each LU, the climatic (seasonal temperature and, for non-irrigated conditions, rainfall) characteristics with the requirements of the crop season to determine crop season suitability, e.g., a LU may be more suitable for summer rice than for spring rice because of temperature constraints; and
b) determining, for each LU, the combined suitability of LUTs, which are specific combinations of crop seasons.

Figure 4 shows the LUs, which are clusters of grid cells. Associated with each LU would be the suitability ratings for each LUT, which constitute the outputs of the land evaluation exercise. This "evaluate first, then aggregate" approach was developed to overcome the limitations of the FAO approach, particularly in dealing with multiple crops in different seasons and with high spatial heterogeneity of environmental factors.

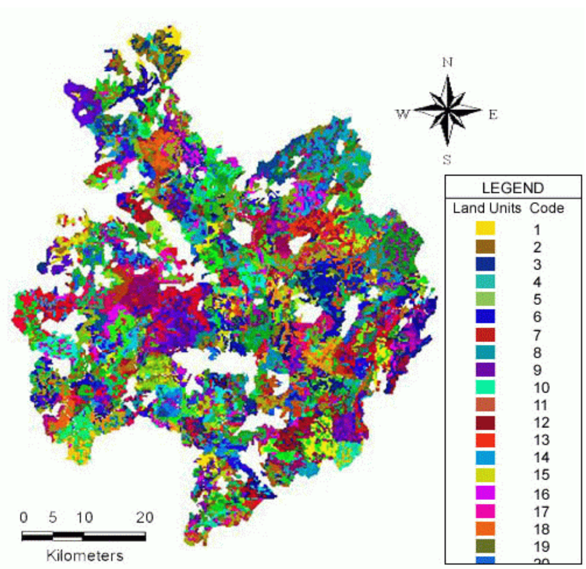

Figure 4. Land Units Formed by Clustering Gird Cells Based on soil-Crop Suitability; Bac Kan Province, Vietnam

FROM LAND EVALUATION TO LAND USE OPTIMIZATION

The outputs from the land evaluation exercise may be considered as value-added land classifications that can be used for determining optimal agricultural land use scenarios, using decision support tools like LUPAS. The LUPAS uses multiple goal linear programming (MGLP) for modeling optimal land use based on user-defined development objectives (which are translated into objective functions) under certain assumptions about resource availability based on the land evaluation and quantification of the available land, water, labor and capital resources (which are fed into the model through input-output tables). The results indicate which LUTs are selected in each LU, how much resources are needed, and the production and incomes expected.

Decisions to be made on allocating limited resources to meet certain development objectives as well as the needs of rural communities involve having to consider trade-offs among different development objectives. For example, a resource allocation scenario based on self-sufficiency in food production can be very different from a scenario that targets profit maximization.

Figures 5 and 6 show the results of exploring various land use scenarios for Bac Kan province. Figure 5 shows the trade-offs between two objectives of maximizing food production and of maximizing annual regional income. The curves lift upwards from (a) to (f) as more resource constraints are removed. When land is the only constraint, the optimal curve (f) is highest, while with all constraints in land, capital, water and labor (i.e., no sharing or movement of labor among villages) the optimal curve (a) is lowest. The current situation (white star) represents the present focus on food production by local people at present. The distances between the curves (a), (b) and (d) clearly indicate that availability of capital and water are two major constraints. The change in direction of curves from (a), (b) and (c) to (d), (e) and (f) shows that when water and capital constraints are removed, food production increases faster than regional income. A large gap between curves (d) and (e) compared with minor gap between curves (b) and (c) indicates that labor sharing would have significant effects only if water and capital constraints are overcome.

Figure 6 shows the main LUTs under two extreme scenarios when land resource is the only constraint: maximize regional income without requirement of food production, i.e., point I in curve (f), and maximize food production without paying attention to regional income, i.e. point F in curve (f). In the first scenario, suitable fruit trees and two or three cash crops are selected, while in the second, obviously food crops such as rice and maize predominate.

The Vietnamese government is now adopting the LUPAS methodology as a decision support tool for land use planning at province and district level.

CONCLUSIONS

Land classification at national level has largely ignored the specific issues of agricultural use and production on sloping lands. The complex terrain of sloping lands poses particular challenges for land classification and its use for determining optimal resource allocation for agricultural use. Various modern technologies and innovative methods are being developed to address these challenges, as discussed in this paper. In the final analysis, land classification alone cannot bring about sustainable production, but rather land classification can be gainfully used as a basis for negotiating, allocating, managing the use of land and its resources in an ecologically sustainable, economically viable and socially acceptable manner.

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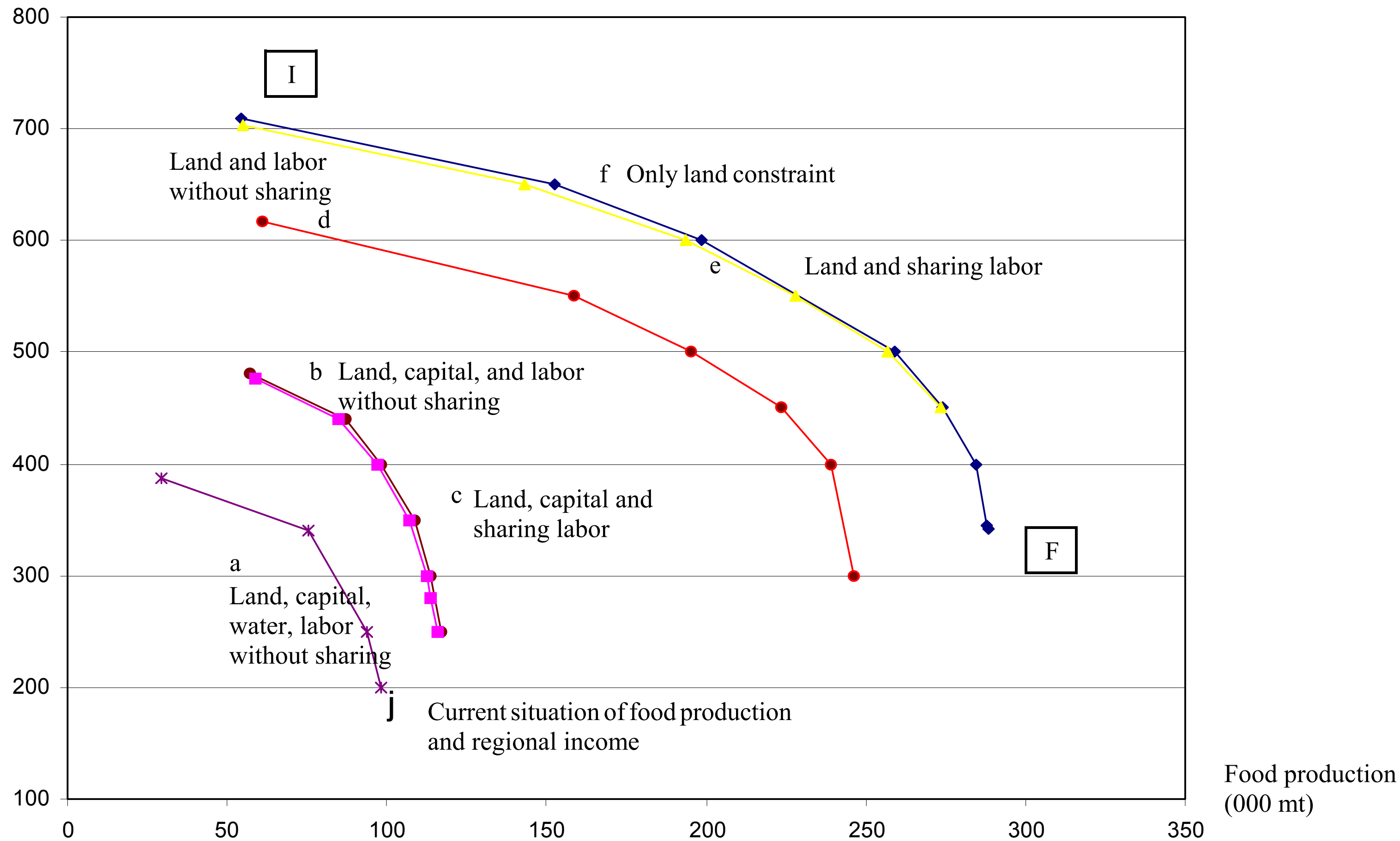

Figure 5. Trade-off Curves of Food Production and Regional Income for Different Scenarios

3. LAND CLASSIFICATION FOR PROMOTING SUSTAINABLE AGRICULTURAL USE OF SLOPING UPLANDS – A CASE STUDY OF TERRACED PADDY FIELDS IN JAPAN

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INTRODUCTION

In Japan, a majority of the farmland is used for growing paddy. While paddy fields are largely located in flat areas such as basins, they have also been developed on hills, foothills and in small valleys surrounded by the mountains. Paddy fields located in sloping upland areas are called terraced paddy fields in Japan. These are regarded valuable – culturally as well as in terms of agricultural production. However, after 1970s farmers started abandoning rice cultivation in the sloping upland areas due to a fall in rice prices. There is a serious concern that this will weaken the multifunction of farmland, which includes retention of water resources. Therefore, efforts have been made to conserve farmland in sloping areas in various parts of the country. For example, as an agricultural policy, a "direct payment system for foot hills and mountainous areas" called as the Japanese-style decoupling, for example, was introduced in the year 2000. However, farmers still continue to quit agricultural production on farmland in sloping areas because of the decline in agricultural labor force in addition to the low productivity of the sloping land. Thus, proper conservation of good farmland under declining agricultural labor force is an urgent need for agriculture in sloping areas in Japan.

OBJECTIVE OF LAND CLASSIFICATION FOR AGRICULTURAL USE OF SLOPING UPLAND

Proper management and conservation of good farmland is indispensable for sustainable environment and productivity. The question is how to identify good farmland that needs to be conserved for the future. To do so, land use planning for farmland conservation is called for and land classification is to serve as a basis for the planning.

It is necessary to secure the effectiveness and durability of land classification in the case of sloping areas. It is because land use planning in sloping areas cannot simply be spatial planning in the beginning but it is an important process to be taken care of by the residents. Effectiveness can be secured by the introduction of measures that involve land use coordination and financial responsibilities of farmland owners and users. The measures will include such cases where farmers are responsible for conservation of farmland. However, in reality, it is difficult to secure effectiveness of such measures where there are diversified interests of landowners and users. Therefore, it is necessary to evaluate the state of land objectively and conduct discussions to form a consensus based on the evaluation.

I propose a method of land classification to secure effectiveness by involving residents in land classification. This method has the procedures in which residents are the main body of planning and they receive support from concerned organizations. They create a land classification system which decides farmland areas to be conserved based on a parcel-by-parcel survey and creating a consensus in the community on land use planning.

In this paper, I will report a pilot case of the decision of land classification, which led me to propose the method. It was Hosono community in Yasuzuka-machi (municipality), Higashi-Kubiki-gun in Niigata Prefecture. The paper refers to paddy field representing farmland use in sloping areas in Japan.

CASE STUDY: PROCEDURE OF COMMUNITY-BASED LAND CLASSIFICATION

Beginning the Land Classification in Pilot Community

Yasuzuka-machi, Higashi-Kubiki-gun in Niigata Prefecture where the pilot community (Hosono community) is located, is a representative sloping area in Japan. Most of the arable land in the area is terraced paddy fields in sloping areas with little flat land. Because it is also an area that has one of the heaviest snow accumulations in Japan, conditions of living and agricultural production are not favorable. Landslides occur frequently in Higashi-Kubiki-gun and there is a common concern of disasters due to serious dilapidation of farmland.

Under such conditions, Yasuzuka-machi regards agriculture as a core industry of the town community. It developed an “agricultural vision of Yasuzuka” in 1995 that was to be known as municipality-based agriculture. Along with the vision the municipality proposed that “verification of land classification by residents” would be made urgently. In reaction to this proposal, Hosono community conducted the land classification as a model community. Land classification made by the Hosono community is regarded as an integral part of formal working plan of the municipality.

The Hosono community decided to create an imaginary kingdom called “Nature Kingdom of Hosono” and launched various community-based activities. One was the rice cake factory which uses traditional skills and knowledges of women. The other was the *Koshihikari* (famous brand rice) paddy ownership program by which city residents buy harvest-right and can harvest themselves the rice. Despite these efforts, community residents have felt a risk that increasing number of farmer household quit agriculture or face a shortage of successor farmers. A wood handy-craft facility and inexpensive inns opened later. They considered that land use planning to utilize local resources and conserve farmland.

Process of Land Classification

The pilot community worked for land classification from 1995 to 1998. They first conducted a parcel-by-parcel survey of farmland in 1995 to identify specific conditions of each piece of farmland. The author assisted the process using geographical information system (GIS). The original land classification plan was made through consensus. The residents have been carrying out various measures for farmland conservation including joint farming in accordance with the land classification.

Procedures and System of Discussions

The core body of planning is the farming households which can take responsibility for the land use coordination and related financial matters. However, because the planning method require some expertise and knowledge, local governments and extension organizations as well as research institutes were requested to support the planning. Staff of local governments, JA and extension centers and I, a researcher, participated in the planning as advisors. A land use examination committee, consisting of 10 members who were representatives of farming households was formed to undertake the total land classification work.

The committee started to make an original plan together with the representatives of farming households. Research institutes brought maps and tables to help farmers to decide good farmland to be conserved. Extension centers and JA were mainly responsible for providing advice on the selection of crops to be planted in the plan. The municipal government staff provide information required for considering possible activities to be introduced in the community and coordinated the plan with upper plans of the municipality. It also worked as coordinator between the land use examination committee and the community and concerned organizations.

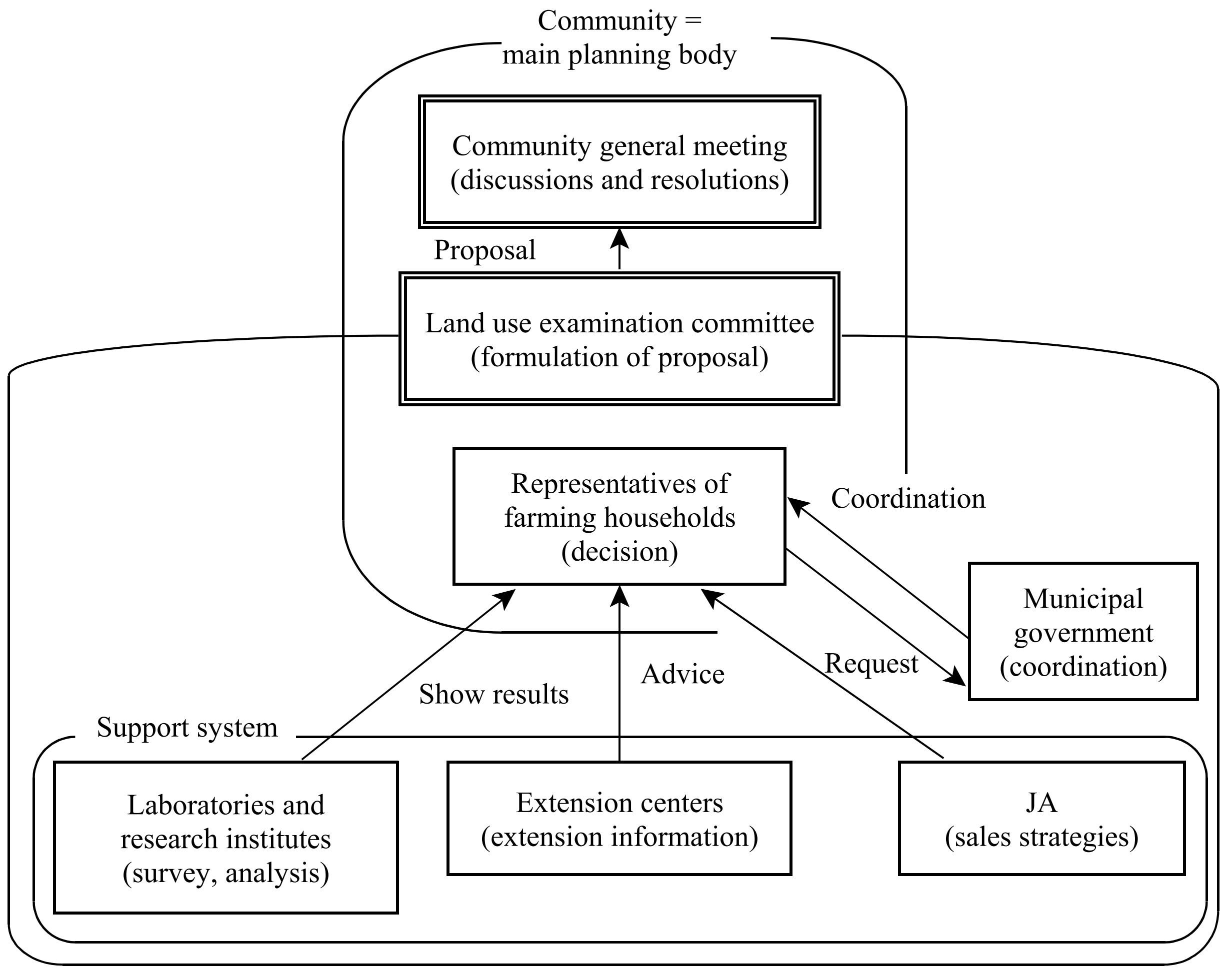

Figure 1. Procedures and System of Discussion for Land Classification

Source: Adopted from Endo.

Procedures of Compiling Basic Materials

Basic inputs for land classification were prepared through the following procedures:

i. Making a field map of the whole community from aerial photos
ii. Conducting a survey on current state of farm management of member farming households and a field survey on a parcel-of-land basis
iii. Collecting of information from topographic maps and aerial photos (including slopes)
iv. Construction of database by each field on a parcel-of-land basis from ii and iii
v. Output into field map of iv.

GIS is used in these series of activities. GIS allows us to analyze altitude, main slopes and sunlight conditions of field, water use, and accessibility to the field on a map. By re-arranging and plotting collected information including farmers' intention to continue farming, we can display various map images so that conditions of field can be understood comprehensively and objectively. From multiple main charts, regulatory elements of land use can be also understood spatially. It is an effective tool to make the process objective when a consensus needs to be formed.

The GIS output helped individual farming households to recognize the objective position of their land, proper land use, need for coordination and consensus on deciding good farmland to be conserved, etc. It was possible by showing the villagers the elements to influence land use on map on a parcel-by-parcel basis.

Sorting out Conditions for Deciding Good Farmland to be Conserved

The concept of 'good farmland' is associated with its productivity and should be understood by economic land classification. A criterion of good farmland is whether the land is managed by farms with good agricultural expertise and strong willingness to engage in agriculture.

In the case of sloping areas in Japan, it is necessary to add a unique viewpoint of planning, i.e., to the extent villagers wish to revitalize the community by conserving farmland.

The trend of farmers leaving their farmland can be economically explained as follows. When farming households have no other choice but to downsize their management because of declining labor force, shortage of capital and stronger production control, they use as much farmland for their cultivation as possible or rent out rest of the land. In such cases, they choose the farmland that will enable them to gain higher land rent. However, if they consider that they cannot gain land rent and they quit cultivation. The judgment is an economic one associated with the land productivity.

In the judgement, four major elements play important role: 1) element of labor productivity; 2) element of land productivity; 3) element of management; and 4) element of external environments. They can be shown in the Table 1.

Formulation of Evaluation Chart

Based on the ideas described above, we formulated an evaluation chart of field. Elements in the Table 1 are used in the evaluation and the corresponding scores are shown in the Table 2 as an example.

RESULTS OF LAND CLASSIFICATION

Conclusion of Farming Households

Residents carried out the land classification of the community with the reference materials such as maps and field surveys and after repeated discussions with staff of concerned organizations. They identified the land that they will continue to use as farmland in the future and the land that they will not use as farmland.

The area has heavy snow in winter and thus a limitation for the cultivation of fruit trees. Paddy farming is regarded as most appropriate because it also prevent from frequent occurrence of landslides. Therefore, the discussions centered around maintenance of the current state of farmland use as rice paddy. Committee held discussions for the expansion of the ownership system of *Koshihikari* rice. They also discussed the possibility of using land where rice cultivation is difficult, for upland crops and orchards. The process of the discussions is shown in Table 3.

Various ideas for land use were raised partly because the people in the municipality had a clear vision about what needs to be done through exchanges with urban cities. Ideas and classification of land use should be decided in accordance with the goals to be achieved and data to be gathered and elements to be examined necessary for each case. This means that clarification of goals is very important for land classification.

Effects of Land Classification on Community

The discussions yielded various effects in the pilot community. One effect is the coordination related to land ownership and use. Because land was classified under the principle of farmers making decisions independently, they strongly insisted maintenance of the current state. In some cases, cultivation had to be given up because priority was given to landowners despite good land conditions. This issue is difficult to overcome because it is related to the landownership. However, through discussions, such difficulties came to surface and community members agreed that they would not give up farmland without consulting with anyone and they would be willingly engaged in discussions about the introduction of projects to improve field even if they quit farming or leave the community.

Table 1. Elements for Land Classification

		Method of Acquisition[a]		
		Topographic Maps, Aerial Photos	Interview of Community Representatives	Management Conditions, Parcel-of-Land Survey
External Environment:				
Sloping	1. Less than 1/12; 2. 1/12-1/8; 3. more than 1/8	"		
Direction	1. Southeast; 2. northeast; 3. southwest; 4.	"		
Altitude	1. Less than 200 m; 2. 200-300 m; 3. more than 30	"		
Frequency of landslide	1. Infrequent; 2. frequent		"	
Sunlight condition	1. Much; 2. average; 3. little			"
Time for snow to disappear	1. Early; 2. average; 3. late			"
Management:				"
Category of farming households[b]	1. Category I; 2. Category II; 3. Category III; 4. Category IV		"	"
Age of owners[c]	1. Younger than 60; 2. 60-64; 3. 65-69; 4. 70-75 5. 75 or older or land without owner		"	"
Labor Productivity:				
Improvement	1. Improved by project; 2. improved independently 3. Yet to be improved			"
Ability for machine entry	1. Tractor can enter; 2. walking rice transplanter can enter; 3. difficult/impossible			"
Difficult to commute to field[d]	1. Easy–5. difficult	"		"
Size	1. Less than 2 a; 2. 2-6 a; 3. more than 6 a	"		
Land Productivity:				
Security of water	1. Use of river water; 2. use of spring water; 3. irrigation pond; 4 rainfed paddy field			"
Yield per 10 a	1. >6 rice bags, 2. 6-7 rice bags; 3. >7 rice bags			"

Source: Endo, 1999.

Notes: [a] Respondents put circles for applicable methods of acquisition; [b] "Category of farming households" is decided in accordance with the scale of management, ownership of combined harvester and thresher and whether they have work entrusted to someone, and the upper-layered farmers are category I, and lower-layered farmers are category IV and those falling in the middle are categories II and III. Absentee landowners are categorized as category IV; [c] "Age of owners" of absentee landowners is included in "75 and older"; and [d] "Difficulty to commute to field" is categorized in five degrees from "Easy" to "Difficult" in accordance with the distance and the road condition.

Table 2. Example of Elements and Scores in Formulating Evaluation Chart

Score	1	2	3
<Element of External Environment>			
Sloping	Less than 1/20	1/20-1/10	More than 1/10
Sunlight	Much	Middle	Little
Snow disappearance	Early	Middle	Slow
Landslide	Occurs		Frequent
<Management Element>			
Age of owners	Younger than 60	60-74	75 or older
<Element of Productivity>			
Field improvement	Introduction of project	Independently improved	Yet to be improved
Ability for machine entry	Tractor can enter	Rice transplanter can enter	Impossible
Size	More than 5 a	1.6-5 a	Less than 1.6 a
Yield	More than 8 rice bags	6-8 rice bags	Less than 6 rice bags
Water	Other than rainfed paddy fields		Rainfed paddy fields
Time required for accessibility to field	Near house	Within 10 minutes	More than 10 minutes

Source: Endo, 1997.

Table 3. Standards to Decide Farmland to be Conserved in Pilot Community

Process of Discussion	Points
1) Selection of farmland to be conserved as rice paddy	C Maintain the current state as much as possible C It is impossible to conserve land where farmers cannot commute as farmland C Place where an irrigation pond can be built (security of spring water)
2) Examination of use of land other than as rice paddy	C List land use to enjoy scenery and yields by month C Examination of land use for exchanges with urban cities, which include the use of land for farm for experience or an ownership system C Examination of products that can be processed
3) Selection of land to be conserved as upland field or orchards	C Use as farmland as much as possible C Place where farmers can commute relatively easily (good road conditions)
4) Examination of use of land other than as farmland	C Maintain and manage roads as areas of mountain vegetables for exchanges with urban cities

Source: Adopted from Endo.

The municipality was examining the introduction of a project on emergency conservation of terraced paddy field at that time. It was financially difficult to improve farmland of the whole municipality and they decided to implement the project on farmland to be conserved using the land classification.

As labor force shortage is predicted, they also discussed promotion of rent of farmland and labor outsourcing. As a measure, they decided to plant the same variety of rice block-wise because it is necessary to control the harvesting time. This led to introducing a joint seedlings work.

In addition to drawing a final spatial plan, land classification enabled discussions on how to conduct the classification and find out points important for the discussion process.

INDEPENDENT LAND CLASSIFICATION METHOD

How could the discussions on land classification be developed into specific action plans to achieve goals? One possibility is that they can be achieved by effective materials and demonstration. Figure 2 shows the process of creating a consensus after discussions on land classification based on the efforts of the community.

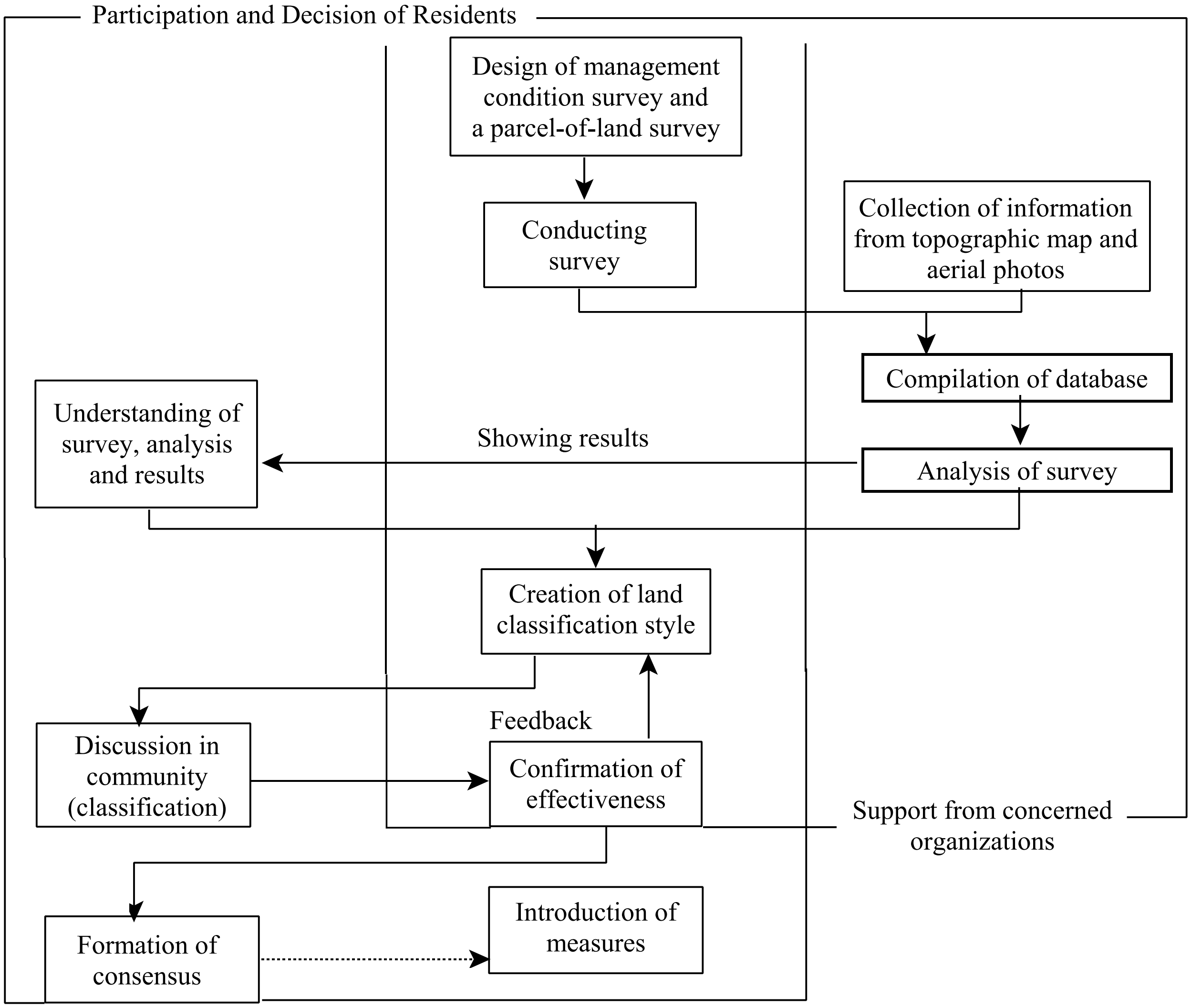

Figure 2. Flow Until Formation of Community Consensus

Source: Endo, 1999.

In this method, independent decision of farming households is respected. The work shown here needs a system to support farming households. Support from concerned organizations including the municipal government, JA and extension centers and participation of researchers and other experts is essential.

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4. SPATIAL AND TEMPORAL CONSIDERATION ASSOCIATED WITH ACHIEVING SUSTAINABLE STEEPLAND AGRICULTURAL PRODUCTION

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INTRODUCTION

Many natural hazards (e.g., hurricanes/typhoons, droughts, earthquakes) are associated with steeplands. An increasing share of these hazards is resulting in natural disasters: "a natural hazard becomes a natural disaster when it outstrips the ability of a country or a region to cope, causing dislocation in the economy and undermining a government's development strategy" (Inter-American Development Bank [IADB}, 2000, p. 47). Worldwide, the incidence of natural disasters tripled between the 1960s and the 1990s, and the real costs associated with natural disasters increased nine-fold (IADB, 2000). One of the causes for this dramatic increase is growing reliance on steeplands for crop production (Arsyad, *et al*., 1992; and IADB, 2000). The linkage between conversion of upland forest to agriculture leading to increased landslide and flooding risk, and what technologies can be applied to minimize these risks, will be the focus of this paper.

STEEPLAND USE TRAJECTORIES – IMPLICATIONS FOR WATERSHEDS

Worldwide, fertile lands conducive to farming have long been settled. The world population is expected to double by the year 2050 with most of this increase (86 million out of 90 million/year) in ecologically sensitive regions of the tropics where arable land is already scarce (Lal and Stewart, 1995). Population growth already exceeds the rate of increase of agricultural output in many of these ecologically sensitive regions. Projected population increases will double food requirements in developing countries and necessitate further expansion to land unsuitable or marginally suitable for agriculture (Lal and Stewart, 1995). Therefore, increasing population, and the associated need for sustenance, is likely to continue to be a contributing force driving the poorer segments of the farming community to cultivate increasingly marginal sites, such as steep and less fertile lands. In tropical regions, land area with slopes greater than 30 percent occupy slightly more than 1 billion ha, approximately 16 percent of the total land area (Purnell, 1986). Upland systems of watersheds, which are often characterized by steep slopes and/or shallow soil, are usually most stable when covered with native forest. More water is returned to the atmosphere from forests via evapotranspiration than from other types of cover, consequently the total amount of water yield from forests tend to be lower than if the vegetation cover is converted to cropland or grazing land (Bosch and Hewlett, 1982; and Hamilton and King, 1983). Even though water yield from forests is lower than on cleared sites, forests produce more consistent stream-flow throughout the year than unforested watersheds. The high infiltration rate associated with forest cover reduces the peak flow, thereby reducing flood risk. Another watershed-scale advantage of the high infiltration rate associated with forest cover is that more water percolates through the soil to provide a more consistent base flow to streams, thereby reducing the chance that upland streams will stop flowing in the dry season (Douglass and Swank, 1972).

Forests also reduce landslide hazard because the tree root systems are effective at tying the soil to the hillside. This very important function is lost when trees are removed, often causing the A and B horizons to become saturated during monsoonal rains which can lead to slips along the contact plane with the unweathered subsurface. Measured rates of soil losses on forested steeplands average less than several mt/ha/year, but when the steepland forests are cleared and used for slash-and-burn agriculture, it has been commonly reported that rates of soil loss increase to between 100-200 mt/ha/year (Pimentel, *et al*., 1995). For example, aerial photographs taken before and after Hurricane Mitch (1997 versus late 1998) were analyzed to determine the landslide relationship with slope and vegetation type (Hurricane Mitch occurred in October 1998 in Central America – 11,000 Honduras died, 1.5 million people lost their homes, the Honduran economy suffered US$2 billion loss of which US$800 million loss was to the agriculture sector). On sites with slopes greater than 30 percent, landslides occurred on 0.4 percent of forested land, on 8.2 percent of planted cropland and on 12.4 percent of recently harvested cropland. These data, which indicate that landslides are 31 times more likely to occur on recently-harvested steep cropland than on steep forest, illustrate how changes in land use and the associated vegetation cover are related to slope stability (Perotto-Baldivieso, 2000). This pattern of increased landslide risk associated with changes in land use/land cover help to explain why the worldwide incidence of landslides is increasing in tandem with more widespread deforestation of tropical steeplands in recent decades (Schuster, 1996).

When storms such as Hurricane Mitch occur (seven storms, each producing at least 17 inches rainfall, occurred in the Caribbean in the three years preceding Mitch), widespread landslides expose bedrock, which render affected areas useless for farming, permanently (Hellin, 1999). This leads to a vicious cycle: as topsoil is lost via soil erosion, there is a corresponding reduction in soil nutrients and the soil's water storage capability, so crop yields decline. Subsistence farmers respond by clearing more adjacent forests, in order to feed their families. Entire communities shift locations as nearby soils are eroded and lost (Cook, 1949). Circumventing this cycle requires strategic soil and water conservation investments on cultivated cropland, to hold the soil on the hillside in place of the forests, which had been performing that function.

IMPORTANCE OF SCALE TO ECONOMIC ASSESSMENT AND TECHNOLOGY SELECTION/LOCATION

To operationalize upland soil and water conservation, there needs to be clear thinking regarding three pragmatic and fundamental issues which are interrelated: (1) which beneficiaries have the most to gain/lose in economic terms, thereby determining who is most likely to be willing and able to pay; (2) where would soil and water conservation investments be best situated to yield benefits to the group paying the bill? (i.e., where should conservation be targeted?); and (3) what should be done? The answers to each of these questions depend on spatial and temporal perspective, as discussed below.

Who Pays?

Landslides and flooding associated with clearing of upland forests are not just a problem for people living on the steeplands; these patterns of land use also jeopardize downstream municipalities and industries. Given the current barriers to widespread forest conservation created by the population's need for access to land for staple crop production, investment in soil and water conservation on cultivated steeplands is a necessary precondition to sustainability of downstream investments. For example, if upland and lowland areas are treated as independent planning units, a mismanaged upland system could trigger a one-way chain reaction of negative impacts that the lowland planning unit would have no control over. Under such a planning system, the upland is a source of "serial externalities" (i.e., the actions of the upland inhabitants affect the downstream inhabitants, but the actions of downstream inhabitants are unlikely to be communicated or have impacts on those upstream.). Such separated planning units create a variety of obstacles to sound economic analysis because the planning unit does not have a realistic scale necessary to cope with the interdependent forces that a watershed manager must deal with (Thurow and Juo, 1995).

The scale of planning unit also influences the economic assessment of soil and water conservation programs, a procedure that usually must be cleared before a project is initiated. For example, if the planning unit is constrained to upland fields, the benefits of soil and water conservation are usually measured in terms of improved food production. Given the cash value of basic grain crops (i.e., as commodities traded on world markets), this evaluation procedure is predisposed to receive an unfavorable ranking using standard benefit/cost analysis of upland soil and water conservation activities when only upland impacts and products are considered. In contrast, if the planning/assessment unit is the watershed, the serial benefits of upland soil and water conservation to downstream interests (e.g., flood and sediment control effecting downstream infrastructure investments) make such projects rank favorably, yielding a high return on investment. Thus, economic assessments of investment benefits from the same project differ according to the scale chosen for the assessment. Economists are usually loath to consider the serial benefits of upland soil and water conservation projects because to do so involves a variety of difficult-to-quantify opportunity costs (i.e., the cost to future production if the project is not implemented) and shadow costs (i.e., intangible costs to society). These concerns were very well expressed in the slogan used by the Chipko, India, watershed protection project: "*What do the forests bear? Soil, water, and pure air*" (Shiva and Bandyopadhyay, 1987). Though the value of pristine and functional natural resource amenities is difficult to quantify, they are legitimate values, and need to be represented as accurately and comprehensively as possible in benefit/cost analysis, even when quantitative measurement is elusive. It is the scale chosen for an assessment or an analysis, which allows (or precludes) full consideration of, and accounting for, serial benefits. Often, using the watershed as the unit of analysis for an assessment allows a comprehensive accounting of serial benefits.

In the aftermath of Hurricane Mitch, this serial externality dilemma was recognized by the IADB and the U.S. Agency for International Development (USAID) as they designed and implemented a several billion dollar reconstruction investment in Honduras. From their point of view, the scope of damages from Hurricane Mitch "*was not only the result of natural forces: human mismanagement of identifiable risks also played a role. The damage was magnified by a variety of unsustainable practices, such as inadequate watershed protection and uncontrolled exploitation of natural resources – including deforestation and hillside farming without soil conservation*" (IADB, 1999, p. 2). Accordingly, post-Mitch reconstruction projects are assessed following a protocol which makes the watershed the fundamental unit of planning, i.e., investments downstream are approved if and only if the vulnerabilities associated with upland use patterns are being managed appropriately. Framing downstream interests as an important beneficiary of steepland conservation should firm up private industry/government financial support for conservation and also refine decisions regarding where to invest conservation dollars (i.e., on the sites that provide the most vulnerability to downstream interests). Crosson (1986) made a similar argument for U.S. agriculture.

Farmers are usually willing to adopt technologies which are profitable (c.f. Ervin and Ervin, 1982; and Pampel and Van Es, 1977); but technology adoption by poor farmers, who are most likely to be the ones who dominate steepland agriculture, are often constrained by investment poverty. Reardon and Vosti (1995) described investment poverty as circumstances where family labor to install and maintain conservation technologies takes lower priority than the family's efforts to meet immediate subsistence needs. Consequently, many farmers never install conservation technologies unless they are helped by a publicly-funded technical assistance project dedicated to this task (c.f. Clay, *et al*., 1998). This is particularly true if the rationale/funding for conservation investments is driven by placing a priority on reducing vulnerability to downstream interests.

The on-farm benefits of soil conservation are improved crop yields and/or assured ongoing sustainability of production (i.e., for steeplands, mitigating landslide hazard). Especially where conservation is practiced on farms producing basic grains for household consumption or for local markets, the value of increasing crop yields and/or of sustaining production is unlikely to offset the public costs of extension programs to promote conservation. Historically, a philosophical justification for governments' and donors' financial support of education and technical assistance programs has been the public-good aspects of the benefits from appropriate soil management (Crosson, 1986).

What Should be Done?

Development of appropriate technology depends on understanding the processes affecting sustainable production. For example, the replacement of upland forests with agronomic crops need not destabilize a watershed, as is illustrated by the ancient (2000+ years old) but well-designed and well-maintained terraces on the steep slopes in Java, Sri Lanka, India, Philippines, Peru (Bennett, 1970; and Lal, 1990). Management of farming systems in these particular agro-ecosystems is the product of climate, soil and the wise application of highly refined knowledge about water control, erosion control and nutrient cycling. The issue facing development is how to foster adoption and do so with economic efficiency. A case study of southern Honduras shows one of the ways this can work.

The spatial scale within which research is structured may lead to quite different conclusions regarding the appropriateness of various soil and water conservation technologies. For example, research on the steeplands of southern Honduras (Thurow and Smith, 1998) demonstrates the importance of scale in understanding erosion processes; an insight necessary for selecting appropriate conservation technology. Small plot data from plots 2 m wide by 22 m long (0.004 ha) indicated that erosion from a 55-percent slope cultivated field could be reduced from 92 mt/ha/year to 0.5 mt/ha/year if the crop residue was left on the hillside as a mulch. However, information collected on field scale catchments (0.3 ha) indicated that soil loss from mulch-covered fields was 19.7 mt/ha. Why this difference? Small plots are well suited for measuring interrill erosion – since most temperate zone soil loss occurs as interrill erosion this is the type of plot that is commonly used in those regions and is commonly cited in the literature. However, small plot study designs are not capable of measuring larger-scale processes that results in the vast majority of soil loss from steeplands. In this Honduras example, about 94 percent of the soil loss from the field-scale plots, during the pre-Hurricane Mitch period of 1993-97 were associated with landslides – a process that was not detectable using the 0.004 ha plots. The implication of this research for a soil conservation organization is dramatic – technologies based on rationales derived from small plot research may not be germane to field-scale conservation concerns. Therefore, while small plot research indicated that mulching would solve the erosion concerns (i.e., the mulch intercepted and dissipated the erosive energy of raindrop impact that drives interrill erosion), field-scale research showed that mulching (or shallow-rooted cover crops) would not achieve sustainable soil conservation objectives because such treatments did not tie the soil to the hillside to address the landslide issue. To achieve sustainable erosion rates on such sites, investments in technologies needed to be made that would substitute for the role of the native forest in tying the soil to the hillside (e.g., constructed rock terraces or biologically stabilized terraces using vetiver grass or agro-forestry species).

The 1990-98 Land Use and Productivity Enhancement (LUPE) project of Honduras was established to foster steepland soil conservation, therefore the lessons learned from the project are particularly germane to the post-Mitch policy debate regarding steepland investment strategies. A joint initiative of the USAID and the Honduran Ministry of Natural Resources, LUPE was the largest soil conservation project in Latin America when it ended in 1998. Total LUPE expenditures for soil conservation, 1990-98, were US$13 million.

LUPE programming was a three-stage process. First, farmer-agents urged farmers to cease the traditional practice of burning crop residues between harvests on steepland fields. After a farmer had the chance to experience that this change in traditional practice resulted in improved crop and soil management, LUPE staff followed with the second stage of their extension program which aimed at convincing farmers to use the crop residue to restore soil fertility and structure instead of allowing livestock to consume it. Instead of using fire to prepare the field, the vegetation is slashed with machetes immediately before the field is replanted. This practice provides an effective ground cover that reduces the energy of rainfall impact and surface runoff, decreasing the erosion rate. The ground cover also reduces evaporation from the soil, reduces soil temperature, reduces weed growth, and increases soil organic matter. Farmers expressed that their primary motive to adopt mulching was recognition that landslides carry the risk of a permanent loss of crop production. Mulching also improves labor efficiency because the extra effort in slashing the weeds prior to sowing reduces the need for weeding during the growing season when labor availability is most constrained.

While mulching substantially reduces erosion, relative to traditional slash-and-burn practices, it does not provide satisfactory erosion protection under all climate conditions. Mulch performs well in low to average precipitation years, but mulching alone does not foster sustainable land use because it does not adequately address the most prevalent erosion problem, i.e., landslides in high precipitation years. LUPE expended US$405/ha associated with implementation of these first two stages of the soil conservation program, documented to lower soil loss to 20 mt/ha/year compared to a soil loss rate of 92 mt/ha/year from traditional slash-and-burn field management. Nevertheless this soil loss rate is still unsustainable (i.e., the estimated rate of soil formation is about 1-5 mt/ha/year, therefore more soil was still being lost than being formed).

The third stage of the LUPE extension program was to work with farmers who experienced the benefits of mulching to take the next step in conservation by helping them to install vetiver grass barriers (VGBs) and/or rock walls, thereby reducing soil erosion to less than 1 mt/ha/year, a rate similar to forested sites (Thurow and Smith, 1998).

Vetiver grass barriers (VGB) took 1-2 years to become fully functional as a dense grass hedge. A VGB filters runoff, retaining the soil and slowly releasing the water. Soil accumulates behind the rigid leaves of the vetiver grass, eventually forming stable terraces. Establishment of VGBs on steepland fields in southern Honduras reduced cropland erosion to less than 1 mt/ha/year (Thurow and Smith, 1998). The cost of installing VGBs is significantly lower than for rock walls, but they require more routine maintenance work: no additional cash outlays are required, but labor is needed to cut the vetiver grass back to a height of about 30 cm several times a year.

Rock walls were built from materials collected from the field. The foundation of the wall is established within a trench that is at least 50 cm deep, and rocks are arranged to fit as solidly as possible to a height of about 1 m above the soil surface. Since rock walls do not contain any cementing material, the runoff water is retained, filtered, and slowly released through the existing crevasses. Eroding soil accumulates when stopped by the wall, to form a terrace behind it. In conjunction with the use of rock walls, soil erosion is reduced to less than 1 mt/ha/year, the soil's water holding capacity improves (Sierra, 1996). Water stored in the deep soil that accumulates to form terraces behind rock walls benefits crop production. This benefit is especially helpful since the growing season in Honduras (May to November) has a bimodal precipitation pattern, interrupted by a dry period (3-6 weeks in July and August). The length of this dry period is particularly important in determining yields from maize and from several types of fruit trees.

Soil characteristics and crop production on 30-60 percent slope steeplands in southern Honduras was evaluated for the period 10-13 years after rock wall terraces had been installed. The soil characteristics on the terraced sites were significantly better (e.g., deeper A horizon, more organic carbon) than on adjacent non-terraced sites. Most of the non-terraced sites had experienced several landslides since 1985, but there had been no landslides on the terraced sites. Consequently, sorghum and maize yield being significantly better on the terraced sites than on adjacent non-terraced sites. The difference in sorghum yield between the local variety and region's best-producing hybrid (DVM-198) was greater on terraced sites than the difference between the local variety and the hybrid on adjacent non-terraced sites, indicating that application of hybrid technology paid greater dividends on the terraced sites. Rock terraces moderated the impacts of drought in the context of maize production which farmers perceive the improved water storage associated with rock walls as an important strategy to reduce drought risk (Toness, *et al*., 1998). A portion of the water stored in soil accumulated behind a VGB is taken up by the vetiver grass; therefore the gains in crop yields are not as great with VGB as with rock walls. Farmers stated that they perceived their rock wall terraced land as being more productive than adjacent non-terraced parcels 7-10 years after they had constructed the rock walls. A testament to the perceived value of rock walls was that farmers voluntarily maintain them without further subsidies.

Data from the nine-year LUPE project show that the cost of installing rock walls (US$12,923/ha) was much more expensive than VGBs (US$2,354/ha), though they provide similar soil loss reductions. However, these data are sensitive to the length of the project. The cost of developing vetiver grass multiplication plots to provide stock for out-planting, formation of dissemination networks, and establishing demonstration sites, made VGBs a much more expensive technique than rock walls during the first several years of the project. The cost of establishing VGBs was dramatically lower once these initial investments were in place. Thus, one lesson of LUPE is that there is an economy of temporal scale relating to project length; if a project is to last only several years, the cost of establishing rock walls will actually be cheaper then VGB's, but VGB's are substantially cheaper than rock walls if a project is horizon. Many development projects operate on a short-term (several years) project planning/funding cycle, which may result in much less cost-efficient techniques being applied than if the up-front planning horizon was longer.

In southern Honduras farmers were motivated to mulch because they realized that otherwise they were exposing themselves to the risk of sloughing, which can permanently render cropland unfit for cultivation. In practice, successful mulching was a necessary precursor to LUPE-supported adoption of VGBs and rock walls. Differences between adoption of mulching versus adoption of rock walls and VGBs were consistent with the general observation that people are reluctant to adopt innovations if their investments cannot be reversed in the future with only minor losses. Adopters are most responsive to technologies, which require the least commitment, in both economic and physical terms. In southern Honduras, switching from a traditional slash-and-burn farming system to mulching required less economic commitment than installing either rock walls or VGBs. Furthermore, it would be easy to return to traditional farming practices if mulching proved unsatisfactory. Rock walls and VGBs are both more expensive and more permanent than mulching. Once implemented, they are costly to remove. If dissatisfied, the farmer will have not only squandered the physical and economic effort expended to implement the practice, but also must commit additional resources to remove them or work around them.

Many of the farmers who adopted rock walls in the mid-1980s reported having made incremental changes in the farming systems on their terraced fields. They observed better grain production on the terraces and began experimenting with planting a mixed assemblage of fruit trees on those sites. As a result, many sites where rock walls were installed in the mid-1980s are now undergoing transformation into orchards, resulting in as much as 10-fold increase in annual income from the terraced sites (Santos, *et al*., 2000). Thus, about 40 years after the native forests were cleared, many of these terraced sites are in the process of returning to forest cover (albeit as fruit trees instead of native forest).

Where Should Conservation be Targeted?

Financial resources allocated to promote VGBs and rock walls on a relatively small portion of the watershed were roughly double what it cost to promote mulching on an area 20 times larger. The rationale for the investment in physical barriers was that this is what it would take to bring soil erosion down to a sustainable level. While this is true, not all portions of the landscape are equal in terms of qualifying for such expensive investments. Most conservation programs, including LUPE, focus on the needs and desires of the farmers, but when using a watershed approach as a rationale for steepland conservation, it is logical that investments need to be targeted for application on sites that will pay the most benefits in sediment and flood control affecting downstream interests. This implies that such investments should be made on sites that meet two criteria: 1) the site is especially prone to landslides; and 2) the detached soil is especially likely to reach a stream and thereby contribute to downstream impacts. Traditionally, the study of participation in publicly-funded extension projects to encourage voluntary adoption of soil conservation practices has focused on farm-level behavior. Rather, there should be an emphasis the watershed-scale ramifications of whether, where, and which soil conservation technologies are installed, as elements of a policy rationale in support of strengthening and targeting public investment in steepland management in southern Honduras.

An analysis of fine resolution aerial photographs taken of the area before and after Hurricane Mitch enabled analysis to determine how slope and vegetation affects landslide incidence (Perotto-Baldivieso, 2000). A comparison of Figure 1 and Figure 2 illustrates how Geographic Information Systems can aid in prioritizing where to make expensive investments in physical-barrier technologies for the case study site in the Namasigüe watershed. While Figure 1 illustrates there is much of the landscape that poses a very high landslide risk, Figure 2 illustrates that a much smaller portion of the landscape poses risk to downstream impacts. Since a compelling economic rationale for soil conservation is to stem the cost of upland practices to downstream interests, it makes sense that conservation investments be targeted to areas that maximize benefits by protecting downstream interests. If all the areas shaded in Figure 2 were forested or protected by a mosaic of forest and either VGBs or rock walls, then 88 percent of probable landslides would be prevented in these corridors, resulting in substantial reductions in associated downstream damages. This type of prioritization rationale would be a new approach for most soil conservation projects, which have traditionally made decisions about the type and siting of technologies independent of downstream considerations.

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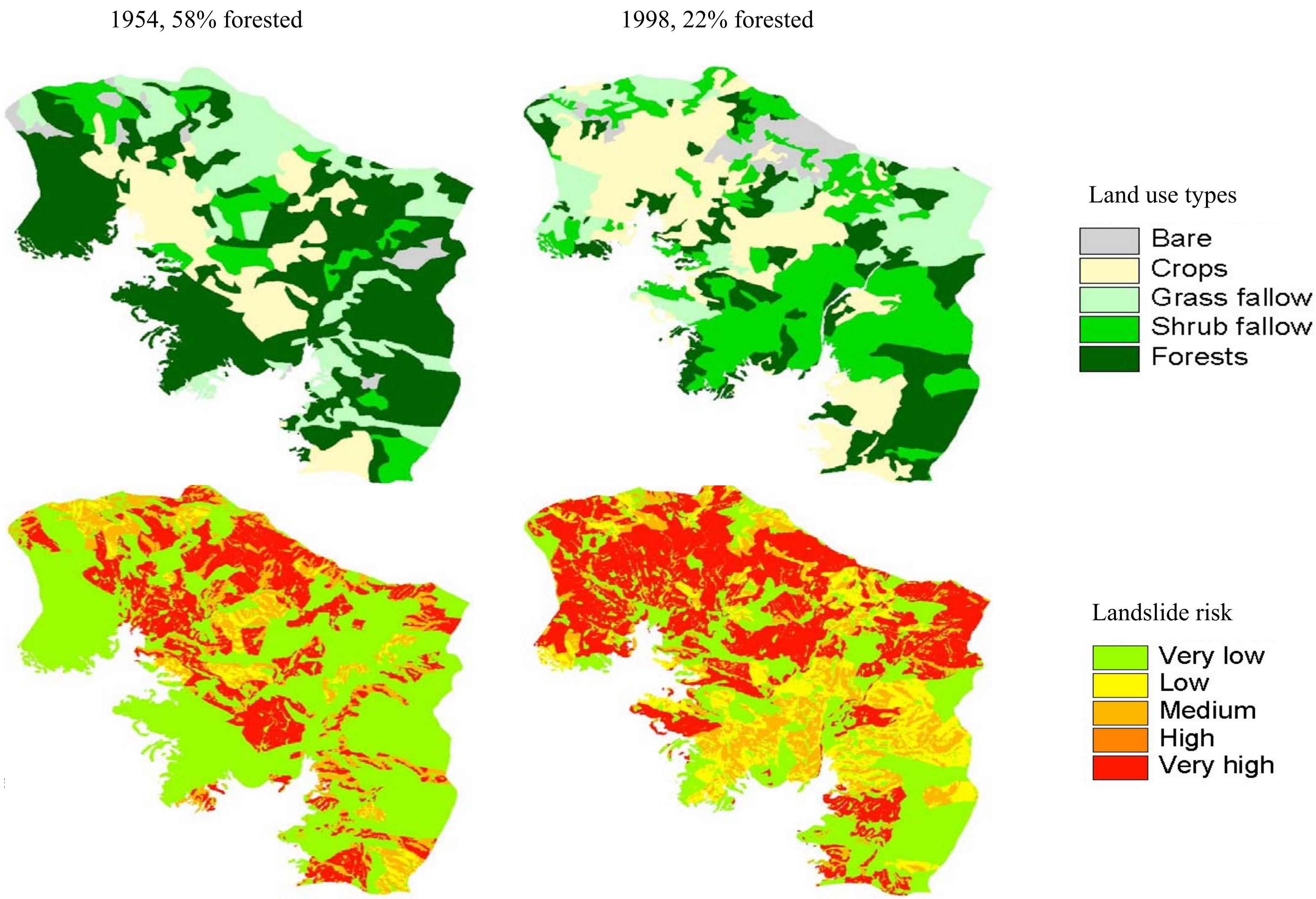

Figure 1. Changes in Vegetation Management Over Time (prior to settlement, the entire site was covered by dense forest) and the Associated Landslide Risk When Considering Vegetation Cover and Slope, Namasingue Watershed, Southern Honduras

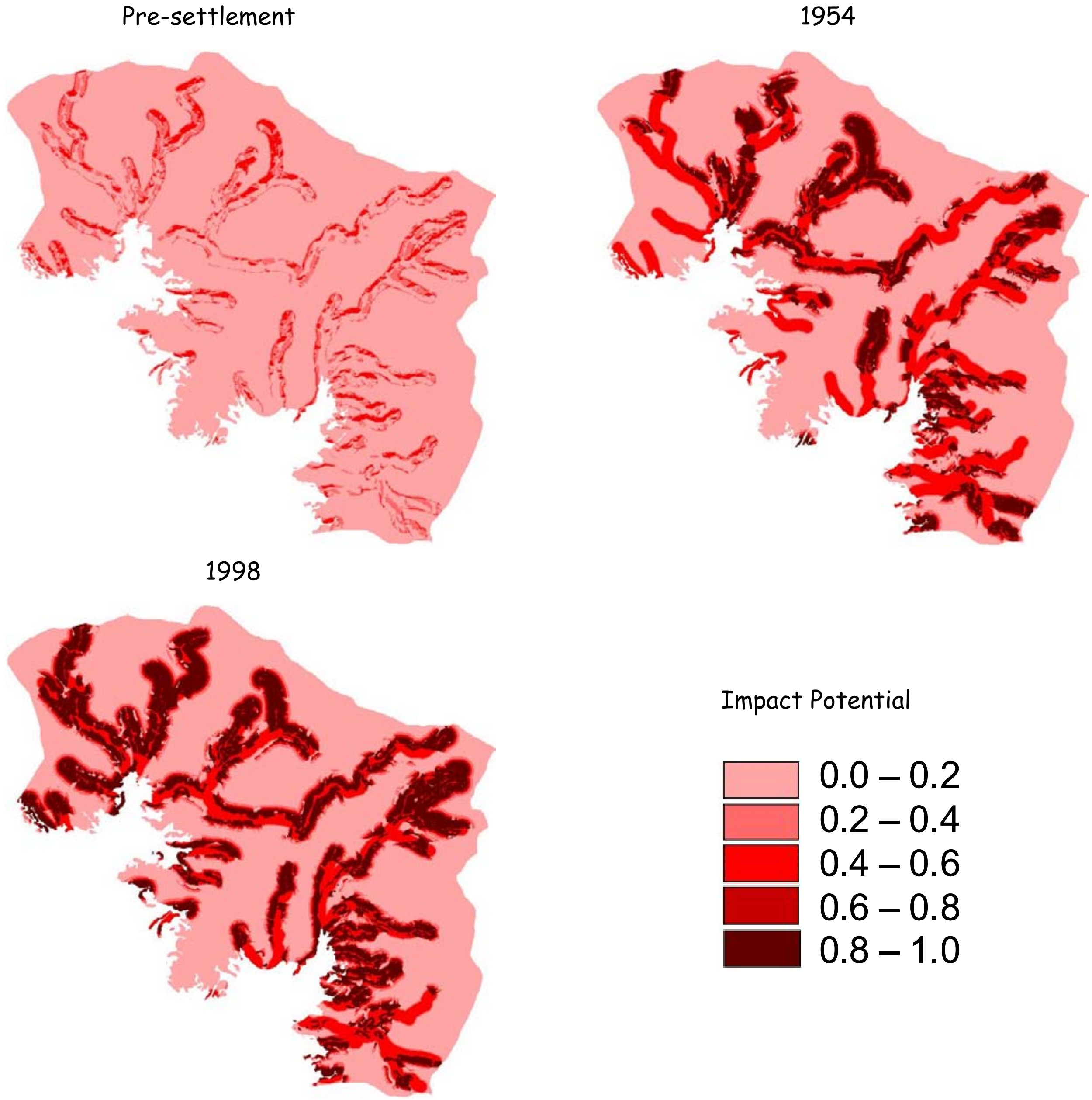

Figure 2. Sites where Prospective Conservation Investments Would Most Reduce Downstream Damages Associated with Landslides in the Namasigüe Watershed, Southern Honduras

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5. DIRECT PAYMENT POLICY FOR SUSTAINABLE FARMING IN HILLS AND MOUNTAINS OF JAPAN

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INTRODUCTION

Since the start of the WTO system and enforcement of the Staple Food Law, the development perspective of Japanese agriculture has gone from bad to worse. The principle of Japanese agricultural policy has been to try to improve productivity and raise the international competitive power in line with the New Agricultural Policy established by the Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) in 1992 (Shogenji, 1995). However, it is difficult for agriculture in the hilly and mountainous areas in Japan (the Japanese less-favored areas [LFAs]) to follow such policy lines. Besides, it is difficult for rural dwellers to live as permanent part-time farmers because such areas are far from the influential labor market. In some regions, it has become difficult for ancestral farm households to be handed down to their heirs and to continue to maintain these farmlands. The main reason is that the population has been decreasing in the Japanese LFAs since economic growth of Japan (Adachi, 1980). Furthermore, a retreat of price supporting policy measures, including even rice, is making the perspective of agriculture in the Japanese LFAs deteriorate rapidly (Kashiwagi, 1997).

Under such situation, the problem of how to deal with terraced paddy field farming and how to prevent an increase of abandoned cultivated land, which must cause a deterioration of the rural environment and a decline of what is called "multiple functions" such as preservation of land and natural habitats and maintenance of favorable landscape, in the Japanese LFAs is arising.

Against such background, the Government of Japan, namely, the MAFF decided to introduce direct payment to farmers in the Japanese LFAs since 2000. It was done to prevent abandonment of farmland and to preserve its precious multiple functions in those areas. Such a policy measure is being implemented for the first time. In formulating the policy, MAFF has taken support of the direct payments to farmers in the LFAs in the EU, which have been enforced since 1975. Japanese new policy measures are also consistent with Paragraph 13 of the Annex in the WTO Agreement on Agriculture. However, many people including researchers hold serious apprehension about its actual impact. Continuation of this new policy depends on how it meets people's expectations, and therefore "transparency of the results" must be an issue in such kind of policy measures (Shogenji, 1998a).

I. CHARACTERISTICS OF DIRECT PAYMENT TO FARMERS IN THE JAPANESE LFAS

Multiple Functions of Farming and Farmland in the Japanese LFAs

In view of the geographical features, the majority of Japan's land is hills and mountains covered with forests. In Japan heavy rainfall is generally concentrated in summer. Under such situation, especially hilly and mountainous areas get eroded and suffer from floods, landslides, soil erosion and other natural disasters. The disasters, which occur in upstream areas, often cause serious damage to the downstream areas including urban areas.

Against such situation, farmlands especially well-maintained terraced paddy fields, which play a role of dams because they store rainfall, are greatly useful for preventing disasters such as floods or landslides. It is farming activity that maintains such farmlands well. Besides preventing disasters, the farming activities in those areas contribute to keep biological diversity and offer precious landscapes to visitors. Specially terraced paddy fields along contour lines in hills/mountains create marvelous landscapes. As mentioned above, Japan's MAFF calls these various benefits as multiple functions (Mitubishi General Institute, 1991;and Institute of Agricultural Engineering, 1993).

However, such areas have been getting severely depopulated, because more and more young people have been deserting them and leaving for cities. Aggravation of depopulation and aging problems in the hilly and mountainous areas have made continuation of farming in these areas difficult. In addition, farming costs in these areas are normally higher than that in plain areas because terraced paddy field, which accounts for the majority of the farmland in such Japanese LFAs, is not only steep but also each plot divided by a ridge between the fields is too small to adopt mechanized farming. These reasons explain why the hilly and mountainous areas in Japan are called handicapped areas. Retreat of price supporting policy measures in Japan under the WTO Agreement on Agriculture has put an additional burden on already daunted farmers in those areas. As a result, farming in these areas is becoming more and more difficult. As more and more farmlands are abandoned, it diminishes the scope of precious multiple functions from farming activities. Against this background, direct payment policy in the Japanese LFAs was introduced in order to prevent farmlands being abandoned and to preserve their precious multiple functions (MAFF, 1999).

Characteristics of Direct Payment Policy

1. ***Regions and Farmland Eligible for the Payment***

As per the provision (a) of the Paragraph 13 in the WTO Agreement on Agriculture, the criteria for the eligibility of region, land, and farm activities for direct payment were formulated clearly and objectively.

Regions eligible for the payments are confined to naturally and socio-economically handicapped areas. In principle, such regions are confined to the areas designated by the existing laws of regional aid and encouragement programs such as the Developing Mountain Villages Act, the Depopulated Areas Act, and the Isolated Islands Act.

However, payments cannot be applied to all farmlands located in the above-mentioned handicapped regions. Among the farmlands in such regions, those eligible for the payments should be confined to the following disadvantaged land where farming costs are much higher than those in the level land: firstly, the very steep farmland whose gradient is more than 20 degrees for paddy fields or more than 15 degrees of steepness for other fields; secondly, small-sized and non-rectangular paddy fields caused by natural condition; and thirdly, the grassland located in disadvantaged areas where more than 70 percent of their total farmland is grassland because no other crops except grass can suitably grow.

In addition, Japan's MAFF left the door open, to a certain extent, for helping farmlands, which do not fall under the above designation. These farmland areas can be included in the category by means of mayors' discretion because of respect for regionalism. Mayors of local authorities may designate the following: firstly, less steep farmland whose gradient is more than 1/100 for paddy fields or more than 8 degree of steepness for other fields; and secondly, farmland where both the ratio of elderly farmers and that of abandoned cultivated land are very high. Such a consideration is significant because causes of abandonment of cultivation are diverse in the Japanese LFAs and may vary from region to region.

2. ***Farming Activities Able to Become an Object for Payments***

Farming activities necessary for receiving payments were framed in consideration of characteristics of farming in Japanese LFAs. The great majority of farming in these areas are paddy field farming. As a general rule, the farm size of Japanese farmers is much smaller than that of European farmers. Especially, in Japanese LFAs farm size is quite small because most of terraced paddy fields are situated on the skirts of mountains. As a result, the average farm size in these areas is less than 1 ha. Then, waterways for irrigation pass through hills or mountains and are normally very long, narrow, and winding. Consequently, it requires a great deal of labor to maintain these well. The same thing can be said of farm roads. In total it is the issue of maintenance of "rural resources" for farming activities. Under such severe conditions, farmers in these areas have been settled in an agricultural commune where they are huddled together in order to cooperate to maintain the above-mentioned rural resources for farming. The cooperative activities in these areas have much significance. If it were not for such cooperation, farming activities in these areas would not have lasted long. If farmers should fail to cooperate, they will face serious difficulties in sustaining their farming. As a result, their farming and farmland will face abandonment. In consideration of such a serious situation, Japan's MAFF introduced a five-year management agreement among farmers in an agricultural commune, as an important condition for receiving subsidy payments. In order to receive payments, a group of farmers in an agricultural commune must in principle make a five-year agreement with government stipulating activities necessary to prevent the abandonment of farmland and a way to distribute the subsidy to farmers effectively. Presupposing this agreement, they must maintain their farming activities, which are environment-friendly and keep or enhance multiple functions. Farmers are not permitted to change from traditional farming to specialized framing and they are asked to ensure that they continue with traditional farming activities that provide multiple functions.

Furthermore, Japan's MAFF approved not only farmers but also an agricultural public corporation (APC) established by municipalities in depopulated areas as the beneficiary of this scheme. Especially in such areas among the LFAs in Japan, many APC have been unavoidably established recently because increasing number of aging farmers caused severe rural depopulation, which adversely affected continuation of their farming activities. Normally, such kind of APC is established by means of a joint contribution of a local authority and an agricultural cooperative in each municipality.

They normally have several farm machine operators and perform contract farming for aged farmers. In general, these APCs go into deficit because they have to be entrusted with large areas of disadvantaged farmlands where cultivation and maintenance has been abandoned. It is against this background that Japan's MAFF decided to pay direct payments to not only to farmers but also to the APCs in order to compensate them for their loss.

3. ***Characteristics of Payment***

According to the WTO's Agreement on Agriculture (the provision (f) of the Paragraph 13 of Annex), the payment per area has to be limited to an amount of extra cost or income loss, which may arise from farming on handicapped farmland. Japan's MAFF decided payment per area at the level of 80 percent of the difference between production costs in LFAs and those in flat areas. The grounds for fixing the level of payments at 80 percent are unfortunately not clear.

With respect to payments per area, two levels of sum are fixed according to a degree of a handicap on farmland of each kind. In case of paddy fields, which occupy major farmland area in the Japanese LFAs, payments are distinguished between very steep land, whose gradient is more than 1/20,[1] and less steep land, whose gradient is more than 1/100 up to 1/20.[2]

According to the WTO's Agreement on Agriculture (the provision (b) of the Paragraph 13 of Annex), payment per area is not distinguished according to farm products. Whatever crops may be cultivated, the same sum is paid for the same land.

With respect to an upper limit on payments, Japan's MAFF put a ceiling of ¥1 million (about£6,000) for an individual farmer, in consideration of the provision (e) of the Paragraph 13 of Annex II in the WTO's Agreement on Agriculture.

However, the cases of above-mentioned APCs, which consist of many operators and must perform a lot of contract farming, or farming cooperative groups, which consist of many members, are made an exception.

4. ***Exposition in Terms of the Cost Curve***

Figure 1 shows that the compensation for the cost differential between the disadvantaged farmland in the Japanese LFAs and the level farmland in the normal areas. SAC_f (SMC_f) is the short-run average cost curve (marginal cost curve) in the level farmland which was fixed as a standard in order for Japan's MAFF to set a price on the subsidy. Similarly, SAC_{ms} (SMC_{ms}) is the average cost curve (marginal cost curve) in the

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1 In the case of paddy field, the term of "more than 1/20" means the ratio that the bottom line is less than 20 and that the perpendicular line is more than 1.

2 The amount of payment per unit area (1 ha) for the very steep paddy fields whose gradient is more than 1/20 is ¥20,000 (£118; £1=¥170).

disadvantaged farmland in the LFAs, which was set as a standard. Shapes of marginal cost curves in each areas are different according to the disadvantage. Without the subsidy, the negative profit accrues (area surrounded with C_{ms}–P–B–A) normally. On the other hand, if a farmer who cultivates the above disadvantaged farmland is subsidized, SAC_{ms} shifts below and the new cost curve (SAC_{mi}') appears. Accordingly, after subsidies are paid, the negative profit disappears and the positive profit may accrue (area surrounded with P–C_{ms}'–D–C). As for a yield, a little increase may arise, but it must be negligible because the shapes of their MC curves are very steep sloped. Moreover, we should consider that farmers in those areas are, more actually, losing capacity for increasing the yield because of their aging (but such situation is not reflected in those figures).

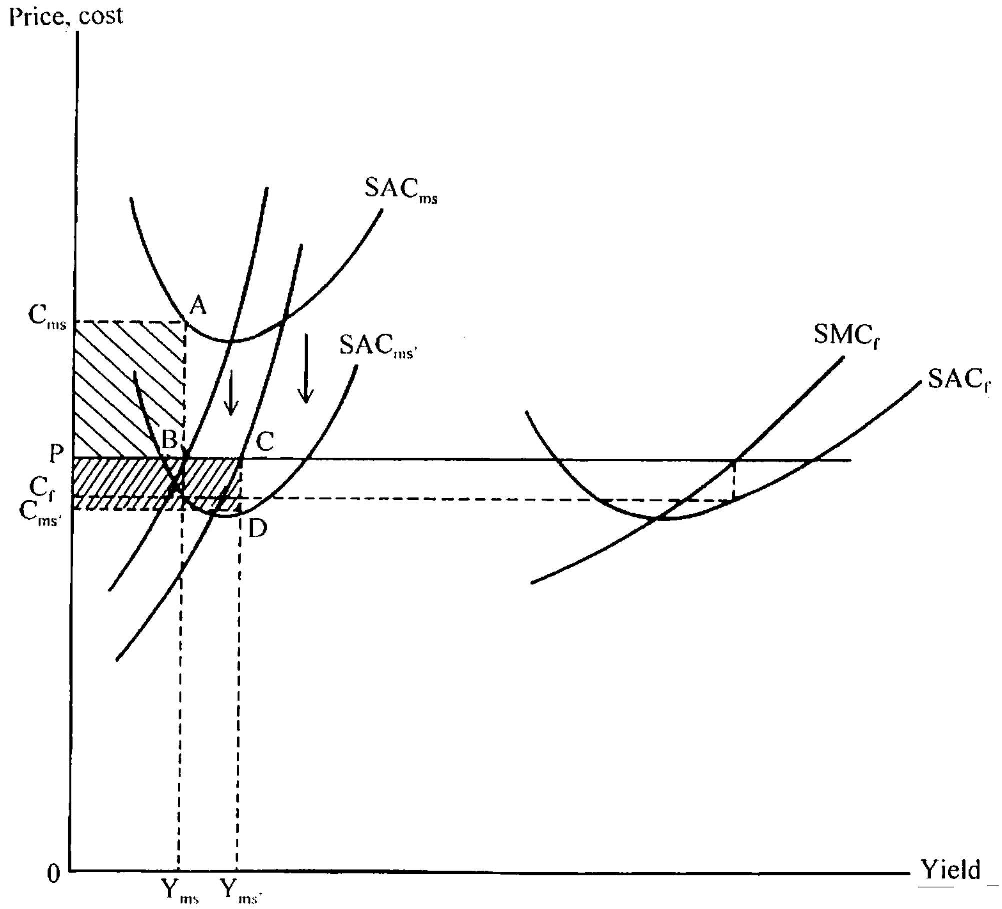

Figure 1. An Effect of Compensation for Farming in the LFAs

Notes: SAC_f and SMC_f are the average cost curve and marginal cost curve in the level farmland field used as standards to set a price on the subsidy for the cost differential. Similarly, SAC_{ms} and SMC_{ms} are the average cost curve and marginal cost curve in the farmland in the LFAs also set as standards. SAC_{ms} is a new average cost curve that appears when the SAC_{ms} shifts downwardly when the subsidy is included in the cost function.

At least, up to the farmland of this condition, the problem of farming accruing the negative profit must be solved by direct payments, but the result depends on whether farmers can get enough income to continue to live there by such a payments. However, unfortunately, it must be said that the amount of payments must be too little to meet the condition in general.

Figure 2 shows an effect of compensation for farming on the more disadvantaged (steep) farmland than that fixed as a standard in LFAs. This figure was composed by adding SAC_{mi}, which was the cost curve in the steeper farmland than that fixed as a standard in LFAs, to figure 2.1. The negative profit accrues (area surrounded with C_{mi}–P–B–A) before farmers are subsidized. But the subsidy makes SAC_{mi} shift below (SAC_{mi}' as the curve). In this case, the negative profit accrues if the difference subtracted area surrounded with C_{ms}'– C_{ms}–D–C from area surrounded with P–C_f–F–E is negative (Shogenji, 1998b).[3] When the difference is negative, the farmland will be continued to cultivate so long as the average variable cost is rewarded while the existing farm fixed capital is available for the time being. However, from the long-run point of view, it may be assessed rational that the land use of such farmland is converted to more extensive one.

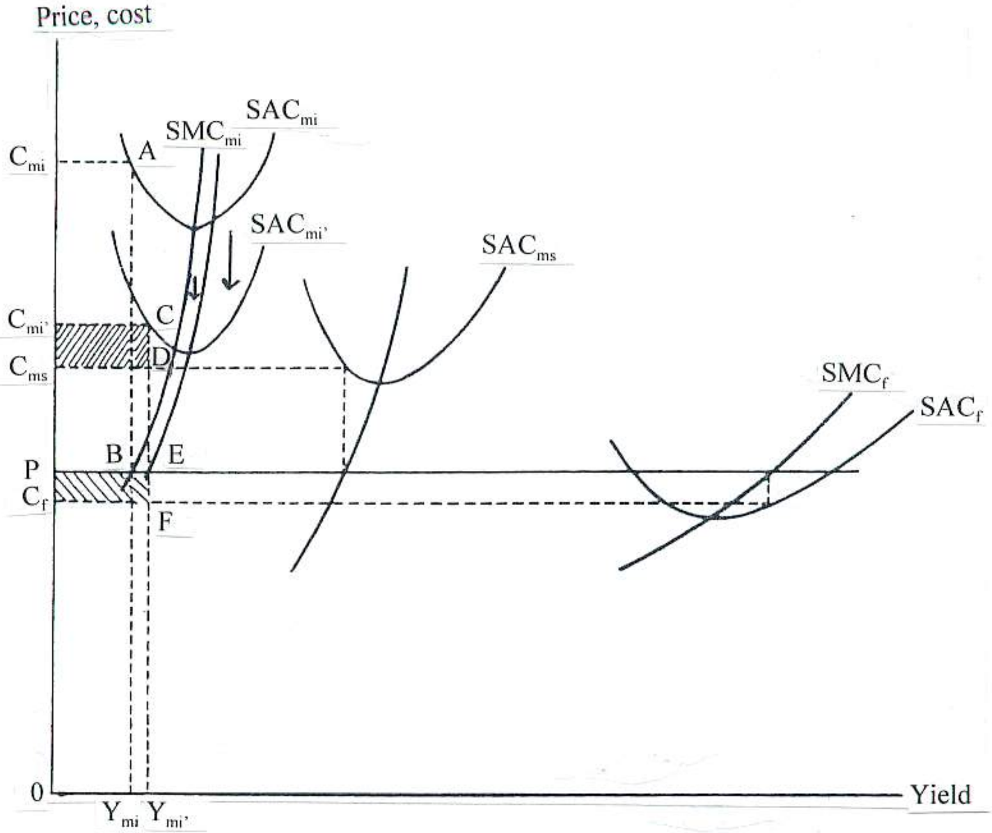

Figure 2. An Effect of Compensation for Farming on the More Disadvantaged Farmland than the Standard in LFAs

Note: This is under the preposition that the costs at the lowest point of the average variable cost curve of the public corporation (producers) are below P or cultivation is continued for its public nature even when they exceed P.

II. LIMITATIONS OF DIRECT PAYMENT POLICY

A direct payment system for farmers of hilly and mountainous areas was introduced in 2000. The system was the first one of its kind in the agricultural policy of Japan. It is a substantial subsidy measure for hilly and mountainous farmers who have been waiting long enough for the introduction of this policy. Therefore, while there are big expectations from this new policy change, there are strong anxieties also about its effectiveness. There is a strong demand for the "transparency of its results". Thus, attention needs to be paid to it, for that is going to influence the continuation of the policy. This chapter discusses the meaning and limitations of the system and makes specific suggestions related to the system.

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[3] In Figure 2, we put those into into another alphabet as following:

C_{mi}'-C_{ms}: α	revenue $R = (\gamma + \delta)q$
C_{ms}-P: β	cost $C = (\alpha + \beta + \gamma + \delta)q$
P-C_f: γ	profit $\pi = R - C = -(\alpha + \beta)q$
C_f-0: δ	subsidy is $(\beta + \gamma)q$
0-Y_{mi}': q	profit after receiving subsidy $\pi' = -\alpha q + \gamma q$
0-Y_{mi}': q	hence, the necessary condition for $\pi'>0$ is $\gamma q>\alpha q$.

Policies related to rural areas were first included as a main issue of the agricultural policy in 1992 in its "new policy". Its focus was, needless to say, the problems of hilly and mountainous areas where all difficulties concentrate. However, the introduction of an EC-type direct income compensation system was denied in the new policy. It was denied the system because agriculture in hilly and mountainous areas in Japan varies as they have unique features, different from EC, and thus it is hard to decide which areas and farming households to be covered under the system with certain standards and also to gain national consensus. After that, the *pros* and *cons* continued to fail to come together even at the interim conclusion of the examination council of food, agriculture and rural areas in 1997. Shogenji pointed out that both sides failed to agree because they continued to discuss "why and how" confusingly. In the discussions, without an agreement, the new policy did not regard hilly and mountainous areas as "*areas under disadvantageous conditions*" and adopted, as a vision for revitalization, local promotion by means of "*labor-intensive, highly-value-added and highly-profitable agriculture*", including processing, by utilizing the gap of altitude and other features of hilly and mountainous areas (Institute of Agriculture Engineering, 1993; and Shogenji, 1995). As Shogenji pointed out, it took a stance of selective promotion of absolutely advantageous crops in hilly and mountainous areas. It also contains the logic to conceal disadvantageous conditions of hilly and mountainous areas. In accordance with the direction of discussions, "*the Special Rural and Mountainous Areas Law*" that aims at the introduction of new crops was introduced in 1993. Needless to say, the direct income compensation system was not introduced at this point.

As the special rural and mountainous areas law that was implemented as an undersized "software-type" measure without substantial financial provision failed to meet the expectations of people in such areas. Consequently, farmland and forest resources in hilly and mountainous areas lost their managers rapidly in the 1990s. Alternative agricultural management at the community level and individual to contain the abandonment of farming by households made little progress. As the direct cultivation system by the semi-public sector (third sector) (municipal agricultural and forestry public corporations) that emerged rather naturally at local municipalities in the late 1980s was recognized (Mountain Promotion Law 1991, enforcement ordinance of the Farmland Law 1992). However, its finances were always in the red and no solution was found. In such a situation, the national government had to take up the direct income compensation system for discussion as a limited policy option. Even though it had rejected it once and continued to be careful, saying "it will conduct further discussions based on the progress of structural policies and national consensus" (supplementary resolution of the agriculture, forestry and fisheries committee when the special rural and mountainous areas law was approved). However, the discussion did not go smoothly. Because of strong opposition including that "the introduction of an EU-style direct income compensation system will help the small agricultural structure remain". At the interim report of the examination council of food, agriculture and rural areas in 1997, no conclusion was made.

The final report of the examination council of basic issues in September 1998 recognized the direct payment as an "effective means". It was because of the multi-functionality of agriculture in hilly and mountainous areas and stated the need for discussions on how to operate the system specifically. In accordance with the final report, an outline of agricultural policy reform agreed by the government and the ruling camp was submitted in December 1998 and concrete discussions on the system were entrusted to the discussion committee of the direct payment system in hilly and mountainous areas in 1999. Against such a backdrop, the new basic law was formed. It clearly stated that "the government will support to correct disadvantageous conditions to ensure multi-functionality" of agriculture in hills and mountains (Clause 2, Article 35).

Meaning and Limitations of the System

The system recognizes the disadvantageous conditions of agriculture in hilly and mountainous areas and demands public support. Therefore, its main focus is the prevention of farmers from giving up cultivation. Meanwhile, the problem of the income gap for the settlement in the areas is not a point of consideration in the system. This is why the system is not "direct income compensation" but "direct payment". This originates the meaning and limitations of the system.

As it is widely known, the system strongly concerns the "Green Policy". Although the green policy states production neutrality or minimum effect, most measures recognized under the WTO agreement have the effect of production increase. Their substantial control is the exclusion of the effect of production increase by supporting prices. It is because it is recognized that the effect of production increase by supporting prices and the effect of production increase by the green policy whose contents include correction of market failure and structural adjustment are different in their quality. Therefore, even if the system assumes that it complies with the green policy, strict production neutrality is not required. A payment system via production can be easily accepted. In making the system function, existing "publicly recognized policies" stated in the WTO agreement should not be the given ones but rather proposition of policies based on the conditions of our country should be its focus.

In such conditions, the system aims to maintain agriculture in hilly and mountainous areas based on public functions, same as the case in EU. Although Japan did so a quarter century later than EU, it should be appreciated. It is a direct payment system leading to production after a certain consideration of so-called "local government-style decoupling" (Kashiwa, 2002) as a support measure unique to our country via production, based on the experiences of local governments (prefectural level.)

Another meaning of the system is that it has a unique means of putting importance on local communities in the maintenance of agriculture. It places importance on "community agreements". It is based on the recognition that because it will be extremely technically externally uneconomical unless rice-paddy-oriented agriculture is conserved as a whole, an increase of farmers giving up cultivation needs to be restricted and that cooperation and collaboration in the community is essential to conserve rice-paddy-oriented agriculture as a whole. In such a condition, such communities are regarded as an essential component for the maintenance of agriculture not as the "end administrative group". As long as the system is a production activity-oriented support system, measures to guarantee positive results are necessary (Kashiwa, 1996). However, the EU system that requires the minimal size of farmland (more than 3 ha as a principle) to be covered under the payment system does not apply to the situation of hilly and mountainous areas in Japan where the size of farmland is small. The Japanese system tried to find its guarantee system in the community agreements. This is a system designed on the characteristics of rice-paddy-oriented agriculture of our country, which is different from EU and thus it can be a starting point. However, the problem is how to establish its content and there are many difficulties there. Whether to solve the problem or not will serve as a test for the success of the system.

I will point out two limitations: problems related to foothilly and mountainous areas consist of problems related to management of agriculture and resources and settlement problems such as income and environment for settlement (Kashiwa, 1996). Although the two types of problems overlap partially, most of them are unique to each type. It is difficult to see a long-term view of the former without the improvement in the latter. Therefore, it is indispensable to take measures to tackle both types of problems at the same time and it is difficult to improve the both by improving one, especially by improving only the former one. The system is to tackle the former problem (ensure public functions of agriculture) as described earlier (setting up short-term and tactic goals), which means that while it prepares a certain clear meaning as a possibility, it also clarifies its limitations. Therefore, successive substantial measures for settlement (long-term and strategic goals) need to be established promptly. The system is part of the substantial measures for hilly and mountainous areas to follow in the future and should be regarded as "forerunner". Substantial measures should center around spontaneous industrial promotion (income measures) based on agriculture, forestry and local industries to be a comprehensive policy system worked on not only by the MAFF but by involving other ministries, agencies and entities. It is difficult to expect the system alone to fill up the past "policy emptiness" at once and it is not appropriate to do so as it may cause confusion.

Secondly, as the system depends on the public functions, there is a limitation of linkage with food policy. One of the issues of the discussion in establishing the basic law is to ensure consistency among the three areas of food, agriculture and rural areas. However, the system failed to have substantial discussions on important issues based on the short-term surplus of supply and possible mid- to long-term tight supply and demand of rice, which is the main agricultural product in Japan. Some examples are the issue of proper farmland management to respond to changes in the long term and the issue of adjustment with flat areas in relation to production control. Issues related to production control are one of the most difficult issues in deciding the system. Discussions on the issues were not fully conducted. Based on the reason that the development of the whole agricultural policy reform is watched and consistency with it is respected, no final clear direction was decided and thus they remain as one of the problems yet to be solved. During discussions, even JA-related organizations did not show their ideas clearly. Ideas about the issues differ greatly among researchers. One idea by Masaaki Ishida and others is concentrating production control to areas where conditions for rice cultivation are disadvantageous, which points out the application of the quarter system (Ishida, 1995). The other idea is suggested by Takeshi Murata and others (Murata, 1998). Both ideas hold points that require attention for discussions. Immediate and intensive discussions by both researchers and governments are necessary.

Ishida (1995) is a strongest advocate of the first viewpoint. He argued in favor of concentration of production control in hilly and mountainous areas based on the "principles of efficiency and fairness". Shinichi Shogenji also showed a similar view on the local allocation of production control and the introduction of strategic crops backed by relative superiority in the concerned areas (Shogenji, 1998c). The induction method common to the both sides is the application of the quarter system. Sadako Nakayasu also proposed the need for areas under disadvantageous conditions for rice cultivation to shoulder more controlled size (Nakayasu, 1995). The following two points need to be considered in the argument. One is the survival of communities threatened due to the loss of the meaning of settlement and weakening social ties because of abandonment of farming ("uneconomic meaning of rice cultivation") and the other is the conservation of resources and environment in areas where rice cultivation is declining.

The second argument supports easing out production control in hilly and mountainous areas. The argument is based on the recognition that production control in the areas causes "domino-like expansion" of abolition of paddy fields and level areas are more suitable for changing crops (such as cultivation of grains) technically. However, this has the problem of intensification of competition with rice cultivation in level areas under excessive pressure. Under such conditions, Murata (1998) proposed the compensation of income for rice cultivation in level areas by price support and relaxation of production controls. Both have points of argument that require attention. Both researchers as well as governments need to be engaged in discussions urgently and intensively.

HOW SHOULD THE SYSTEM BE OPERATED?

Induction of Formation of New System to Secure Successors

As described earlier, the system is mainly responsible for tactic goals including the prevention of farmers from giving up cultivation. Therefore, additional comprehensive measures for settlement with mid- to long-term strategic goals are indispensable. If it is realized, both types of measures will have their own roles while having some common areas. However, even if the system is responsible for the goals mentioned above, it will be meaningless if it guarantees temporary, superficial and insufficient effects and serves as a defensive measure with very-short-term effects to delay destruction.

This caused a serious concern about the system being a mere "squandering of funds". Therefore, the system needs to guarantee the management of the farmland at least for the time being, until the above-mentioned settlement measure begin to function. For this purpose, it is desired that the system will be able to induce the creation of agricultural maintenance and resources management for mid to long term. It is because the trend of households in hilly and mountainous areas consisting of one old generation mainly in Chugoku/Shikoku cannot make the direct payments as an effective tool for agricultural and resources management without the creation of a system of new successors. If the decline in population due to aging is a given condition, the paid money under the system should be spent as funds to create a system for successors of agricultural and resources management. In that sense, the system should not be simply defensive but it should aim to be a semi-offensive system.

Although the system putting its importance on community agreements should be highly regarded, the problem is the contents. "Egalitarianism" in communities tends to fall into ineffective use of paid money. If community agreements become just formality and paid money simply supports not only self-concluded cultivation of small farming households of old single generation but an old-fashioned cultivation system of "landed farmer-type" community farm management that requires labor of all households and high land rent putting importance on "equality" and "order", the system will have a mere short-term effect to prolong life. Or we cannot say that it will not have a side effect to prevent nurturing successors. In the following, I will examine a new successor system to be introduced and how it should be introduced to ensure the effectiveness of the system.

NEW SYSTEM TO SECURE SUCCESSORS THROUGH COMMUNITY AGREEMENTS

A new system to secure new successors should be in accordance with local characteristics, because the characteristics differ in nature with each successor. However, at least in areas with a high rate of old single generation households, an important option will be a successor system getting out of the old-fashioned community farm management described earlier and centering around local farm management groups as a new receiver whose quality differs from that of the old-fashioned one. It is because although the third sector and individually developed management that are the last resorts of farmland management are important options, they have a certain limitations in their scale of cultivation and resources management. The community function in hilly and mountainous areas is weakening. However, in reality, it is difficult to find a new effective agricultural maintenance system to take the place of community production groups in hilly and mountainous areas. In such a situation, the direct payment system puts importance on community agreements and sees nurturing of community production organizations, which should be highly regarded as a starting point. Community agreements need to be regarded as a starting and security for the creation of a new successor system. I will make specific suggestions to the system through points that require attention under an assumption for creating a successor system.

Need to Induce Creation of a New Successor System for Community Agriculture

It is difficult to find permanent successors under the old-fashioned community farm management that is "mutual support based on the voluntary principle" (Kajii, 1973). Therefore it is important to first create a successor group (second-tier part) as a new receiver of maintenance of farming that puts importance on efficiency and has a new profit distribution structure and secondly to promote the formation of a landowner organization (first-tier part) that supports the successors' organization with the function of using farmland as a mass and function.

It is a multilayered local farm management group (Nagata, 1987). It is because an increase in old single generation households calls for the existence of "dependable" sustainable successors of key industries at community level.

Need for Community Agreements that Guarantee Formation of New Agriculture Maintenance System

Community agreements are the key to getting out of old cultivation maintenance systems and forming an autonomous successors' organization that will not be bound to community order although supported by the community. Community agreements should be regarded as one that ensures an autonomous organization of operators and officials. In doing so, a profit distribution system that ensures fair wages not only for operator labor but labor for management and planning (officials' wages) and labor for accounting and other paper work should be clearly stated in the regulations or articles of the organizations. The community agreements should involve not only issues related to organization of landowners but also issues related to the organization of successors.

Local governments' role must become important to avoid obstructions of "egalitarianism" of the community, prevent the agreements from becoming just a formality and as a result prevent the system from becoming "squandering of funds". The application of the system should be examined in the basic planning by community under the leadership of local governments. In that sense, planning ability and leadership of local government is questioned. However, many local governments and communities lack such abilities. Although routine work needs to be decreased in order to promote strategic activities of local governments, it will not be enough to solve the problem. As it will be described later, it is necessary to examine the establishment of a new receiver for local management.

Need for Measures to Ease Dynamic Disadvantageous Conditions

It is necessary to establish measures to ease disadvantageous conditions caused by expansion in order to promote growth of private successors described earlier. Establishment of prices per unit with attention paid to the "static disadvantageous conditions" (cost gap in a short-term perspective) between flat areas and hilly and mountainous areas is being examined under the system. However, measures to decrease "dynamic disadvantageous conditions" (cost gap in a long-term perspective) are necessary for the growth of successors. It is because scale merits disappear at an early stage and move to the zone where cost rises in proportion in hilly and mountainous areas. The average income of farming households in hilly and mountainous areas is less than that in flat areas; the disadvantage of trading costs of land accumulation per unit size of land needs to be pointed out. In such conditions, the system should introduce a way to add money in proportion to the scale of expansion.

However, it is not appropriate to regard the system as "structural reform" that has a selective concept same as flat areas. It should be regarded as part of core training measures indispensable for building a relationship of systematic group-oriented work sharing among unique farming households. This needs to be fully understood.

Importance of Creation of "Core" of New Receivers of Community Agriculture

It is necessary to create a measure of training human resources that will serve as core of new successors' organizations according to a plan and have it established in the community (return-to-community-style incubation). As described in the first part of Part I, it is because "costs for transfer and participation" to be successors are particularly high and it is difficult to become successors independently in hilly and mountainous areas. Public corporations and corporation directly managed by agricultural cooperatives can be incubators. However, for effective incubation the possibility of the costs being shouldered publicly based on the recognition of incubation costs should be examined under the system because unique costs arise. Agricultural policies have traditionally supported successors including new participation; it has provided little financial support for bodies that train successors. Such support should be given consideration as investment in relation to the problem of lack of successors in hilly and mountainous areas.

Response to the Problem of Excessively Small Communities in Mountainous Areas

It is also necessary to consider the excessively small communities in mountainous areas in dealing with the private training of successors. The average size of paddy field per community in hilly and mountainous areas is 9.4 ha at the prefectural level excluding Hokkaido. This average is smaller in Chugoku region at 6.7 ha. It becomes even smaller when limited to mountainous areas. It is difficult to manage rice cultivation effectively by a single community in many hilly and mountainous areas. In such a case, it is necessary to examine the possibility of creating units of farmland use consisting of multiple communities. Forming groups in an extensive area covering more than one community is originally difficult. Therefore, it is necessary to examine the introduction of a system to add money to promote the establishment of organizations for coordinating land use among communities.

III. CONCLUSION

I have discussed the meaning and limitations of the direct payment system in hilly and mountainous areas in Japan. Although the system has serious limitations in relation to settlement effects and food policy, putting importance on communities in relation to agricultural maintenance and resources management has certain value as "Japanese-style decoupling". However, it is essential to operate the system in such a way that will induce the formation of a new successor system for farmland management for future sustainability. For such operations, the ability of the management body of local agriculture becomes very important. It is necessary to discuss who should be in the body and how to create an effective body.

The system has a serious limitation as a policy for hilly and mountainous areas. When a local industry policy is established what the local management body should be like remains an issue.

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1. BANGLADESH

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INTRODUCTION

Total area of Bangladesh is about 147,570 km^2 having a land area of 14.75 million ha. Her population is 128 million (January 2001). The per capita GDP is US$363 (2001). The gross cropped area is about 11.58 million ha and the net-cropped area is 6.658 million ha (Bangladesh Bureau of Statistics [BBS], 2001). The river and inland water bodies occupy about 0.97 million ha (6.57 percent) whereas the forest occupies 1.89 million ha (12.8 percent) (Das, 1992). The dominant land use category is agriculture, which is 78 percent of the total area of the country. At present, around 75 percent of the land area is under crop production and rice is grown in almost 75 percent of the cropped land area.

Geo-morphologically, the soils of Bangladesh are floodplains and deltaic sediments (80 percent), terraces (8 percent), and hills (12 percent) (Ahsan and Karim, 1986). If we consider the hills and terrace soils as upland, then the upland areas constitute 20 percent of the total area of the country. Land use in the sloping upland areas are somewhat different from that of the plain alluvial areas; although the valleys and level to nearly level Barind and Madhupur tracts are cultivated as the criteria followed in the adjacent alluvial plain lands.

This paper is an outcome of analysis of relevant data and research findings collected from different sources; namely, research institutions, government and semi-government organizations. The author had discussions with almost all the Heads of the Departments/institutes dealing with soil resources, agriculture, forestry and upland agriculture to get an idea of the problems and prospects of this hill production system. Field visits to the sloping upland areas and the discussions with the *jhum* cultivators and research workers provided ample opportunity to enrich the paper. This report is concerned mainly with the sloping upland areas of the country. The information on general agriculture sector has been used only for highlighting the relative socio-economic significance of upland agriculture in the country.

DATA COLLECTION TECHNOLOGIES APPLIED IN BANGLADESH

Bangladesh applies the latest technologies for collecting data on land, soil and agriculture on a limited scale. Recently, Bangladesh Agriculture Research Council (BARC) and Environment and Geographic Information System (EGIS) jointly developed a methodology to update the inundation land type map and data on Bangladesh through the application of remote sensing (RS) and geographic information system (GIS) tools and techniques in three *upazillas* (sub-district). Spatial distribution of inundated area at different times of the flood season, obtained through RADARSAT images overlaid on updated elevation data leads to the classification of areas under different inundation land types (BARC, 2001).

In 1960s, Soil Research Development Institute (SRDI) carried out a reconnaissance soil survey which formed the basis for generating land type data using 1:125,000 scale mainly through aerial photo interpretation, field survey and interviews with the farmers. The Flood Action Plan-19 compiled, improved and analyzed the digital data to produce a reconnaissance level inundation land type map for the country. After 20 years, SRDI, with active cooperation of Bangladesh Agricultural Research Institute (BARI), BARC, Bangladesh Rice Research Institute (BRRI), Bangladesh Institute of Nuclear Agriculture (BINA) and Department of Agricultural Extension (DAE) initiated the process of producing a Land and Soil Resources Utilization Guide for all *upazillas*. The Master Plan Organization (MPO), while preparing the National Water Plan (NWP) used SRDI database and further refined the classification developed in 1980s. The maps of the Guide were produced at the 1:50,000 scale with a database on morphological, physical and chemical soil properties along with inundation land type information; but no spatial distribution could be shown in those maps (BARC, 2001). In 1999, BARC and SRDI started converting "soil and land type maps" and tabular data into digital GIS map layers with soil properties as an attribute to the map unit, completing 400 *upazillas* to date (Bangladesh has 469 *upazillas*). Modern tools and techniques including GIS and RS have opened up the scope of using scientifically sound methodologies to develop and update different information in place of existing data of 1960s.

LAND CLASSIFICATION SYSTEMS IN BANGLADESH

The land classification systems developed for uplands of Bangladesh are given below:

Land Type Classification Based on Flooding Depth

The farmers of Bangladesh have their own traditional system of land classification for practical purposes. They classify their lands on the basis of normal flooding in the rainy season that concerns their crop selection (Table 1). A crucial factor for selection of crops in *kharif* (summer) season is the depth of seasonal flooding and for dry land *rabi* (winter) crops, attaining field capacity and available moisture holding capacity of soil are important. They are well aware of these factors and select crops or crop sequences according to those criteria. These are as follows:

- High Land: Land lying above normal flood level and can be used for annual or perennial dry land crops (such as sugarcane, bananas, fruit trees, etc.)
- Medium High Land: Flooded only up to 1 m deep during the monsoon season on which transplanted Aman[1] variety of rice can be grown.
- Medium Low Land: Flooded 1-2 m deep. It is suitable for jute, and varieties of rice such as broadcast paddy, *Boro*[2], broadcast *Aman*, etc.
- Low Land: Flooded 2-4 m. Broadcast *Aman* and *Boro* varieties of rice are the crops of this land.
- Very Low Land or Bottom Land: This land is flooded above 4 m where only deep-water *Aman* and *Boro* varieties of rice can be produced.

Table 1. Comparative Land Type Classification of MPO and SRDI

MPO Classes		SRDI Classes	
Nomen-clature	Depth of Inundation	Nomenclature	Depth of Inundation
F_0	Intermittently flooded up to 30 cm	High land	Flood free
		Medium high land-1	Intermittently flooded up to 30 cm
F_1	Seasonally flooded up to 30-90 cm	Medium high land-2	Seasonally flooded up to 30-90 cm
F_2	Seasonally flooded up to 90-180 cm	Medium low land	Seasonally flooded up to 90-180 cm
F_3	>180 cm where deep-water rice (DWR) can be grown in the monsoon season	Low land	Seasonally flooded up to 180-300 cm
F_4	>180 cm where DWR cannot be grown in monsoon season	Very low land	>300 cm seasonally perennially flooded

1 Rice varieties grown in the monsoon season and harvested in November-December.

2 Rice varieties grown in the dry season, usually with the help of irrigation.

Land Capability Classification

Land capability classification, developed by the United States Soil Conservation Service in 1961, was not found applicable to Bangladesh. However, the classification was reproduced by SRDI to accommodate the soils of the country. As in the American system of classification, three levels of generalization are recognized: land capability class, land capability sub-class, and land capability unit. There are the following five classes of land capability:

Class-I:	Very good agricultural land. This class has two sub-classes
Class-II:	Good agricultural land. This has three sub-classes
Class III:	Moderate agriculture land. This has 10 sub-classes
Class IV:	Poor agricultural land. This has 10 sub-classes
Class V:	Very poor and non-agricultural land. This has five sub-classes.

In this paper, land capability classes and sub-classes representing the sloping upland areas of Bangladesh (Classes III, IV and V) are briefly discussed:

1. ***Class III: Moderate Agricultural Land, Sub-class III Dr***

Here 'D' stands for soil lying above normal flood level and 'r' for soil having irregular local relief hindering irrigation, drainage or tillage. Soils in this sub-class are well to imperfectly drained, gently rolling but usually of low relief (FAO, 1971). Part of the sloping upland, i.e., the terrace areas, belongs to this class. Except for their occurrence on irregular topography, these soils have only slight to moderate limitations for plant growth. These lands are suitable for orchard, rubber, tea and forest plantations.

2. ***Class IV: Poor Agricultural Land, Sub-class IV De***

Soils in this sub-class dominate hill areas of the country and have severe limitations for crop production throughout the year. Here 'D' stands for soils lying above normal flood level and 'e' for severe erosion and unfavorable relief (on slopes), rapid rise of flood water and very low nutrient and water holding capacity. Traditionally, these soils are used for forest, softwood, permanent grassland, perennial tree crops and *jhum*. With modern management, the moderately shallow clay soils can produce poles and fuel-wood from *sal* (*Shorea robusta*) forest.

3. ***Class V: Very Poor and Non-agricultural Land, Sub-class V De***

Soils in this sub-class are moderately well to excessively drained, sloping to very steep, often shallow and rocky or very stony. These lands have severe erosion hazard that occupies mostly the hill region of the country, and are used for supply of wood, bamboo or for hill top homestead sites. Only at a very high cost could some areas produce moderate yields of tree crops. These lands are best used as natural watersheds and for the production of wood, cane and bamboo or to be left as natural herbarium.

CROP SUITABILITY CLASSIFICATION

Crop suitability classes (rating) are similar to land capability classes but two important differences should be noted. The crop suitability class rates or grades individual crops, whereas the land capability class grades or rates the overall crop production. Moreover, crop suitability rating takes into account only the most favorable season of the year, whereas land capability rating is based on the limitations of a soil for crop production for the whole year. In the Reconnaissance Soil Survey Reports of SRDI, five crop suitability classes were adopted, which are as follows:

1. ***Crop Suitability Class 1: Well Suited***

Soils of this group have favorable physical, chemical and hydrological characteristics and no significant limitations for cultivation of the crop under consideration are required.

2. ***Crop Suitability Class 2: Moderately Suited***

Soils of this group have a number of slight and/or moderate limitations that render it less productive than soils rated "well suited" for the crop under consideration.

3. ***Crop Suitability Class 3: Poorly Suited***

Soils of this group have a number of slight, moderate and severe limitations for the production of the crop under consideration.

4. ***Crop Suitability Class 4: Very Poorly Suited***

Soils of this group have many slight, moderate and severe limitations for the production of the crop under consideration.

5. ***Crop Suitability Class 5: Not Suited***

Soils of this group have a large number of severe limitations for the production of the crop under consideration. Either the crop cannot be grown, or productivity is very low and risky.

MAJOR PHYSIOGRAPHIC UNITS AND LAND USES

Out of 22 recognized physiographic units of Bangladesh (SRDI, 1997), four major ones are: a) alluvial plain, 75 percent; b) mangrove forest, 5 percent; c) terrace, 8 percent; and d) hills (high and low), 12 percent.

Alluvial Plain

Unconsolidated alluvial soils occupy the major part (75 percent) of Bangladesh, formed by the deposition of alluvial and colluvial sediments under piedmont, meander, estuarine and tidal environments in different areas of the country. These alluvial soils are highly fertile, but extremely vulnerable to flood and drought, mostly level to nearly level by nature and widely devoted to rice, jute and wheat cultivation. In the plain areas there is hardly any scope to expand the command area for alternative crops, as the cropping intensity has already exceeded 250 percent. Only alternative is the sloping upland areas.

Mangrove Forest

Bangladesh is fringed on the south by the Sundarbans, the world's unique natural marshy deltaic forest. Measuring about 10,000 km^2, this world's largest mangrove ecosystem stretches across coastal India and Bangladesh.

Terrace Areas

The Barind tract (locally called *Borendra*) consists of hillocks with varying height of about 30 m from the mean sea level. Madhupur clay underlies the Barind and Madhupur tracts. Both Barind and Madhupur tracts mainly lie only 1-5 m above the adjoining floodplains areas. The formation is almost horizontal and broken into a number of blocks, some of which are tilted. Extensive areas of the Barind tract have almost level, terrace-like topography, but the western part of Barind tract is closely dissected; valley sediments occupy only 10 percent of the whole area.

In the north-central part of the country, is the Madhupur tract, where 10-20 m high hillocks exist in association with dissected, nearly level and poorly drained cultivated valleys. Valley sediments occupy about 30 percent of the Madhupur tract. The content of easily weatherable minerals ranges from 4 to 9 percent.

Even after lots of deforestation, Barind and Madhupur tracts are still dominated by open deciduous *sal* (*Shorea robusta*) forests, whose hardwoods are comparable in value and utility to *teak* (*Tectona grandis*). Indiscriminate exploitation of the *sal* forest over the centuries has converted the thickly stocked forests of the past into a depleted forest of miscellaneous tree species. Nowadays, there are extensive vacant/fallow and grassland areas within the sparse *sal* forest. In recent years, rubber and pineapple cultivation appears to be encouraging and economic in the region. The level terraces and inter-ridge depressions (valleys) are judiciously used for different field and horticultural crops as the soils of plain area.

North and Eastern Hills

The major sloping upland area of the country represent the hills of districts of greater Mymensingh, Sylhet, Chittagong and Chittagong Hill Tracts (CHT). These hills aligned, approximately, north north-east to south south-east in the districts of greater Chittagong and CHT and the south of the district of greater Sylhet swinging round to almost east-west in the north of the districts of greater Sylhet and Mymensingh. The hills of Bangladesh are part of Hindu Kush-Himalayan mountain ecosystem and are considered to be one of the youngest mountain chains of the Mio-Pliocene to Early Pleistocene age. Three series of rocks have been identified in the region, of which the two older series (Surma and Tipam) are exposed in the higher elevations of the anti-clines, and the relatively younger Dupi Tila series has been eroded at higher elevations and now underlies the low hills of the synclines (Hassan, 1999). Most of these hills are closely dissected and sharp edged, slopes are mainly steep to very steep, ranging up to an altitude of 1000 m. Towards the center of the valleys between the ranges, the hills become lower, more gently sloping and rather flattened on the top low bumpy hills.

Smaller areas are occupied by the Dihing formation of Pliocene to Pleistocene age, which includes pebble and boulder beds along the northern border of greater Sylhet and Mymensingh districts. The total content of easily weatherable minerals (feldspar plus biotite) is generally less then 10 percent. This may be up to 15 percent in some hills in the northern borders of greater Mymensingh district.

Within the hills of Bangladesh, CHT alone represents 76 percent hilly area of the country. Nearly 26 percent of CHT is under reserved forest (RF) and the rest is under un-classed state forest (USF). Besides the vast fallow areas (abandoned *jhum* fields), horticulture, forest plantation, rubber and tea are the major crops. The hills can be efficiently used as water reservoir if model watershed manage-ment approach is followed. Instead of bigger dams, smaller earthen dams proved efficient for preserving year round water. The artificial water reservoir of the Soil Conservation and Watershed Management Center (SCWMC), Banderban has the water depth of 7-10 m at an altitude of 150 m, which can be a model of this kind (Figure 1).

Figure 1. Artificial Water Reservoir of the SCWMC,

Land Capability Class and Distribution in CHT

The soils of CHT have been mapped at reconnaissance level by SRDI (1986) based on the previous survey and mapping done (except the reserve forest area) by the Canadian consultant group, Forestal in 1964-65. The land capability classes of the surveyed area (excluding RF) and the area under different land classes are also assessed by the SRDI (1986) report as shown in Table 2. This demonstrates the paucity of suitable agricultural land with 89 percent of the surveyed area having severe to very severe limitations to agriculture, mainly due to the presence of steep slopes and accelerated erosion.

Table 2. Land Capability Classes of the CHT

Land Capability Class	Percent Slope	Area (ha)	Percent
Class A (few limitations)	0- 5	30,969	3.1
Class B (moderate limitations)	5-20	27,488	2.7
Class C (severe limitations)	20-40	148,482	14.7
Class D (very severe limitations)	>40	735,882	72.9
Mixed C and D	-	12,970	1.3
Settlement and water	-	53,535	5.3
Total		1,009,326	100.0

Source: SRDI (1986).

CLASSIFICATION OF HILLS BASED ON THEIR ALTITUDES

The hills of Bangladesh are classified into three groups on the basis of their altitude. These are: i) low hill, <150 m; ii) medium high hill, 150-300 m; and iii) high hill, >300 m. Hill heights regulate the climatic condition of an area that in turn influences the land use potentials of the area.

***Jhum* Cultivation in the Hills of Bangladesh**

The *jhum* is shifting cultivation (SC). It is an indigenous mixed cropping system in the hilly areas of Bangladesh. Currently, *jhum* is mainly concentrated in the hills of CHT, and in the hills of greater Chittagong district adjacent to the hills of CHT. It is a mixed upland cultivation system in which an area is entirely cleared from natural vegetation by slashing and subsequent burning in the dry season, then sowing/ broadcasting seeds after the first rains in April (Figure 2). The seeds of hill paddy, maize, millet, vegetables, chilly, melon, pumpkin, hill cotton, spices and tobacco, etc. are mixed and sown in small holes in the *jhum* plot. After the initiation of rain, seeds germinate along with numerous weeds. Usually, the weeds grow fast and cover the newly germinated seedlings within 2-3 weeks after planting. Consequently, weeding becomes urgent to save the newly emerging crops from weed suppression and to reduce nutrient removal by the weeds (Gafur, *et al*., 2002a). But very little weeding or tending is carried out, except in some cases, to provide protection against the depredation of wild animals. *Jhum* crops are harvested as they ripe successively between July and December. Afterwards, the plot is fallows and the cultivator selects another site for the next season. Formerly, *jhum* was practiced in Bangladesh hills with fallow periods of 15-20 years, which was desirable to restore natural fertility and satisfactory production. But, due to increased population pressure in the hills and scarcity of suitable land for *jhum*, the rotation has been reduced to 3-5 years in recent years (Gafur, *et al*., 2002b). During the peak *jhum* season (May to July) hilly area receives heavy and high intensity rainfall, which accelerates soil erosion and runoff as the hill slopes slashed and burned for *jhum*, remain bare or sparsely covered with newly emerging seedlings and therefore are vulnerable to water erosion (Gafur, 2001).

Figure 2. Clearing Natural Vegetation through Slash-and-Burn

During the fallow period, abandoned *jhum* fields are left for natural regeneration and the *jhum* cultivators do nothing to improve the nutritional status of the degraded land – mostly due to lack of ownership. This results in considerable degradation of soil, severe erosion, runoff and destruction of vegetation and organic matter, and subsequent decline in the soil fertility and crop yield. The abandoned *jhum* fields produce weeds, sun grass, and shrubs and trees which have little or insignificant economic value.

After the fallow cycle of 3-5 years, same area may be cleared again in the similar manner but not necessarily within the same boundaries or by the same cultivator. Since the fertile topsoil of the hill slopes washes away on account of faulty soil management of *jhum* each year, vast areas of Bangladesh hills turn into barren, nutrient deficient, unproductive landmasses (Table 3). Commenting on *jhum* of Mizoram, India, i.e., adjacent to CHT, Lienzela (1997) concluded his article saying, ‘to save Mizoram and her environment, *jhumming*, i.e., shifting cultivation should be totally banned’. The situation in Bangladesh is much more alarming due to high demographic pressure (three times higher) and exceptionally short fallow period (3-5) years.

At present, only 2.5 percent of the hilly area of CHT is used for shifting cultivation each year, other areas of similar size were used in previous years (Gafur, *et al*., 2002a). So, nearly the whole mountainous area except the Kaptai Lake and RF is affected. Thus the long-term combined effect of such cultivation is more wide-ranging than is usually presumed. Fire is used as land clearing tool, but also as a weapon in the social conflicts, which accompany forest conversion (Tomich, *et al*., 1998).

Table 3. Results of Soil Loss Study Conducted at Different Research Stations and Experimental Sites in CHT

Land Use	Slope (percent)	Soil Texture	Average Soil Loss (mt/ha/year)	Research Station/ Experimental Site
Fallowed *jhum*	5-30	SCL-CL	10	SCWMC, Banderban
Mixed garden	5-30	SCL-CL	12	SCWMC, Banderban
Jhum	10-20	SCL-CL	41	SCWMC, Banderban
Jhum	15	SCL-CL	25	SCWMC, Banderban
Jhum	25	SCL-CL	33	SCWMC, Banderban
Jhum	36-46	SCL-CL	40	SCWMC, Banderban
Jhum with fertilizer		SCL-CL	47	CHTDB, Khagrachari
Jhum with hedge (*Laucaena* spp.)		SCL-CL	17	CHTDB, Khagrachari
Jhum with hedge (*Flemingia* spp.)		SCL-CL	9	CHTDB, Khagrachari
Jhum with hedge (*Indigofera tysmanii*)		SCL-CL	17	CHTDB, Khagrachari
Agro-forestry	60-65	SCL-CL	8	FSRD, Banderban
Hill paddy	60-65	SCL-CL	10	FSRD, Banderban
Pineapple	55-60	SCL	24	FSRD, Banderban
Fallow	60-65	SCL-CL	28	FSRD, Banderban
Pineapple	5	-	12	BARI, Ramghar
Pineapple	50	-	35	BARI, Ramghar

Notes: CL: Clay loam; SCL: sandy clay loam; SCWMC: Soil Conservation and Watershed Management Center, SRDI, Banderban; CHTDB: Chittagong Hill Tracts Development Board, Sloping Agricultural Land Technology (SALT) Site, Alutila, Khagrachari; and FSRD: Farming System Research and Development Site, Bangladesh Forest Research Institute (BFRI).

Figure 3. *Arum* spp. Grown on Along Hill Slopes

The population increase by migration, especially, from the plain areas, has induced new ideas in agricultural practices resulting in the use of more intensive and destructive hill farming systems. Inappropriate tillage techniques like digging by spades is practiced on hill slopes (mainly by the migrants) to grow tuber crops like potato, aroids, ginger, turmeric, etc. Very often, farmers grow the tuber crops along hill slopes ignoring the contours (Figure 3). An alarming message concerning soil fertility declination, yield decrease in *jhum* plots, and reduction of fallow period to less than five years was given by the Canadian Forestal Survey Group in 1965 (SRDI, 1986). This report also described increase of landslide and soil erosion, nutrient depletion and irreversible degradation of land, soil and environment in CHT. It should be noted that these observations and comments were made 37 years ago. It is needless to say that the situation has aggravated many folds since then as the present population density in CHT is 96 persons/km^2 (Gain, 2000) compared to only 29 persons/km^2 in 1961 (BBS, 1993).

Thirteen tribes of CHT practice mainly *jhum* whereas settlers are not, accustomed to this system. The major tribes are Chakma (48 percent), Marma (28 percent) and Tripura (12 percent). At present, their number is about 728 thousand which is 0.568 percent of the total population (128 million), covering about 10 percent land area of the country (BBS, 2001).

ECONOMIC SUSTAINABILITY OF *JHUM* IN CHT

In a recent socio-economic study on *jhum* in CHT, Gafur, *et al*. (2000) observed that with an estimated output of only US$362 against an input of US$380/ha/year (benefit-cost ratio [BCR] 0.95) the system is not cost-effective under the present socio-economic conditions of CHT (Gafur, *et al*., 2002). At the present production level, the system cannot feed even a family of four members. It seems to be the most labor-demanding agriculture system where 88 percent of the total expenditure is spent for labor and only 12 percent for all other purposes. Moreover, the system results in severe loss of soil and essential plant nutrients by erosion. Assuming 2.5 percent land of CHT is put under *jhum* each year, it has been estimated that nearly one million mt of soil containing several mt of nutrients will be lost from the entire *jhum* cultivated area of CHT every year. To compensate the loss of only N, Ca, K, P, S, B and Zn by commercial fertilizers, approximately 14,000 mt of different fertilizers are required annually for the entire *jhum* cultivated area of CHT (~33,000 ha). The monetary loss at the March 2001 price level for these commercial fertilizers amounts to approximately US$1.8 million per *jhum* season. It is quite alarming to the agrarian economy of CHT (Gafur, *et al*., 2002b).

LAND RIGHTS IN THE UPLAND AREAS

The major hill area of the country is CHT. Out of a total area of 13,237 km^2, in CHT the reserve forest is 3,483 km^2 or 26 percent of the region and the rest USF areas are being used by the hill dwellers where the tribal people mostly practice *jhum*. The problem of land ownership rights is acute here. Historically, the major development in this regard was the CHT Regulation, 1900. The objectives of this Regulation were to 'protect the rights and interests of tribal people, their customs and practices, their local and racial peculiarities and prejudices and thus preserve their cultural identities' (Khan, 1998 and 2002). CHT was divided into three taxation circles headed by three tribal chiefs called the *Chakma, Mong* and *Bohmong* chiefs (locally called as *Raja*). The rules under the Regulation were amended a numbers of times until 1935. These amendments led to repealing of permit system and declaration of CHT as a backward tract enabling the Governor General of India to govern CHT as 'excluded area'. The restriction of non-tribal's entry to CHT was totally lifted in 1964. This action caused dissatisfaction among the tribal people (Khan, 1998). Thousands of people were displaced for this reason and also for other troubles. A Peace Treaty signed on 2 December 1997 between the government and the tribal leaders ended the trouble. Regional council has been constituted and is now functioning there. As per the Treaty, a Land Commission was constituted on 3 June 1999 to solve the land problems of the displaced people.

The plain areas of Bangladesh are well demarcated by cadastral survey, which was not completed in CHT. So land ownership is not as yet clearly defined there. A mixed land administration with the district administration and the tribal chiefs is still continuing. This creates many discrepancies. Land ownership is very much essential for sustainable production system. It creates a social, political and economic awareness among the farmers. So a cadastral survey leading to some sort of permanent ownership or a long-term lease system should be implemented. It is also expected that the above-mentioned Land Commission will solve the land tenure problem, especially of the displaced hill people. In other upland areas, there is no such problem.

AGRO-FORESTRY AND SLOPING AGRICULTURAL LAND TECHNOLOGY IN BANGLADESH

The hills of Bangladesh represent the potential agro-forestry (AF) area of the country. Since 1986, BFRI is engaged in research and development works in AF in the hilly areas in collaboration with BARC. The land use appraisal in this region is attached to various impediments towards sustainable development viz. high altitude, deeply dissected irregular terrain, steep to very steep slopes, severe erosion, rainfall pattern, seasonal drought, volatile land right and title, poor literacy and inaccessibility. Out of this endeavor, several AF practices like: i) alternate contour rows of tree plantation intercropped with shade loving/tolerant crops; ii) bench terracing method; iii) sloping agricultural land technology (SALT-1 and 2); iv) differentiated slope agro-forestry (DSA); v) natural vegetative buffer strip (NVS) and; vi) contour trash line (CTL) method were found suitable for the region (Paul and Hossain, 2001).

Each of the above-mentioned AF practices has its own problems and prospects for application in the sloping upland. The slope gradient for SALT and other AF practices were recommended up to 40-45 percent. However, for SALT, CHTDB has allowed up to 35 percent slope gradient for seasonal crops, 35-70 percent for fruit trees and more than 70 percent for forest species (Paul and Hossain, 2001).

Alternate Contour Rows of Trees Intercropped with Shade Loving/Tolerant Crops

This is an easily manageable AF practice for the hill farmers, where fruit trees or forest species are grown in contour rows, under 1-2 m plant to plant spacing. Within the tree rows 6-10 m inter-spaces are kept for cultivation of seasonal crops.

Bench Terracing Method

The bench type terraces of about 1 m wide and 3.5 m long are constructed along contour with 2-3 m interval throughout the selected hillside. The space between the terraces down the slope can be 3-6 m. The bench terraces as well as inter spaces, both along and against contour are cultivated with seasonal, annual, biennial and perennial crops. Under this technique, soil erosion is less (in the range of 16-22 mt/ha) and water infiltration rate is high. However, due to high cost (Tk.60,000-1,00,000/ha, i.e., US$1,040-1,650/ha) bench terrace construction is commonly discouraged (Paul and Hossain, 2001).

Sloping Agricultural Land Technology

SALT was introduced by the Mindanao Baptist Rural Life Center (MBRLC), Mindanao Island, Philippines in 1975-76. It is an effective AF practice, where six modifications have been found. Out of six, four modifications are tested and practiced effectively under Bangladesh environment. These are:

SALT-1: Sloping agricultural land technology;
SALT-2: Sloping agro-forest land technology;
SALT-3: Sloping agro-livestock land technology; and
SALT-4: Sloping agro-fisheries livelihood technology.

In Bangladesh SALT-1 and SALT-2 were first tested at Khagrachari of CHT with several hedgerow species, e.g. *Gliricidia* spp., *Leucaena leucocephala, Desmodium* spp. and *Indigofera* spp. Out of these species *Indigofera tasmanii* showed better performance as hedgerow species. The sustainability of SALT as an AF practice is associated with slow but continuous improvement of soil fertility by proper management of the systems' organic matter and controlling erosion.

It has been mentioned earlier that *jhum* is not, at all, sustainable in the present context. So recognizing the value of conserving soil resources for economic growth and poverty alleviation, SALT has been considered imperative. It may control soil erosion effectively, and improve fertility and productivity of sloping uplands. This concern has prompted to introduce and popularize the SALT and associated appropriate technologies, which are elsewhere known to be effective in reducing soil erosion and maintaining soil fertility (Partap and Watson, 1994; Palmer, 1996). The CHTDB, since 1993, has been working on popularizing modified SALT as part of the program on 'Appropriate Technologies for Soil Conserving Farming Systems (ATSCFS)' supported by the International Center for Integrated Mountain Development (ICIMOD). On-farm tests and demonstration of contour hedgerows were carried out at about 80 ha sloping upland at Alutila under Khagrachari (Figure 4) following methodological guidelines were outlined in the Planning Workshop (ICIMOD, 1994).

Figure 4. Demonstration of Contour Hedgerows

Studies at Bandarban noted that among the grasses, vetiver showed better performance; and *Thysanolaena maxima* (broom grass) and napier showed invading tendency from the hedges to the alley area (SCWMC, 1998). Maintenance of hedgerow was found cost-effective compared to farming in the slopes without any hedge. Experiment showed that hedgerow could retain 60-80 percent topsoil and 40-50 percent runoff water from the same slope class (SCWMC, 2000).

Differentiated Slope Agro-forestry

The major feature of this AF system is the division of entire hillside into upper, middle and lower part. The less fertile upper part is used for cultivation of forest species, the moderately fertile middle slope is for horticultural crops, and the lower fertile portion for cultivation of seasonal crops.

Natural Vegetative Buffer Strip

Under this AF system natural vegetation of local origin is intensively utilized for hedge in place of nitrogen fixing hedge plants as in SALT. Trees and crops are grown in the inter-spaces of vegetative strips.

Contour Trash Line

In this practice, natural weeds as weed out materials are left on contour lines with 2-4 m interval throughout the hill slope. Formation of CTL is continued along with cropping practice for several times. AF crops are grown in inter-spaces of the CTL. This system seems effective in controlling soil erosion and runoff, increase water holding capacity, restoring soil fertility and crop productivity.

Moreover, the simple land husbandry practices like zero tillage, retaining cover crops, using bio-hedge and mulching can increase crop production by reducing soil erosion and enriching soil nutrient status in the sloping lands. Use of leguminous cover crops (LCC) as green manure crops have been found successful in restoring soil fertility in many regions of the world (Shamsuddin, *et al*., 2002).

TWO MAJOR UPLAND PLANTATIONS: TEA AND RUBBER

Tea (*Camellia sinensis*)

Bangladesh is a tea exporting country. In the financial year 2000-01 the country produced 53,144 mt of tea and exported 16,530 mt worth of US$20.77 million. Bangladesh Tea Board (BTB) formed in 1950, expanded tea cultivation and developed existing tea gardens. The Bangladesh Tea Research Institute (BTRI) is performing research work on tea plantation and promotion of quality of tea. Presently, the annual production of tea has increased by 1 percent whereas the annual domestic consumption increased by 3.5 percent. The statistics based on the domestic consumption of the last 20 years, indicates that, the country will not be able to export tea after 10-15 years. It is alarming that the national tea production is only 1,176 kg/ha; nevertheless, in about 12,324 ha old tea gardens, this is 460 kg/ha. The average land use is 44.27 percent of the grant area.

In 1980s, about 80 percent of the total production was exported which came down to 30 percent in 2000. But the consumption increased from 25 to 75 percent in the same period. So a major intervention is required within 10 years. 'Feasibility Study for Small Holding Tea Plantation' conducted by BTB suggests that an additional area of 16,000 ha in Panchagarh district and 46,000 ha virgin land in CHT can be brought under tea cultivation, in the form of smallholding tea plantations without any legal complication. This will create livelihood opportunities for about 150,000 families, reduce soil erosion and improve local environment by afforestation. Moreover, if the land utilization can be raised to 50 percent and yield to 1,500 kg/ha by rehabilitation of the old gardens, in addition to, improved cultivation systems, the production will be raised to 111.79 million kg by 2021.

Rubber (*Hevea brasiliensis*)

In Bangladesh, planned rubber plantation started in 1961 by the Bangladesh Forest Industries Development Corporation (BFIDC). Over the last two decades, it has emerged as a sustainable economic activity. A good number of countries have reportedly accepted rubber cultivation as an alternative to soil conservation for better economic return, more equitable distribution of income and wider coverage on the forest that reduce soil erosion (Jayasena and Wickramanayake, 1996). The BFIDC sponsored estimates suggest that rubber cultivation is economically sound and the internal rate of return is 15 percent. According to the estimates of the Forest Department about 0.24 million ha medium sloping unproductive uplands are suitable for rubber, coffee and other AF crops (Khisa, 1991; and Khisa and Husain, 2002). However, at present an estimated 24,977 ha land (10 percent) are used for rubber plantation (Table 4). In the CHTDB projects, rubber is planted in a block of 81 ha managed by a village project generally consisting of 50 *jhum* farming families and the rubber block are adjacent to their village.

Table 4. Distribution of Rubber Gardens and Achievements

Name of Organization	Total Area under Rubber Plantation (ha)	Total Number of Trees (million)	Production (mt/year)
BFIDC	13,191	4.36	4,000
CHTDB	3,238	-	800
Private cultivation	8,548	4.00	500

When compared to plantation forest, planting rubber with cover crops (immediately after clearing of forests) has been found to give better protection to the land from erosion (Goldthorpe, *et al*., 1996). Biomass production on the rubber plantation was high and soil fertility was conserved with the application of some soil erosion management techniques through contoured terracing, use of mulch and the planting of legume cover crops (Khisa and Husain, 2002).

RECOMMENDATIONS AND FUTURE PERSPECTIVES

- To maintain a long-term sustainability and productivity of the hill soils and to improve the socio-economic status of the hill dwellers, *jhum* should be abandoned gradually.
- Deforested fallow areas of Barind and Madhupur tracts should be afforested by forest species, rubber and horticulture. The area can be well utilized as a game park.
- Leaving the reserve forest area intact, massive afforestation program should be taken up in the USF lands of CHT giving special attention to tea, rubber, orchard, spices and forest species.
- Steep and very steep hill slopes should not be used for annual/seasonal crops, but for permanent AF or natural vegetation where contouring, strip cropping, SALT and/or introduction of hedgerows can be practiced. Contour cultivation is the best option for sustainable use of hill slopes.
- Secured land title should be ensured. Cadastral survey should be completed in CHT. The land disputes should be solved and rehabilitation of displaced people should be done soon.
- The rubber plantation should be taken as a suitable alternative to upland agriculture. Only 10 percent (24,977 ha) of the total usable upland is utilized now for this. These uplands should be utilized for the plantation of rubber, along with timber, fruit trees as cover crops. This will reduce fire risks and increase cash returns. Practical on farm tests on rubber should be initiated to identify high-yielding variety (HYV) and suitable clone of rubber appropriate for Bangladesh environment.
- The tea plantation should be increased. It is a major field where the government can, aptly, intervene. All suitable areas should be brought under tea cultivation. The rehabilitation of old and uneconomic gardens and utilization of modern techniques can raise the production of tea three times and an additional expansion of about 62,000 ha upland area as suggested by the BTB, can make it further double.
- Land classification in the hilly terrain by GIS technology is essential. With this technology, accurate mapping and classification of the sloping lands is possible. This will also give location-specific information of the existing land uses.
- Some parts of hills areas of Bangladesh can be well utilized as water reservoir if managed properly on a model watershed basis. Instead of constructing big dams, small earthen dams proved efficient in preserving year round water in different watersheds in the hills. Multipurpose (dairy, poultry, duckery, silviculture, etc.) uses of this reserved water will ensure better socio-economic condition of the hill dwellers by reducing dry season water scarcity. In some cases, this water can be the source of energy generation in the mini hydraulic projects, which already proved successful and economic in remote

areas of the hills. Identification, evaluation and sustainable use of such watershed approach should be the prime thrust of the researchers, planners and most notably the end-users of the fragile hill ecosystem.

CONCLUSION

The classification of upland areas and introduction of sustainable production systems is a tough job. Most people, even many specialists in this line, are skeptic about this. The study on the subject was a difficult task as the information was collected from many sources under different ministries. After the preparation of the paper, the author, himself has become confident that the introduction and implementation of sustainable production systems in the upland areas for poverty alleviation of the people is possible and this can be an important component of national economic planning. Some suggestions have been put forward to that end. Nevertheless, there remains scope of formulating more brilliant ideas on the issue. The author looks forward with a view to observing the sloping upland areas of Bangladesh as the habitat of diversified flora and fauna, which will ensure rational and prudent management of its natural resources for future generations instead of diminishing biodiversity and increasing natural disasters. This may be true for the other APO member countries.

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2. REPUBLIC OF CHINA

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INTRODUCTION

Taiwan is a small island with a broad range of environments. Almost three-fourths of the main island is slope land (i.e., land over 100 m elevation and 5 percent slope), and nearly half of the total area is above 1,000 m. Different forest types resulting from the mountainous topography have retained much of their environmental integrity and these forest types with large-scale human development have created ecological islands. Due to the environmental characteristics, soil and water conservation has become an important issue in Taiwan. In summer time every year, concentrated heavy rainfall from torrential typhoons and cold fronts constitutes the major causes triggering natural landslides. Steep topography and young geologic formations are unfavorable natural factors contributing to the acceleration of geologic erosion. In addition, human activities, which have extended to mountainous areas, have also caused serious landslides in hilly areas. This situation makes the management of slope land areas more complex. Therefore, the enhancement of soil and water conservation in slope land area is a crucial subject in Taiwan (APO, 2000).

Protecting Taiwan's natural ecosystems has become another important issue. Due to the diversified climate and complex topography, Taiwan nourishes various floral and faunal communities with a variety of species. Thus the commitment to long-term preservation of the island's biodiversity is the goal of Taiwan's nature conservation. To preserve the island's precious natural resources and the rare and endangered plants and animals, various measures have been initiated since 1965. In fact, protecting Taiwan's natural ecosystems is a difficult challenge.

Conservation of forest resources is the third important issue in Taiwan. Taiwan is dominated by forests (about 58.5 percent of the total island). The vast majority of these forests are on steep, rugged forestland. Because sound forestry practices are vital for soil and water conservation and nature conservation, the government policy, i.e., Taiwan Forest Management and Administration Policy, was initiated in 1991 for forest resources conservation to help maintain the integrity of land resources (Council of Agriculture [COA], 1993).

Environmental legislation in Taiwan includes three laws (the Cultural Heritage Preservation Law, Wildlife Conservation Law, and National Parks Law) which address issues of forest management, soil and water conservation, and environmental protection, and specifically authorize the designation and protection of nature reserves, nature protected areas, national parks, and wildlife sanctuaries. Various agencies carry out the goals of these laws. Six years after the promulgation of the above three laws, the concept of a 'central mountain eco-corridor' has been proposed. The idea is to connect all the protected areas from north to south. The total area would cover about 630,000 ha occupying 17.5 percent of the main island. All operations related to the 'central mountain eco-corridor' were established in 2000.

A CASE STUDY ON THE USE OF FORESTLAND CLASSIFICATION FOR TAIWAN'S SUSTAINABLE FOREST MANAGEMENT

Introduction to Study

There is a growing consensus that natural resources should be managed according to the principles of sustainability. Management practices must be ecologically sound, economically feasible, and socially acceptable (Salwasser, *et al*., 1992), and must reflect a clear vision of the desired conditions of the land to maintain soil and water processes, biological diversity, areas of special sensitivity to disturbance, etc. In the area of forestry, forest ecosystem management is regarded as a process for implementing principles of sustainability (Gregg, 1994). However, the prerequisite process for forest ecosystem management is forestland classification with ecosystem principles, i.e., ecosystem classification. Therefore, in correspondence to the spatial scales of ecosystem management, the development of a forestland classification system with a hierarchical ecosystem scheme has become an important and necessary task.

As to land classification in Taiwan, in addition to delineation of protected areas, there is a slopeland classification system developed by the Soil and Water Bureau, which is similar to the land capability classification system developed by the Soil Conservation Service, U.S. Department of Agriculture (USDA). The system is based on slope, soil depth, and erosion conditions to classify the slope land into six classes. However, it only focuses on soil classification without a hierarchical ecosystem scheme. As for forestland, there is no particular classification system. It is only based on the "Third Forest Resources and Land Use Inventory in Taiwan" (Taiwan Forest Bureau [TFB], 1995). According to the inventory, there is 2,102,400 ha of forestland occupying 58.5 percent of the total island (3,591,500 ha). Due to a consensus for ecosystem management, recently forest ecosystem management is greatly being emphasized in Taiwan, and an island-wide classification of forestland to be used to assist forest ecosystem management is underway. Many research units have been trying to develop a scheme of forestland classification as a reference to island-wide forestland classification. The following is a case study using the Liukuei Experimental Forest of the TFRI as a study site. The methods were: (1) to develop a hierarchical forestland classification system; and (2) to establish a forestland classification decision support system (DSS) for forestland suitability analysis and site selection. Certainly the main purpose is to extend the results for forestland classification island-wide.

Study Area and Materials

The Liukuei Experimental Forest occupies an area of about 9,616 ha with 25 forest compartments. Elevations range from 350 to 2,400 m. The average annual temperature, rainfall, and relative humidity are 16-23ºC, 2,150-3,748 mm, and 71-86 percent, respectively. The major forest type is natural forest intermixed with a proportion of man-made plantations. Among all man-made plantations, Taiwania (*Taiwania cryptomerioides*) plantations constitute the majority (about 800 ha occupying 60 percent of total man-made plantations).

The digital terrain model (DTM) with a 40 × 40-m resolution for each pixel was used to derive three terrain data layers of elevation, slope, and aspect, and also to automatically extract watersheds, which were treated as basic ecosystem units. All data layers were then established into a geographic information system (GIS) for developing a hierarchical classification system. In addition, the Ecosystem Management Decision Support (EMDS) system developed by the USDA Forest Service (Reynolds, 1998) was applied to integrate the database and the knowledge base to generate a forestland classification DSS. In the application of site selection for Taiwania, soil data and a 1/5000-scale forest type map were used in the forestland suitability analysis. In this case study, the hardware included a PC, plotter, and color laser printer, and the software included ARC/INFO AML (ARC Macro Language), ArcView, SAS (statistical analysis system), and EMDS.

Methods

The methods fall into the following two categories: (1) developing a hierarchical forestland classification system including automatic ecosystem delineation using a DTM and developing a hierarchical ecosystem classification using a GIS and multivariate statistical analysis; and (2) establishing a forestland classification DSS using an EMDS system for forestland suitability analysis and site selection for Taiwania. The steps for each method are briefly described as follows:

1. ***Automatic Ecosystem Delineation using DTM***

This case study treated watersheds as the basic ecosystems according to previous studies (Bailey, 1996; and Lotspeich, 1980). The DTM was used to automatically extract watersheds. Meanwhile, the watersheds extracted from different stream orders were regarded as ecosystems of different sizes. A computer program in ARC/INFO AML was written to delineate the watersheds. Two major steps of extraction of stream networks and delineation of watersheds are described as follows.

a. Extraction of Stream Networks

The determination of a threshold value is very important for extracting stream networks (Cheng, *et al*., 2000). Although there are several approaches for setting the threshold value (Montgomery and Foufoula-Georgiou, 1993), this case study was based on Cheng's studies and used 400 as the threshold value to extract stream networks. Furthermore, each stream in the stream network was assigned a distinct number, and a numeric order using the Strahler method was used to assign the correct order to the watersheds.

b. Delineation of Watersheds

Following extraction of the stream networks, a modified automatic approach written in ARC/INFO AML was developed and implemented to overcome the problem of delineating different-sized watersheds as different ecosystem units, which is important for hierarchical ecosystem classification. The approach is unique in its capability to automatically identify streams of different orders and to search for the outlets to watersheds using the stream networks extracted from the DTM.

2. ***Development of a Hierarchical Ecosystem Classification using GIS and Multivariate Statistical Analysis***

GIS and multivariate statistical analysis were applied for grouping watersheds according to their spatial similarities using SAS software. During the grouping process, the k-means approach of nonhierarchical clustering analysis was implemented for grouping smaller watersheds into larger watersheds, and the cubic clustering criterion (CCC) was used for determining the optimal number of clusters (Cheng, 2001). Meanwhile, only three data layers (i.e., elevation, slope, and aspect) were used as input variables for clustering analysis.

3. ***Establishment of a Forestland Classification DSS for Forestland Suitability Analysis and Site Selection for Taiwania***

The EMDS was used as a framework to establish a forestland classification DSS by integrating the above results of ecosystem classification with a GIS. There are two key components to support these activities (Reynolds, 1998): (1) NetWeaver for knowledge representation, i.e., to provide an object and fuzzy logic-based propositional network architecture; and (2) the EMDS extension to ArcView, i.e., to include system objects and methods of processing knowledge bases in a GIS application.

The database including all GIS themes of different hierarchical schemes and the knowledge bases describing relations among ecosystem states and processes of interest were first constructed. Then the true value representing the basic state variable was used to express an observation's degree of membership (Zadeh, 1995; and Reynolds, 1998). In this case study, the true values of slope and soil properties, which are important variables for forestland productivity (TFRI, 1997), were assigned according to Cheng's study (Cheng, *et al*., 2001). More information concerning the EMDS framework and the assignment of membership is contained in the EMDS user guide and NetWeaver for EMDS user guide (Reynolds, 1998; and Cheng, *et al*., 2001).

Regarding site selection for Taiwania using the established DSS, topographic factors (e.g., elevation and slope) and soil factors (e.g., soil texture and soil suitability) were assumed to be the main factors influencing Taiwania habitat according to the management plan of the Liukuei Experimental Forest (TFRI, 1992). As for membership representation, soil texture focused on moderate texture, while other data were based on fuzzy arguments and standardized as 1 to -1. In addition, only first-order watersheds were used for site selection of Taiwania because we regarded site selection as a small-scale management practice.

RESULTS

Ecosystem Delineation using DTM

Figure 1 depicts stream networks and encoded streams with different orders. The result indicates that the maximum stream order of the Liukuei Experimental Forest is 4. The stream networks obviously form two separate stream systems. One comprises second-order streams in the upper part, and the other comprises fourth-order streams in the lower part. From Figure 1, clearly four different kinds of watersheds can be delineated in response to the need for different-sized watersheds. Figure 2 shows the result of delineating watersheds by specifying different stream orders as the minimum order. Obviously, the number of watersheds decreases as the stream order number increases, e.g., the numbers of watersheds for first, second, third, and fourth stream orders are 100, 20, 4, and 1, respectively.

To retain the boundary of the Experimental Forest, we cannot accept a stream order number that is higher than 2, otherwise the upper part will disappear, Therefore, first- and second-order watersheds were considered for ecosystem classification. Ultimately this study decided to use second-order watersheds because the number was close to the number of compartments.

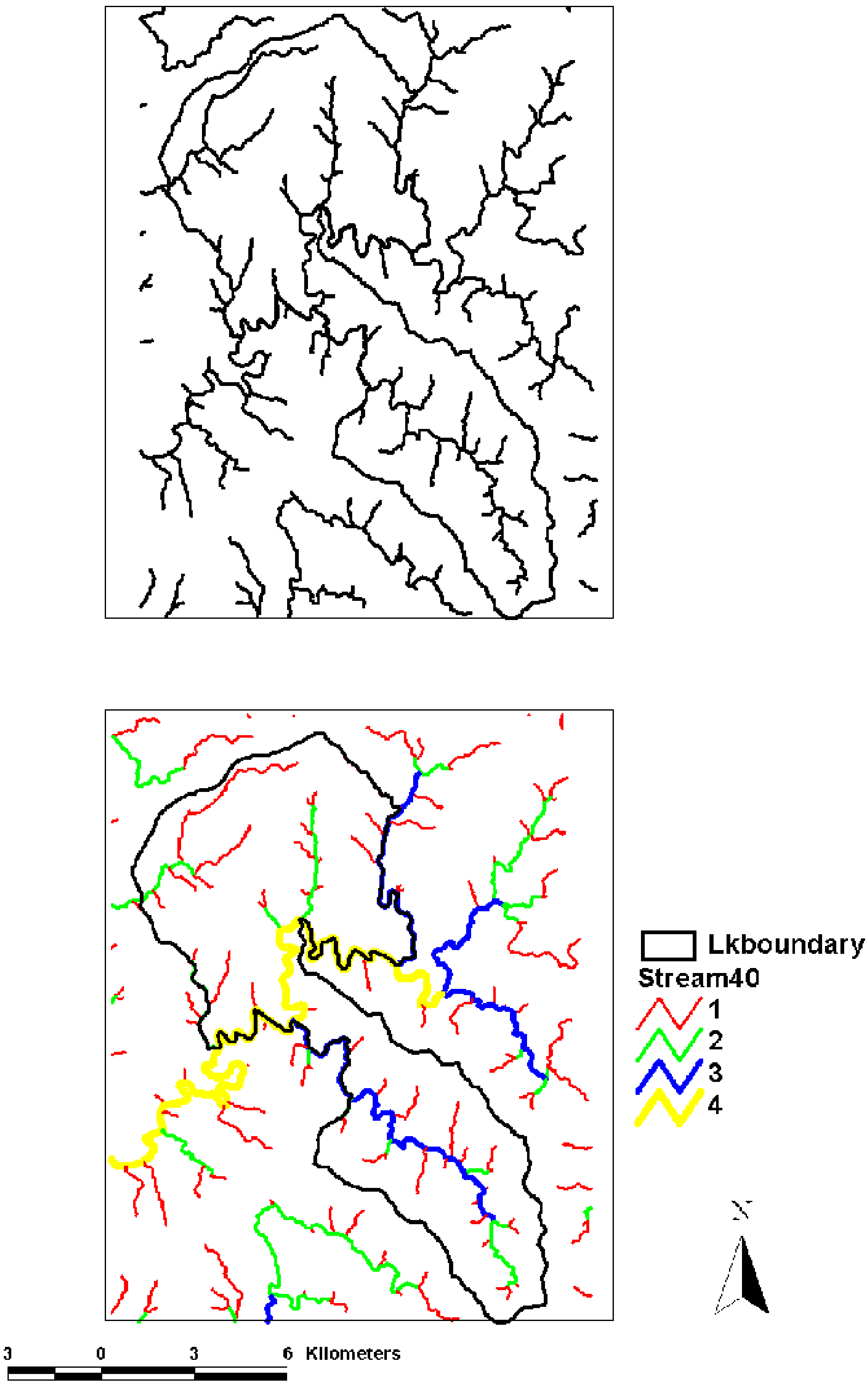

Figure 1. Extraction of Stream Networks Depicting Stream Networks using 400 as the Threshold Value and Encoding Streams with Different Orders

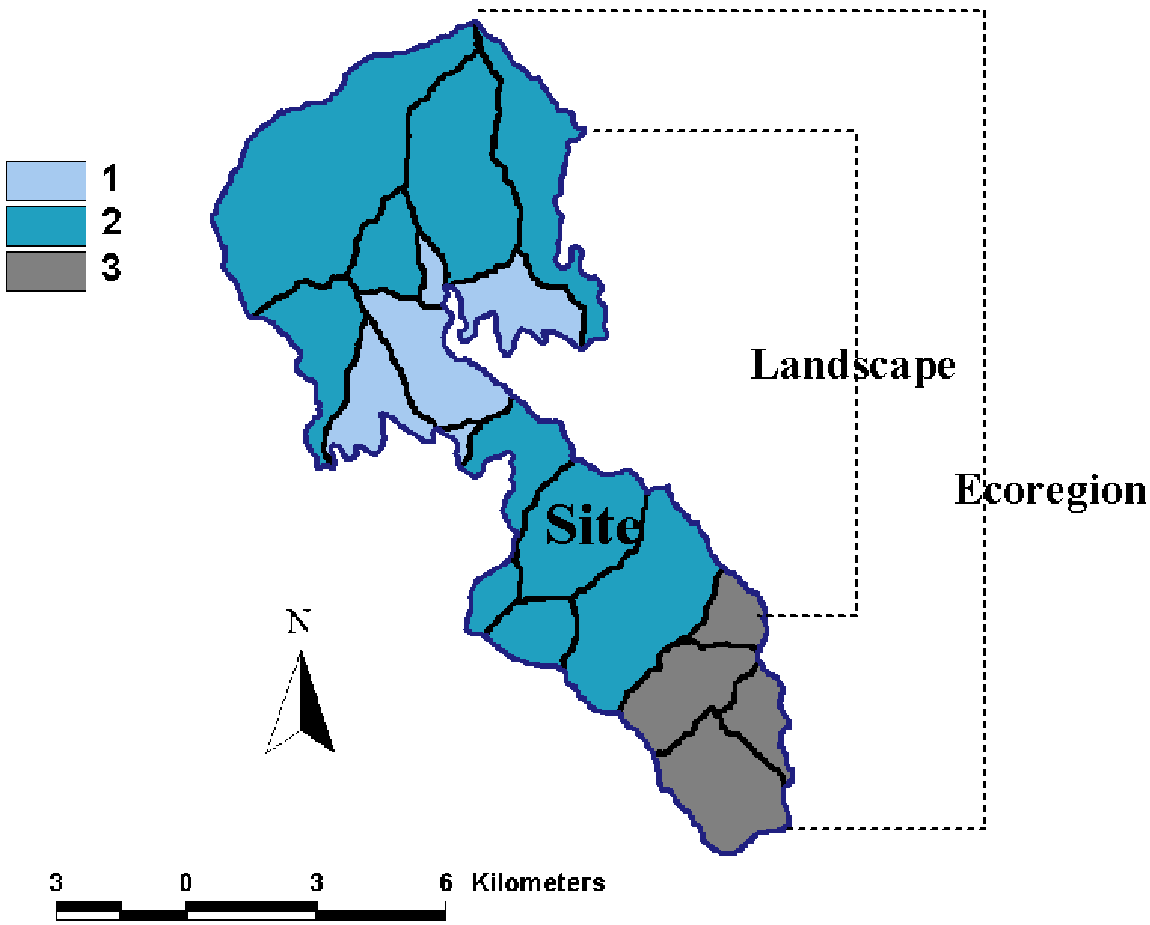

Figure 2. Watershed Delineation Based on Different Stream Orders

Development of a Hierarchical Ecosystem Classification using GIS and Multivariate Statistical Analysis

Figure 3 is the result of a hierarchical ecosystem classification using watersheds encompassing streams of order 2 and above. Obviously the Experimental Forest was classified into three different clusters (or zones) based on three data layers. The result is quite satisfactory because the distribution of the clusters coincides with the terrain characteristics and varies along a continuum. For example, the first cluster is located in the downstream area of lower elevation and slope, while the third cluster is located in the upper stream area of higher elevation and slope. The result indicates that the Experimental Forest can be geographically divided into three large ecosystems. If Miller's scheme of 3-scale perception (i.e., site, landscape, and eco-region) is applied (Miller, 1978), it means that the Experimental Forest is regarded as an eco region, the clusters grouped by watersheds are regarded as a landscape mosaic, and watersheds encompassing streams of order 2 are regarded as sites.

Establishment of a Forestland Classification DSS for Forestland Suitability Analysis and Site Selection for Taiwania

A forestland classification DSS was established by integrating ecosystem classification with the EMDS framework as shown in Figure 4. Based on this established DSS, the output of forestland suitability analysis using different ecosystem units (e.g., site, landscape, or eco-region) are as shown in Figure 5a-d. For easy discrimination, the output map was displayed in three different classes (low, moderate, and high forestland suitability). From a comparison of Figures 5a-d, the area of forestland suitability analysis clearly varies with different hierarchical ecosystems (Table 1). This result points out the relationships existing between management and ecosystem hierarchies.

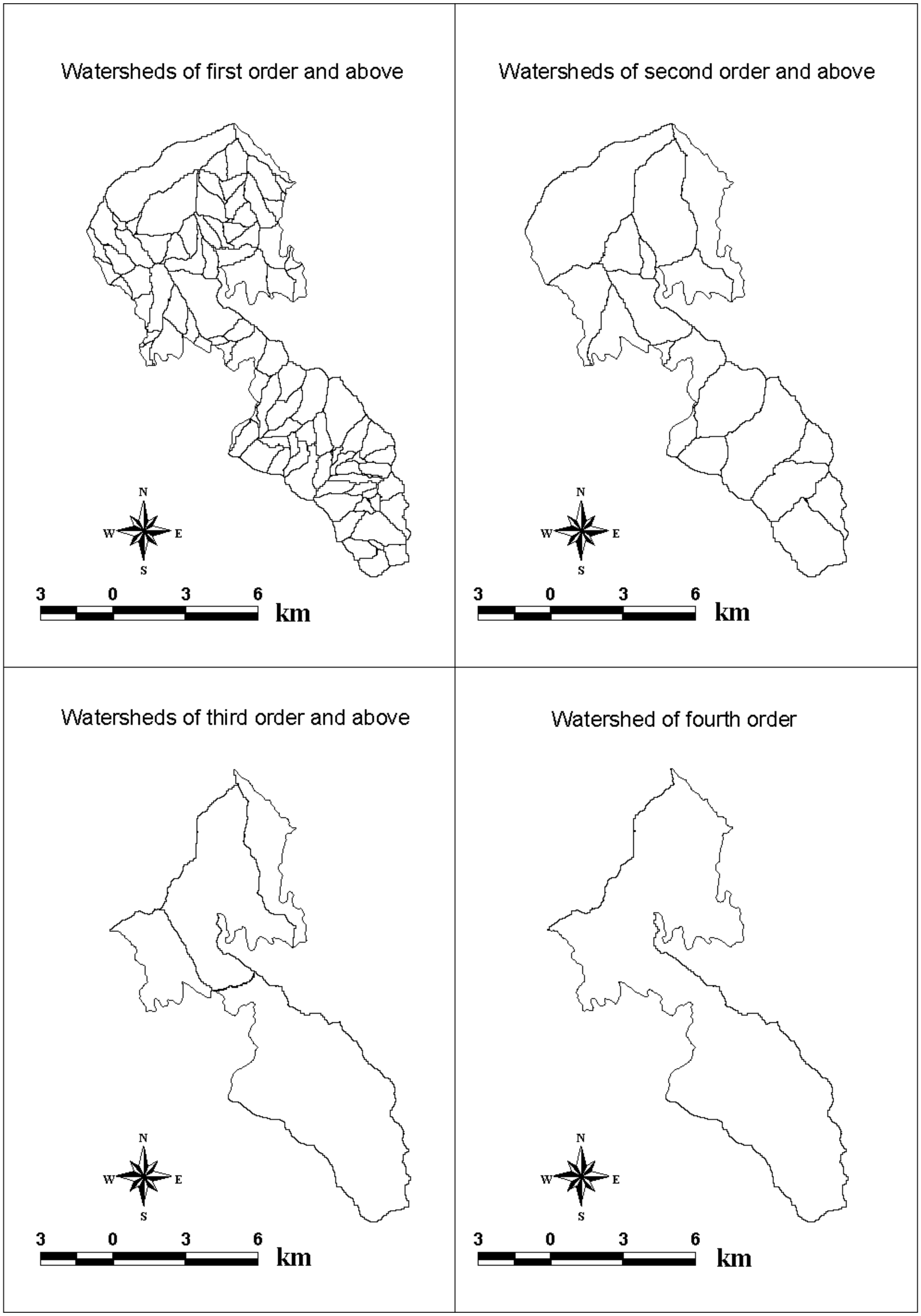

Figure 3. Hierarchical Ecosystem Classification of the Liukuei Experimental Forest

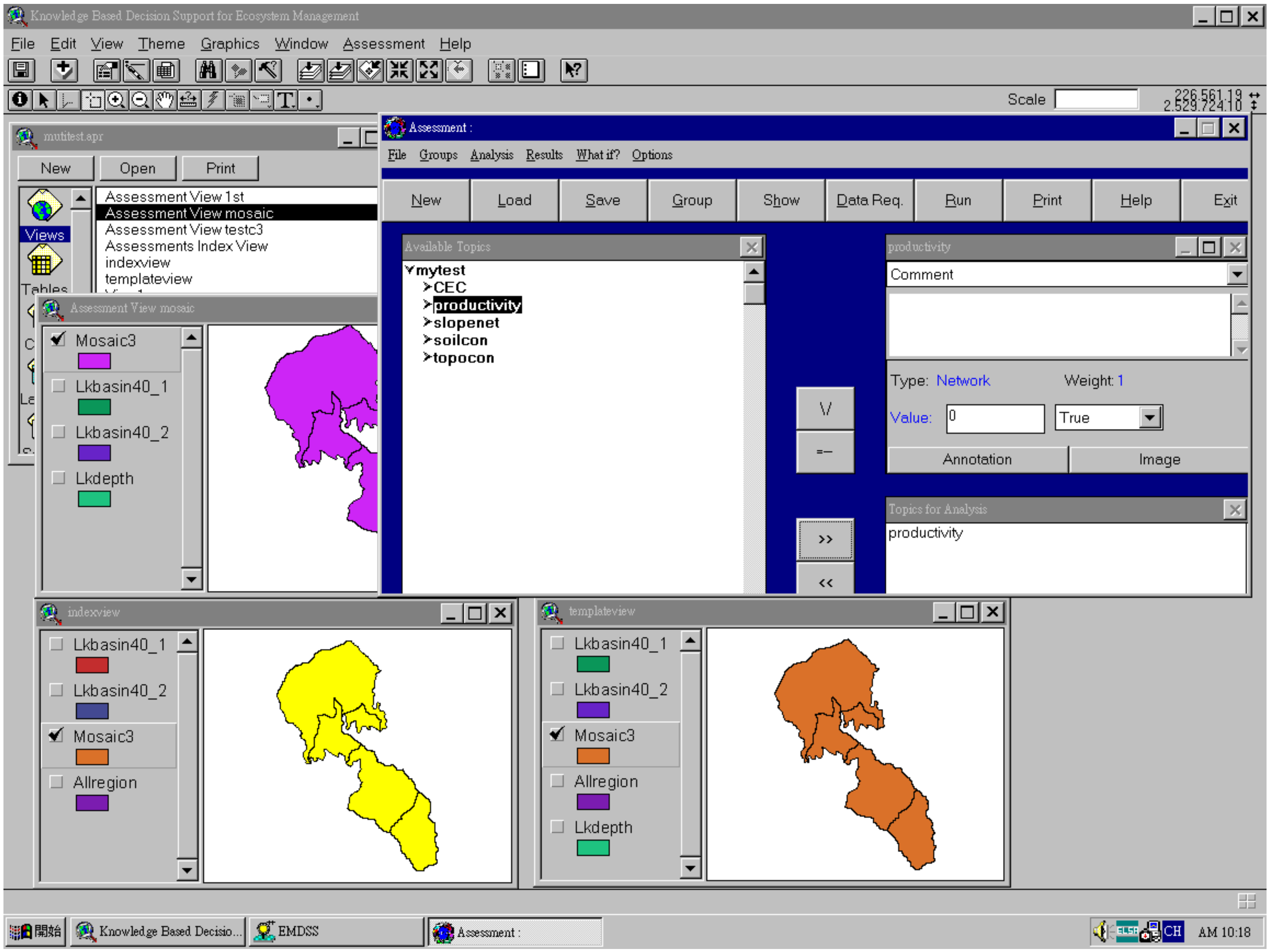

Figure 4. Forestland Classification Decision Support System

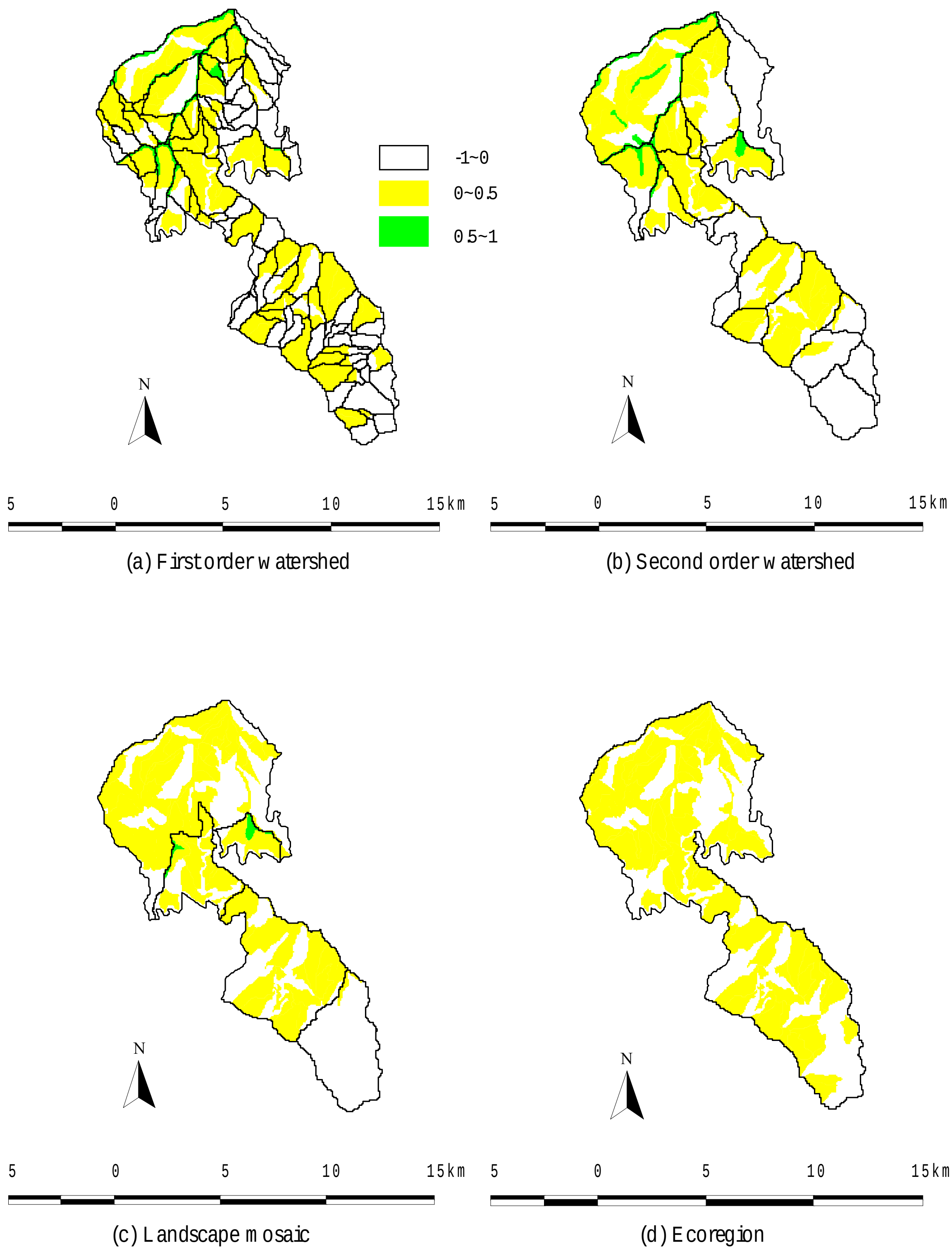

Figure 5. Comparisons of Forestland suitability using Different Hierarchical Ecosystems:
(a) first-order watershed; (b) second-order watershed;
(c) landscape mosaic; and (d) eco-region

Table 1. Comparison of Forestland Suitability Analysis among Different Hierarchical Ecosystems

Site	First-order Watershed	Second-order Watershed	Landscape Mosaic	Eco-region
Suitability area (ha)	5,189	4,938	5,394	6,075
Number of units	100	20	3	1
Calculation time (sec.)	60	40	32	31

Figure 6 is the result of site selection for Taiwania using the established forestland classification DSS. The suitable area for Taiwania is about 1,633 ha. If the result with actual Taiwania plantations derived from the forest type map are compared, it can be seen that most northern areas in the study area match quite well, but the southwestern areas show much greater differences, e.g., more suitable areas have no actual distribution of Taiwania. This result demonstrates that forest managers can easily apply this established DSS in site selection for Taiwania.

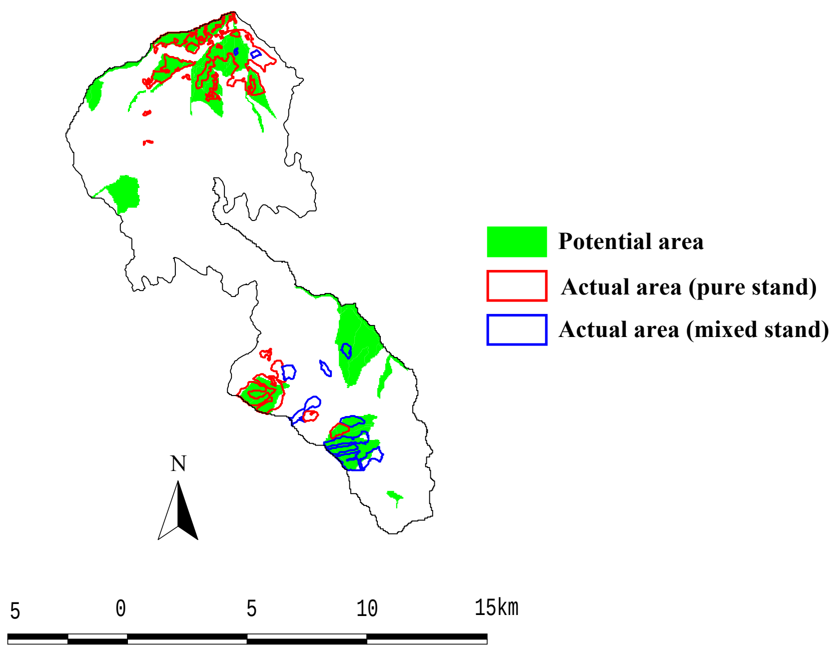

Figure 6. Site Selection for Taiwania

MAIN ISSUES AND PROBLEMS IN TAIWAN'S FORESTLAND CLASSIFICATION

Ecosystem Delineation using DTM

Different ecosystem units are used by various disciplines in Taiwan, e.g., stands for foresters and watersheds for water quality analysis. If each discipline selects its own land unit for analysis, then analyzing resource interactions becomes more difficult. From the case study, watersheds can be feasibly treated as ecosystems, and they can automatically be delineated using the DTM. Therefore, use of watersheds as the basic ecosystem unit can be adopted for Taiwan's forestland classification. However, several problems were encountered when dealing with watershed delineation, because different criteria and algorithms will generate different watershed maps for the same area. In addition, the DTM resolution is also an important factor affecting the delineation of watershed boundaries because the patterns of ecosystem boundaries for various resolutions may differ. Therefore, it is suggested that Taiwan's forestland classification focus on DTM resolution and the algorithm for extracting watersheds.

Hierarchical Scheme for Ecosystem Classification

Ecosystems exist at multiple scales. Therefore, ecosystem analysis must be carried out at multiple scales. In fact, the hierarchical ecosystem classification system allows us to see ecosystem connections at various scales, and thus one prerequisite for rational ecosystem classification is to delineate ecosystems at various scales because management occurs at various scales, e.g., from national to local. Therefore, a hierarchical ecosystem classification system is needed to achieve management objectives and proposed uses. Several countries have proposed and implemented schemes for recognizing such scale levels (Miller, 1978; Salwasser, 1990; and Bailey, 1996). Thus, a suggestion for Taiwan's forestland classification is to determine what kind of hierarchical scheme is needed.

Forestland Classification DSS for Forestland Suitability Analysis and Site Selection

The establishment of a forestland classification DSS can help forest managers analyze and assess forestland suitability and site selection in a reasonable, fast, and interactive way. It has the following advantages: (1) forest managers have a high degree of control over problem definition by adjusting the assessment areas, variables, and criteria; and (2) knowledge bases developed for one area can easily be adapted to other areas. Site selection for Taiwania can also be adapted to other species.

Although the established forestland classification DSS has many advantages, there are some problems regarding the selection of variables and criteria, the assignment of membership, and the analysis unit. Therefore, it is suggested that Taiwan's forestland classification should focus on solutions to the above problems. Particularly for analysis units, a concept of common units is recommended.

CONCLUSIONS

Taiwan's forests should be managed according to ecosystem management practices. To achieve this goal, it is first essential to adopt a hierarchical ecosystem classification scheme for forestland classification. The related process, which is important for forest managers to carry out forestland classification includes determination of ecosystem units, development of a hierarchical ecosystem classification system, and establishment of a DSS. Also, techniques such as DTM, GIS, multivariate statistical analysis, and DSS can be applied to achieve the above process.

From the case study of forestland classification for Taiwan's sustainable forest management, it is concluded that it is essential to understand the relationship between ecosystem and management hierarchies, which means management should move from a traditional single-scale ecosystem (e.g., site of plots and stands) to a multi-scale ecosystem (e.g., landscape mosaics or eco-regions), because if management and ecosystem hierarchies are well correlated, management strategies will work better and form a more-consistent and efficient management process. To achieve the demands of management hierarchies, forest managers should pay close attention to forest management at various scales in addition to using techniques such as DTM, GIS, and DSS. Therefore, further challenges to Taiwan's forestland classification and ecosystem management are not only to adopt a common ecosystem unit, but also to integrate ecosystem hierarchies and management hierarchies into GIS and DSS.

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3. FIJI

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INTRODUCTION

Land capability classification is the foundation of proper land use. Since the first classification scheme was developed in late 1930s by the United States Department of Agriculture (USDA), it has been employed in similar surveys by many counties. The USDA scheme, however, is based mainly on their agroclimatic conditions and land resources. While the general principle may be applicable, the question always remains as to how it should be modified to fit the particular conditions of other countries.

In Fiji, the Ministry of Agriculture, Fisheries and Forests (MAFF) finally decided to adopt with modifications to suit the local conditions, the New Zealand (NZ) Land Use Capability System as described in the *Land Use Capability Survey Handbook*, 1974 edition. The NZ classification system is itself a modified version of the American system. In modifying the NZ System to suit Fiji's conditions, changes were made to areas affected by differences in climatic conditions, in type of crops grown and their land requirements, in the kind and level of management system applied and in the cultivation methods used.

This new classification replaces the seven-class system introduced by the Land Use Section in 1972. At the time the classification was considered to be sound and adequate, and should, therefore, more than satisfactorily meet the country's present and future needs in the field of land development planning, land valuation, soil conservation, as well as the promotion of recommended land use practices for safeguarding expanding and sustained production from land.

In country like Fiji where 85 percent of the area is sloping land, the ever-increasing population and more people turning to the land for their livelihood the need for cultivation, especially of hilly marginal land has increased.

Land degradation due to soil erosion and nutrient depletion is increasingly a serious problem in Fiji. This, in turn, has adverse effects on food production and the environment.

The land use area in Fiji has increased by more than 240 percent over the past 40 years due to the marginal hilly lands being brought into cultivation. Only a little over 60 percent of the total land is suited to some form of agricultural activity of which about 16 percent is suited to sustained arable farming.

Realizing the need to address degradation caused by unsuitable smallholder agriculture in Fiji, especially on marginal hilly land, called "the Pacific land". Management of sloping lands was established in 1991 at Waibau. The project aimed to assist in the development and extension of appropriate technologies for the management of sloping agricultural land. Technologies being assessed against current farmers' practices include vetiver grass and pineapple hedgerows. Results from the research in Waibau are used to illustrate sustainability of these land management treatments. Over the past seven years at Waibau, the two treatments (pineapple and vetiver) grown in contour hedgerows significantly reduced soil erosion up to 26º slopes compared to current farmers' practice.

The results also revealed that the vetiver grass effectively controlled soil erosion with less than 2 mt/ha/year, whereas pineapple was an added source of income. The research data from Waibau clearly indicate that the marginal hilly lands up to 26º slopes in Fiji can be cultivated sustainably with soil conservation treatments.

The Land

The Republic of Fiji Islands comprises an enormous archipelago with diverse landscapes and climate.

The larger volcanic islands are dominated by steep, deeply incised mountainous terrain. The highest summit, Tomaniivi (Mt. Victoria), is 1,323 m; there are 30 peaks over 1,000 m. Table 1 sets out the balance of land based on slope classes. The land use capability (LUC) classes for each category based on the Fiji

LUC classification system (1977) are also included. There is a sharp contrast in Viti Levu between the steep mountainous terrain (67 percent) and the flat land (16 percent) of the coastal plains and river deltas. The latter are the main areas of settlement and production. A great many of these plains, but not all, are subjected to inundation during periods of prolonged rain in the interior. Undulating to rolling land (4-15º) makes up 17 percent of the Viti Levu land area. A similar terrain distribution pattern occurs in Vanua Levu (Table 1) but with a larger area of steep land.

Table 1. Slope and Land Use Capability Classes

Slope Group(s)	LUC Class	Viti Levu (percent)	Vanua Levu (percent)
Flat (1-3º)	I	16	15
Undulating to rolling (4-15º)	II-IV	17	13
Steepland (16º+)	V-VIII	67	72

Land Utilization Classes

Table 2 shows the areas in the primary divisions of Fiji of the major land utilization categories. The basis for this classification is the suitability of the land in its natural state for agriculture. If the land in its natural state is not suitable for agriculture, how can it be made suitable?

Table 2. Major Land Utilization Categories

(Unit: Percent)

Class	I	II	III	IV	Total
Viti Levu	21.46	7.67	29.01	41.86	100.00
Vanua Levu	14.66	12.61	41.67	31.06	100.00
Total Fiji	19.36	10.51	31.93	38.20	100.00

Category I

This may be described as the first-class land. It is considered suitable without modification for some form of land use, although the particular kinds of usage are not specified. This is to avoid the fallacy that, in a group of mountainous islands, particular forms of land use are ‘higher’ than others. Good cocoa, mango or *dalo* land is just as first-class as good cane land in that ‘first class’ returns can be achieved if the land is properly farmed. It is evident that only 355,902 ha in Fiji (19.4 percent) fall into this category. In Viti Levu, the proportion is 21.5 percent whilst in Vanua Levu it is only 14.7 percent.

Category II

The land under this category may be thought of a second-class land, i.e., good land, as fairly minor improvements are needed. There are 193,277 ha of these soils in Fiji (10.5 percent); 7.67 percent of Viti Levu is of this class, 12.6 percent of Vanua Levu and as much as 42.8 percent of Taveuni. This land requires minor conservation on the predominantly steep slopes. If the potentially very productive soils were fully developed; the figure compensates for low proportion of first-class land.

Category III

There is 587,002 ha (31.9 percent) of category III land in Fiji. These are third-class lands because they need a great deal of attention before they can be adequately developed and fully utilized. Many of these lands may be truly described as ‘problem soils’. They cover a larger area than both of the ‘good’ groups of soils added together – a fact that highlights the difficulties that must be overcome in any expansion of agriculture. Category III lands lie chiefly in the two main islands especially in Vanua Levu (41.7 percent); Viti Levu (29.0 percent).

Category IV

This is the largest class comprising 702,391 ha of lands. These lands are considered quite unsuitable for agricultural development according to the present knowledge, though they may be of limited use for productive forestry. No less than 38.2 percent of Fiji is composed of these poor classes of land. Viti Levu has the largest proportion of this type of land (41.8 percent) and Taveuni the smallest (24.4 percent). The proportion of Vanua Levu that consists of category IV land is 31 percent.

The total amount of classes I and II soils in Fiji is 549,179 ha, i.e., 29.9 percent of the total land area. This is the extent of the area for sustainable agricultural land use, i.e., those classes of land for which moderate to no modification is needed before they can be developed fully for agriculture. However, these soils are mainly those on which current agriculture already exists. Therefore, much of the possible new development lies in the agronomic and land conservation improvement of present practices. An accurate present land use survey would show how much undeveloped land is available that is easy to farm. Commonly there is more that one subclass type recognized and an Arabic numeral is added to the subclass symbol (for example, III E 1; III E 2).

At one time Fiji was virtually covered with forest. The present plant cover forms a complex mosaic comprising fernland, open grassland, reed grass, shrubland, savannah-like transitional vegetation and tall forest. The areas of open grassland, fernland, and reed grass and savannah are largely man-induced and, when given complete protection from the fire and other interference (particularly by humans), the ecological succession shows a slow but steady return towards a forest cover. However, the extensive areas of the introduced mission grass seen in the dry zones are considered to be a fire climax association and will, therefore, not return to forest unless there is some intervention such as re-afforestation.

Current Status and Trends in the Agricultural Sector

Components of the agriculture sector in a broader sense include arable farming (including subsistence cropping), livestock, fishing and forestry. For the purpose of this discussion, fishing is excluded in order to focus on the land-based elements of the agriculture sector.

MAFF recognizes agriculture's importance to the economy and the rural community and its strategic plan has committed itself to the sustainable development of Fiji's primary sector resources. Environment, poverty alleviation, women in development, management of natural resources, greater agricultural diversification and export enhancement are deemed crucial in supporting growth and sustainable development.

The Commodity Development Framework (CDF) Program, which was implemented by MAFF with an investment of US$69.1 million, was designed to accelerate the nation's diversification efforts. The program specifically encourages priority 'comparative advantage' commodities for production on a commercial basis for processing and marketing, but does not address land conservation issues.

Land Development and Resettlement

Over the period 1997-2026, approximately 11,800 leases issued under the Agricultural Landlord and Tenant Act (ALTA) will expire. MAFF's Land Development and Resettlement Unit (LDRU) was established in 1998 to develop and make available land for farmers whose leases have expired. The unit has begun the process of determining the number of farmers requiring resettlement and identifying land for development. Current indicators reveal that only 3,500 farmers (30 percent) will require resettlement. To date, several properties have been purchased in Nadroga, Serua, Namosi, and Macuata, which will accommodate approximately 300 farmers.

Some potential negative impacts include the shortage of good land in suitable locations, unwillingness of farmers to move to new areas, and lack of credit to the agriculture sector. However, there are real opportunities for high returns from non-sugar agricultural commodities if the resettlement program can be implemented smoothly. Production of different agricultural commodities in Fiji is given in Table 3.

FIJI'S LAND USE CAPABILITY CLASSIFICATION SYSTEM

LUC classification can be described as the systematic arrangement of different kinds of land according to those properties that determine its capacity for sustained production, where capability is used in the sense of suitability for productive use. The MAFF Land Use Section assesses LUC based on its LUC Land Inventory System. This system was developed in 1977. It is based on the U.S. Department of Agriculture (USDA) Land Use Capability and has been adapted to the Fiji environment. Soil is a key element in determining LUC as most forms of land utilization ultimately depend on soil as the medium for plant growth.

Table 3. Agricultural Commodity Production by Area and Number of Farmers, 1996

Crop		Area (ha)	Farmer (number)	Production (mt)
Sugar		73,900	n.a.	453,000
Coconut		64,953	n.a.	11,003[a]
Cocoa		578	2,220	126[b]
Ginger:	Mature	24	700	1,140
	Green	46	n.a.	1,080
Rice		8,411	11,320	18,888
Pineapple		193	1,428	2,161
Vegetables/fruits		4,280	14,132	22,000
Root crops:	*Dalo*	2,400	n.a.	22,613
	Yam	428	n.a.	4,401
	Cassava	2,610	n.a.	40,247
	Kawai/Kumala	1,328	n.a.	7,821
Yaqona		2,200	n.a.	2,685

Source: MAFF 1996 Annual Report.
Notes: [a] Copra; and [b] dry bean.

The capacity for sustained production depends largely on the physical qualities of the soil and related environmental factors. These factors are regarded as limitations when they are not ideal in some way. The limitations affect the productivity, the types of corrective measures required, and the intensity and type of land use. The degree of the limitation is assessed on the basis of evaluation of the following factors: susceptibility to flooding; liability to wetness or drought; salinity; depth of soil; soil characteristics (texture, structure, fertility, etc.); and climate.

As a basis of this assessment an inventory is undertaken in the field. This ‘land inventory phase’ maps rock type, soil type, slope, erosion, vegetation and current land use. Land inventory units describing these factors are delineated on the final land inventory map. Based on the land inventory, the LUC is classified. The land inventory units are classified into one of eight LUC classes.

LUC classification system in Fiji is summarized in Table 4. To reflect limitations or hazards, subclasses can be recognized for some of the major LUC classes. The four general kinds of limitations recognized are: erodibility (E); wetness (W); soil limitation within the rooting zone (S); and climate (C).

ISSUES AND PROBLEMS IN CLASSIFYING SLOPING UPLAND AREAS IN FIJI

Demographic Changes

The increase in Fiji’s population over recent decades has placed pressure on the land, particularly marginal land, and this has resulted in significant land degradation and soil erosion.

While the majority (54 percent) of the population still lives in rural areas, there has been an absolute decline in the rural population over the last decade due to rural urban migration; a trend that is driven by the perceived prospects of employment, problems of access to rural land, limited income-generating opportunities and poorer services and infrastructure in the rural areas. The amount of unused land suitable for development is quite small and land use is becoming increasingly intense. The uneven distribution of arable land has resulted in some localized demographic imbalances. The environmental impacts of uncontrolled urbanization combined with land degradation are seriously impacting on the quality of living and the sustainable income-generating capacity of Fiji’s natural resources.

Land availability and land quality, land tenure, labor mobilization, depopulation in some outer islands and sugarcane areas and, in the Fijian village context, a changing balance between the subsistence and commercial agriculture are all factors contributing to fewer people being supported directly in primary production.

Table 4. Fiji's Land Utilization Capacity System

Land Class	Slope	Soil	Potential Land Use
I	0-3º	Well-drained alluvial soils	Wide range of crops
II	4-7º	Alluvial soils either slightly or poorly drained or subject to regular flooding	Wide range of crops
III	7-11º	Humic latosols, nigrescent and cley soils	Fairly wide range of crops
IV*	12-15º	Humic latosols, ferruginous latosols, cley soils	Tree crops and subsistence-oriented cultivation under traditional method
V	16-20º	Major soils of hilly land – humic latosols, ferruginous altosols, podsolic soils	Grazing and forestry
VI	21-25º	Major soils of steepland – humic altosols, ferruginous altosols, podsolic soils	Marginal grazing and forestry
VII	26-35º	Very steep mountain land, also includes peat and mangrove swamp where development is not likely to be economically viable	Forestry
VIII	35º	Humic latosols, ferruginous latosols, podsolic soils	Watershed and wildlife protection (Nature Reserve)

Note: * Land class IV also includes: lower river terraces subject to regular flooding; mangrove swamps; areas which are very stony to boudery or very shallow soils; soils low in moisture holding capacity; soils with low to very low fertility; and saline to extremely saline soil.

It is becoming more difficult to absorb (at a satisfactory level of living) within the subsistence-farming sector those who cannot find work in the urban or fully commercial rural sectors. The conversion from the subsistence to commercial agriculture, and the inferior quality of each parcel of land brought into use have meant that the average new rural family requires more land than their predecessors did. About 60 percent of farmers are small cultivating less than 3 ha of land each. This forces farmers into intensive cultivation (often mono-cropping) for high output, short-term production without or with only minimal fallow periods.

Pressure on the Production Base

Apart from the commercial crops (sugar, ginger, *yaqona, dalo*) most farmers are still locked into subsistence production, for example, root crops, pulses and rice, but not in a diverse farming system involving a mix of crops (perennials, fruit and nut trees plus the subsistence crops) that would increase income and self-reliance. Market crops have higher value and perennials are more appropriate for soils prone to erosion.

Because of competition and pressure for land, subsistence gardens are increasingly being relocated onto steeper slopes because of the expansion of cash cropping and grazing on the flatter lands. Some gardens experience soil loss, especially when traditional mulching is not practiced and fallow periods are too short.

Soil loss measurements clearly demonstrate that the agricultural by productive base in many sugarcane areas, and with ginger on slopes, is declining at a rate that is well above what would be regarded as economically acceptable.

The new system of cash cropping is based on a slash-and-burn practice of agriculture and is not sustainable. The method here is to move into a new area, clear a relatively large block (10-20 ha) by slash-and-burn method, cultivate the land until depleted of nutrients and eroded and then, if more land can be leased, move to a new area and repeat the process.

Goat grazing areas are invariably overstocked and show bare eroded patches due to the typical farmer's need to recoup expenses as quickly as possible and a ignorance of controlled grazing techniques.

Over-dependence on the Sugar Industry

The country's high dependence on the sugar industry and its quota and incentive system encourage cane farmers to move onto slopes greater than 11° and, commonly, to not practice any soil conservation measures. Over a short period of time, many of these areas experience soil depletion, soil moisture defects and decreasing productivity. Where land degradation has become extreme, farmers are forced into growing non-cane crops.

Overall the sugar industry is experiencing declining productivity and efficiency. Sugar prices have declined and there is little new investment in this sector. There are growing uncertainties about land tenure and there is a high level of farmer indebtedness.

There is a prevalent attitude that soil's only function is to physically support the cane crop and that all nutrient inputs are artificial. Moreover, there is little regard for the soil's role as a 'bank' for the moisture and nutrients. Fiji Sugar Corporation (FSC) (apart from recent Taiwanese assistance) has long ceased research into soil conservation. This is in a situation where estimates point to 15,000 ha of cane land on Viti Levu being in urgent need of soil conservation works and a further 6,500 ha that should not be under cane at all.

Use of Appropriate Technologies

Pressures on land indicate an urgency to increase sustainable production per unit area. However, there is poor understanding throughout the agriculture sector about a much closer matching between land use/crop type and land capability if productivity goals are to be met. There is very low farmer participation in technology generation.

The use of vetiver grass planted along the contour in the cane belt was a widely promoted practice until 30 years ago. The Fiji model for the use of vetiver grass is described widely in world soil conservation literature; unfortunately, this is no longer the case with only a fraction of vetiver grass areas remaining. It is a proven technique to control soil loss on sloping land.

The burning of cane trash, while illegal, is a widespread practice, combined with long fallows of 4-5 years, results in serious depletion of fertility and soil loss. Trash is burnt, and then follows a period where soil surface is bare and exposed to high-intensity rainfall. This period coincides with the wet season and on the sloping land commonly results in severe sheet erosion.

Mission grass areas are burnt each season. The grass 'browns off' early and when fired at a late growth stage, the entire cover is lost due to total combustion and extremely hot fires. This results in a high percentage of bare ground (mission grass dominates, with other species smothered) and exposure to rainfall impact. There is a widespread culture of burning and growing incidence of wild fires in the indigenous forests and pine plantations.

In the 1960s, up to 140,000 ha of Fiji's forests were converted into non-forest land use leading to serious soil degradation. It was particularly so where logged areas had no subsequent management. Here the incidence of mass movement and soil erosion is high. In many cases, forest logging practices have caused avoidable environmental damage the National Code of Logging Practice has been adopted – but its enforcement is often inadequate.

Because of the predominantly poor adoption and application of land husbandry practices and the resultant degradation of the land and water resources, the impact of natural disasters is becoming increasingly more acute, in particular, increasing vulnerability to droughts and flooding.

The unplanned alignment of mining and logging roads has both on-site and off-site consequences on the environment with siltation of creeks and runoff surges during storm events.

Lack of Physical Infrastructure

Too many rural areas have poor roads, utilities, transport (to market) and social services – all disincentives to follow anything other than a subsistence lifestyle.

Weak Institutional Infrastructure

There is serious under-resourcing by the government for line ministries having responsibility for agriculture, forestry and land use in general. The public sector commonly lacks the effective funding, resources and trained technical staff to undertake environmental planning, management and enforcement.

Expertise in the areas of agricultural extension, soil conservation, land use planning and environmental planning, management and enforcement is below critical mass in the responsible line ministries.

The resources devoted to soil conservation are inadequate for the implementation of significant measures, either in terms of providing information or incentives.

The Land Conservation Board (LCB) has no public profile and there is little understanding about its role and responsibilities; yet it is charged with an enormous national task. The LCB has been ineffective for a number of years. The Board is in urgent need of revitalization concurrent with a national awareness program. The primary responsibility of the LCB is the 'supervision over land and water resources' as per the Land Conservation and Improvement Act, 1953. Yet expenditure has been on coastal zone/floodplains drainage schemes, not towards solving the causal factors responsible for the downstream problems.

The LCB is not acting on the powers vested in it and while the Board has 'ownership' of the problems and solutions there is minimal government support and intervention for the Board to fully implement its 'powers to exercise general supervision over land and water resources'. This is not a recent phenomenon, but rather a situation that has prevailed for 20 years or more. With regard to the scope of the Board's work, little attention has ever been given to the issue of water yield and quality.

Environmental issues are not well addressed in the planning process. There is no national level planning and environmental policy guidelines backed by legislation. Environmental analysis is currently not a requirement in the planning system nor is an environmental impact assessment (EIA) on land development proposals before decisions are made. MAFF Land Use Section activities, due in part to limited resources, are mainly directed at planning land use with regard to production potential rather than to longer-term land degradation issues.

There is a poor awareness of the interdependence of conservation and development. There is widely held view in influential ministries that conservation and environmental management are obstacles to development or at best irrelevant to it.

Land conservation is generally ineffective because there is no strong executive authority in a coordination role, nor is there close integration between government departments and other stakeholders. Above all one finds total lack of any strong political will to care for land resources problems.

Inappropriate Land Use in Watersheds

Erosion resulting from inappropriate land use and land management practices in watersheds has led to progressive siltation of rivers resulting in deterioration of drainage on floodplains, frequent inundation and the formation of shallow bars across the river mouths. Dredging of rivers has become a very costly necessity. Land degradation in watersheds causes peak flows in rivers during high-intensity storms. This results in downstream sedimentation and flooding with serious implications for settlements, domestic water supplies, infrastructure (roads, bridges) and crops. There is general lack of attention by loggers to erosion, stream flow and ecological considerations.

The consequences of land degradation and inappropriate land use practices have the potential to impact negatively on the tourist industry. Sectors of the industry already express concern about dirtiness in the rivers, frequency of flooding, water rationing and poor quality water, unsightly landscapes, pollution and visible waste. Environmentalists point to the vulnerability of the coral reefs to excessive sediment brought into the lagoons by flooded rivers from eroding watersheds.

Ecologists have concerns over the forest hardwood program. These relate to the vigor of mahogany that potentially could lead to a monoculture and elsewhere, invasion of native forests. Also, as mahogany plantings often follow logging, a high proportion of Fiji's native production forest is being lost. Planting of mahogany on steep slopes and riparian zones (which is illegal) poses a potential erosion risk at logging time.

Inappropriate Land Use in the Coastal Margins

Large-scale reclamation of mangroves for rice production in particular has proven to be economically unviable with significant net financial losses (refer P. Lal's Raviravi analysis). This national loss is in addition to the loss of benefits for subsistence villagers from mangrove removal.

Information

There is a very poor public understanding in the rural sector about various legislation that pertains to land, land use practice and soil conservation. This situation results in part from the fact that the majority of government and corporate (e.g. Native Lands Trust Board [NLTB], FSC) field officers responsible are themselves not conversant with the various laws. Also, there have been no public awareness programs to inform about the land husbandry provisions stated in these laws and written into rural leases. For 30 years, there has been in essence no enforcement or policing of these provisions; in effect, a whole generation has been kept in the dark since land conservation laws were regarded seriously and enforced.

The level and standards of technology transfer from officials to farmers is inadequate on matters of land use diversification and intensification, farming systems and their development needs, new systems, costs of inputs and gross margins, postharvest support and marketing.

Soil conservation legislation is not being used due to poor understanding of the issues at both planning and implementation levels. Resources devoted to soil conservation are inadequate for applying significant measures either for information or incentives. The LCB does not have available information and publicity material for land users/farmers about soil and water conservation and land management.

There is a lack of clear guidelines on what constitutes 'bad' land husbandry practices, and poor institutional understanding about the magnitude of the soil erosion problem. There is also very little literature about land use farming practices available in Fiji Hindi or Fijian.

Land Tenure

Over the period 1997-2026 approximately 11,800 leases issued under ALTA will expire. While many leases will be renewed there will still be a number of farmers to be resettled. Noting the shortage of good land in suitable locations, the questions arise as to where these displaced farmers will be settled and whether farmers will move to the areas identified. A number of landowners are concerned at the provisions for a minimum lease period of 30 years, which effectively removes for more than one generation any say in the use of their land. A number of landowners are concerned that the lease rental is based on the unimproved capital value of the land and not its commercial value. A lease rent based on the market value of the land would be more remunerative to the landowners.

STRATEGIES TO ADDRESS PROPER LAND USE IN FIJI

Soil Conservation Treatments

The use of vetiver grass for erosion control has a long history in Fiji. As early as 1946, the Department of Agriculture was using a range of conservation measures. These included the vegetable barriers planted along contours using vetiver grass and pigeon pea.

Due to the lack of arable flat lands to produce more cane, the only other option for expansion is to move the sugarcane planting to the marginal steep slopes. However, problems were envisaged, particularly when in certain months of the year, the soil is too dry and erodible. According to scientists putting cane fields in the slopes could be disastrous to the company, the cultivation and the country.

The use of mechanical barriers was also promoted heavily by the Department of Agriculture and the sugar industry. Bulldozers were used to cut broad dirt barriers (bunds) along contours, which was a standard process for controlling erosion in the commercial cropland in most parts of the world in that era.

The vetiver fared well during heavy rains but bulldozer earthworks did not prove that effective. Water collected behind these bands until the weakest spot could hold no longer than the dammed-up body of runoff cascades through gashing jagged gullies into the erodible slopes.

The 1970s and the early 1980s have seen a shift in the focus of the Department of Agriculture and the sugar industry on the promotion of conservation. The MAFF through its CDF and now its Agricultural Diversification Program (ADP) is providing funds to promote conservation farming throughout Fiji, using vetiver hedgerows with cash crops combination in the alleys.

Treatment-oriented Land Capability Classification

To use every piece of land according to or within its capability is probably the first step to any soil conservation project whether it is in a demonstrated area or a farm. Fiji, since 1972, has been using a modified version of the NZ Capability Classification, which is derived from the USDA system.

The classification is now causing some dilemma to both MAFF and farmers. For instance, Fiji as a whole has 85 percent of its cropland on sloping lands and numerous small farmers are making a living on such slopes. Yet using Fiji's Land Classification System, these slopes should be excluded from the cultivation.

Realizing the need to address degradation caused by unsuitable smallholder agriculture in Fiji, especially on marginal hilly land, the pacific land. Management Project for sloping lands was established in 1991 at Waibau. The project aimed to assist in the development and extension of appropriate technologies for the management of sloping agricultural land. Technologies being assessed against current farmers practices include vetiver grass and pineapple hedgerows. Results from the research in Waibau are used to illustrate sustainability of these land management treatments. Over the past seven years at Waibau, the two treatments (pineapple and vetiver) grown in contour hedgerows significantly reduce soil erosion up to 26º slopes compared to current farmers practice.

The vetiver grass effectively controlled soil erosion with less than 2 mt/ha/year, whereas pineapple was an added source of income. The research data from Waibau clearly indicate that the marginal hilly lands up to 26º slopes in Fiji can be cultivated sustainably with soil conservation treatments (Table 5).

Table 5. Effect of Different Management Practices (Treatment) on Soil Loss in Experimental Plots in Waibau

Management Practices/Land Use	Soil Loss in Five Years (mt/ha)
Farmers practice	93.97
Pineapple barrier	2.66
Vetiver grass barrier	1.94
Total soil loss in five years	98.57
Soil loss from each crop:	
Ginger	75.13
Taro	18.82
Cassava	1.96
Fallow	2.66

Vetiver Grass Barrier

Results have shown that vetiver grass is the best barrier for the control of soil erosion in sloping land cultivation. Vetiver grass barrier has several favorable characteristics. Using this system, for instance, land up to 25º (47 percent) with deep soil is allowed for cultivation provided the land will be treated with conservation measures accordingly. Slopes up to 30º can still be used for fruit trees, tree crops and agro-forestry when conservation practices are applied. This system is close to the reality of farmers land use practice and therefore creates less land use conflicts between government and the farmers. Based on the experiences in classifying Navovo Resettlement Area (438.79 ha) more than 40 percent (188.27 ha) of the area would be rendered unsuitable for cultivation under the old system of classification. The task of resettling exiled tenants will become more difficult if the present system of land classification is not reviewed.

CONCLUSION

Fiji has yet to develop a system for classification of sloping upland areas for sustainable production. This new system of classification should consider the experiences and lesson learnt as follows:

- Fiji like many other countries in the tropical and subtropical regions possesses problems of unemployment or underemployment and insufficient food production. Any land, which can be cultivated safely by hand, should also be classified as land suitable for cultivation.
- Keeping in view the population pressure on the land, it seems proper and justified to place more emphasis on management and land improvement aspects rather than to classify the land according to its original status. A piece of land which can be treated and protected by appropriate soil conservation measures for permanent cultivation should be considered as cultivable land.

- Because of the marginal nature of sloping lands and intense rainfall in Fiji, soil conservation treatment is a must and a prerequisite when these lands are brought into any degree of tillage or cultivation. The land classification system should, at the same time, consider the treatment needs and classify the land according to the expected results of the treatment or the improvement.
- In Fiji where skilled professional staff is scarce, information is lacking and farmers are mostly illiterate. Therefore, the capability classification system should be direct, simple and easily comprehendible.

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4. INDIA

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INTRODUCTION

Agriculture is the mainstay of the Indian economy and contributes 26.8 percent to GDP. It employs about two-thirds of the country's work force. Out of over one billion population, about 200 million Indian farmers and farm workers depend on agriculture. Several major Indian industries such as sugar, textiles, jute, food processing, etc. depend on agriculture. Indian agriculture has, since independence, made rapid strides. Food production has gone up by four times, i.e., from 52 million mt in the early 1950s, to 209 million mt at the turn of the century. It has contributed significantly in achieving self-sufficiency in food and in avoiding food shortages in the country. Despite having achieved national food security, the well-being of the farming community continues to be a matter of grave concern for the planners and policymakers in the country. The pattern of growth of agriculture has brought in its wake uneven development, across regions and different sections of farming community and is characterized by low levels of productivity and degradation of natural resources in some areas. Agriculture has also become a relatively unrewarding profession due to generally unfavorable price regime and low value addition, causing abandoning of farming and increasing migration from rural areas.

The geographical area of the country is 329 million ha, which supports more than one billion population. The major portion of land resources is under agriculture covering about 156 million ha. Forests cover about 69 million ha and remaining area is under miscellaneous uses. With only 2 percent of the geographical area and 1.5 percent of forests and pastureland of the world, India supports 18 percent of world's human population and 15 percent of animal population.

LAND CLASSIFICATION

Land Classification According to Land Use

Department of Agriculture and Cooperation of Ministry of Agriculture has been compiling, updating and publishing the land use classification for different usages for the country. The land use data are broadly grouped into three sectors, i.e., (i) agriculture sector (60 percent), (ii) ecological sector (33 percent), and (iii) non-agriculture sector (7 percent) (Table 1).

Land Use Classification of Uplands

Uplands of India include the regions of Himalayas (East to West), Western Ghats, Eastern Ghats and Vindhya Satpura hills. No systematic surveys have been undertaken to delineate uplands in these geographic regions. Out of 329 million ha of geographical area of the country, about 93 million ha is mountainous of which a major part (51.3 million ha) lies in the Himalayan region. The Himalayas are the youngest chain of mountains in the world extending over a length of 2,500 km and average width of 250-300 km, from Northwest to Northeast covering an area of nearly 50 million ha. Broadly the hills of Himalayan region are classified into three longitudinal zones, i.e., Great Himalayas (above 3,000 m elevation), lesser (middle) Himalayas with width ranging from 65 to 75 km and average height between 900 m and 3,000 m, and lower (Shivalik) Himalayas with average height of less than 900 m.

Table 1. Land Use under Various Sectors

Land Use	Area (million ha)	Percentage
Geographical area	329.0	
Reporting area:	304.9	
Agriculture sector:		
a) Net cultivated area	142.0	46.6
b) Current fallow	14.4	4.7
c) Other fallow	9.7	3.2
d) Cultivable wasteland	13.9	4.5
Ecological sector:		
a) Forest	68.9	22.6
b) Permanent pasture and grazing lands	10.9	3.6
c) Miscellaneous trees and hedges	3.6	1.2
d) Barren and uncultivable wasteland	19.0	6.2
Non-agriculture sector:		
Under non-agricultural uses	22.5	7.4

The Northwestern Himalayan region is located in the states of Jammu and Kashmir, Himachal Pradesh, and Uttaranchal and low tracts to temperate cold alpine and cold arid in the northern high mountains. The annual precipitation varies from 8 cm in Ladakh (cold desert) to 115 cm in Jammu and 50-350 cm in the hills of Himachal Pradesh. The Northeastern Himalayan region spreads over an area of 17.7 million ha covering the hills of Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Assam, Nagaland, Tripura and West Bengal States. The average rainfall varies from 132.3 cm to as high as 1,200 cm with mean value of 280 cm. Out of 4.37 million ha area affected by shifting cultivation, about 2.7 million ha is located in this region. The land utilization for the Himalayan States is given in Table 2.

According to an estimate, 17.3 million ha is degraded land in Indian Himalayas falling in Hindu Kush-Himalayan region, The soil erosion from sloping farm lands is very high in Himalayan region ranging from 1 mt/ha/year to 120 mt/ha/year. In eastern Himalayas of India, the soil loss in sloping land is about 54 mt/ha/year. In addition to soil loss, there is nutrient loss leading to declining crop yields and thus food insecurity. The major contributing factors, which are responsible for degradation in mountain agriculture, are population pressure, poor land management, increasingly intensive farming, lack of appropriate technology, prevailing shifting/*jhum* cultivation, etc.

MANAGEMENT OF SLOPING UPLAND AREAS

Sloping lands of hills, and mountains and high land areas are sensitive to agricultural encroachment and suffer from widespread soil erosion and land degradation. Small and marginal farmers have traditionally used sloping lands for subsistence farming despite poor yields and low farm productivity. Initially compelling conditions in plain perhaps due to increase in population may have pushed men onto sloping lands to find alternative livelihoods.

The uplands of Himalayan region have limited cropland, i.e., 11 percent of total area to support livelihoods of most rural households. It is reported that 37 percent of the cropland is sloping land of various degrees. The farmers of Himalayan hills are even cropping sloping lands beyond 25 and 30 degrees. The key issues include shrinking size of landholdings, erosion from sloping farmland and decline in soil fertility and inadequate food production.

Prescriptive models and packages of technology are seldom transferable from site to site. Conditions within watersheds and even within communities are generally too diverse for top-down models to be applied at the farm level. Apart from agro-ecological diversity, there is a diversity of clients to address large and smallholder farmers, marginal farmer, the landless, rural industry workers, shopkeepers, towns' people and urban dwellers – all with different socio-economic and cultural characteristics and needs. Agro-forestry is the dominant sustainable farming system, being followed in upland management. It is the deliberate growth and management of trees along with agricultural crop and/or livestock in systems that are ecologically,

Table 2. Land Utilization in the Himalayan States

(Unit: 000 ha)

Himalayan State	Geographical Area	Cropped Area	Horticulture Area	Forests	Pasture	Miscellaneous Trees	Cultivable Wasteland	Fallow Lands
Arunachal Pradesh	8,400	200	8	5,750	-	35	47	80
Assam Hill District	1,500	240	-	940	180	250	107	180
Himachal Pradesh	5,600	980	150	870	1,160	40	130	70
Jammu and Kashmir	22,200	1,020	160	2,750	123	75	152	90
Manipur	2,200	220	223	600	-	24	-	-
Meghalaya	2,200	220	55	810	17	145	454	310
Mizoram	2,100	60	7	1,300	4	3	74	440
Nagaland	1,660	180	1	290	-	202	62	360
Sikkim	700	90	-	260	70	5	1	10
Tripura	1,000	40	30	580	-	98	47	80
Uttar Pradesh (U.P.) Hill Region	5,100	1,100	170	3,440	272	208	320	60

socially and economically sustainable; or more simply agro-forestry is the use of trees in farming system. The villagers in the hilly areas normally own 0.1-1.0 ha of the land and adopt sophisticated and management patterns to get all the benefits from limited land, i.e., food, oil for cooking, fodder for cattle, fuel wood for cooking, fruit for nutrition or as cash crop. Various specific eco-systems in different parts of the Himalayas include shifting cultivation, cold deserts and migratory grazing.

For the management of uplands, the combination of different treatment measures are adopted based on the need of the areas. These include bench terraces, composting, contour tillage/planting, cover crops, crop rotation, diversion ditches, drop structures, grass strips, hedgerows, minimum tillage/zero tillage, mulching, ridge terraces, shifting cultivation, soil barriers, soil traps, water harvesting and sloping agricultural land technology.

Sustainable Production Initiatives

There are various programs being implemented by different ministries of the central government, namely; Ministry of Agriculture, Ministry of Rural Development, Ministry of Environment and Forest, etc. for the development of degraded lands. In addition, a number of programs are being implemented under State sector. Since inception of the program till end of IX Plan, an area of 27.5 million ha has been treated/ reclaimed under various centrally sponsored/central sector schemes including bilateral projects and other central ministries. The scheme-wise area treated up to March 2000 is shown in Table 3.

About 27 million ha have been treated till end of IX Plan. Following are the main programs being implemented by various Union Ministries:

- National Watershed Development Project for Rainfed Areas
- Soil Conservation for Enhancing Productivity of Degraded Lands in the Catchments of River Valley Projects and Flood Prone Rivers
- Watershed Development Project for Shifting Cultivation Areas
- Drought Prone Area Program
- Integrated Wasteland Development Project
- Technology Development, Extension and Training
- Investment Promotional Scheme
- Wasteland Development Task Force
- Integrated Afforestation and Eco-development Project Scheme
- Externally Aided Projects.

Impact of the Initiatives

In order to assess the performance of various ongoing projects/programs of watershed and land reclamation, evaluation studies have been conducted by Indian Council of Agricultural Research (ICAR), state agriculture universities, National Remote Sensing Agency, agro-economic research centers, Indian Institute of Management and independent agencies like Agriculture Finance Corporation (AFC), Institute of Development and Communication, Institute of Economic Growth, Development Center for Alternative Policies, etc. The summaries of these evaluation studies are below:

1. ***Increase in Agriculture Yield***

- The evaluation study conducted by AFC in the catchment of Matatila (U.P) has reported that the crop yield in case of *arhar* (pigeon pea), barley and mustard has increased from 5, 4 and 3 quintals* per ha to 19.5, 12.0 and 10.0 quintals per ha, respectively.
- The increase in crop yield in paddy, *ragi* and red gram has been from 9.37, 7.5 and 6.25 quintals per ha to 15.0, 20 and 7.5 quintals per ha, respectively in Machkund-Sileru catchment in Andhra Pradesh.

2. ***Increase in Cropping Intensity***

- The study conducted by AFC has revealed that the cropping intensity increased from 85.6 to 115.4 percent in Matatila (U.P.) and from 89 to 100 percent in Ukai.

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* 1 quintal = 100 kg.

Table 3. Area Developed under Various Watershed Development Programs Since Inception up to March 2000

S.No.	Ministry/Scheme (year of start)	Up to VIII Plan		During First Four Years of IX Plan (1997-2000)		Area Treated since Inception up to March 2000	
		Area Treated (million ha)	Total Investment (Rs. million)*	Area Treated (million ha)	Total Investment (Rs. million)*	Area Treated (million ha)	Total Investment (Rs. million)*
I. Ministry of Agriculture, Department of Agriculture and Cooperation							
i.	NWDPRA (1990-91)	4.22	9,679.3	2.12	7,921.5	6.34	17,600.8
ii.	RVP & FPR (1962 & 81)	3.89	8,199.5	0.82	4,701.4	4.71	12,900.9
iii.	WDPSCA (1974-75)	0.074	937.3	0.13	634.0	0.204	1,571.3
iv.	Alkali soil (1985-86)	0.48	622.9	0.10	137.5	0.58	760.4
v.	EAPs	1.00	6,460.0	0.50	14,250.0	1.50	20,710.0
	Sub-total	9.664	25,899.0	3.67	27,644.4	13.334	53,543.4
II. Ministry of Rural Development, Department of Land Resources							
i.	DPAP (1973-74)	6.86	11,099.5	1.94	4,482.9	8.79	15,582.4
ii.	DDP (1977-78)	0.85	7,227.9	0.85	3,697.9	1.69	10,925.8
iii.	IWDP (1988-89)	0.28	5,429.6	0.65	3,268.0	0.93	8,697.6
iv.	TDET (1993-94)	Neg.	Neg.	0.032	415.7	0.032	415.7
v.	IPS (1994-95	Neg.	Neg.	0.001	5.9	0.001	5.9
vi.	WDTF	0.001	47.4			0.001	47.4
	Sub-total	7.991	23,804.4	3.473	11,870.4	11.444	35,674.8

... To be continued

Table 3. Continuation

S.No.	Ministry/Scheme (year of start)	Up to VIII Plan		During First Four Years of IX Plan (1997-2000)		Area Treated since Inception up to March 2000	
		Area Treated (million ha)	Total Investment (Rs. million)*	Area Treated (million ha)	Total Investment (Rs. million)*	Area Treated (million ha)	Total Investment (Rs. million)*
III. Ministry of Environment and Forests							
i.	IAEPS (1989-90)	0.29	2,031.2	0.12	1,415.4	0.42	3,446.6
	Grand total	17.945	51,734.6	7.263	40,930.2	25.198	92,664.8

Notes * About 2.3 million ha is likely to be treated during 2001-02 and therefore, total area treated at the end of IX plan would be 27.5 million ha; and US$1 = Rs.47.75.

<Details of Abbreviations>

NWDPRA – National Watershed Development Project for Rainfed Areas
RVP & FPR – River Valley Projects & Flood Prone Rivers
WDPSCA – Watershed Development Project for Shifting Cultivation Areas
EAPs – Externally Aided Projects
DPAP – Drought Prone Area Programme
IWDP – Integrated Wasteland Development Project
TDET – Technology Development, Extension & Training
IPS – Investment Promotional Scheme
WDTF – Wasteland Development Task Force
IAEPS – Integrated Afforestation & Eco-development Project Scheme

- The study conducted by Administrative Staff College of India, Hyderabad has revealed that the cropping intensity was increased from 3.8 to 19 percent in the catchment of Sutlej due to watershed management.

3. ***Reduction in Sediment Yield***

- According to the evaluation studies conducted by AFC, the reduction in sediment at watershed level in the catchment of Ramganga has been 92.5 percent. Another study in Matatila catchment for the watershed Sankerwar indicated that the sediment reduction has been 64 percent.
- Evaluation study conducted by Administrative Staff College of India, Hyderabad for the catchment of Machkund-Sileru has indicated that there had been reduction in sedimentation up to 81 percent.

4. ***Reduction in Peak Rate of Runoff***

- A study conducted by Indian Resources Information and Management Technologies, Hyderabad for the catchment of Sahibi had indicated that there has been reduction in runoff coefficient from 46.6 to 1.6 due to treatment. Also the suspended sediment was reduced by 67 percent.
- Another study conducted for Damodar Barakar catchment indicated that peak rate of runoff in a treated watershed was reduced by 36.3 percent and sediment yield was lowered by 53.3 percent. In case of Mahi catchment the reduction in runoff has been 32 percent.

5. ***Increase in Employment Generation***

- Implementation of the scheme helps in creating employment generation especially in remote rural areas as high and very high watersheds that are critically degraded (being treated under the scheme) are usually at remote places and poorest of the poor are inhabitants in such areas.
- Out of total the outlay for works, about two-thirds is utilized for creating employment generation.

6. ***Other Benefits***

- The implementation of the program especially the management of the drainage lines through appropriate structures helps in creating new land areas due to silt deposition, which is used for agricultural purpose.
- The implementations of water harvesting structures create supplementary irrigation, which has potential for increasing agricultural production in rainfed areas.
- These schemes also help in groundwater recharge. The evaluation studies have established this fact.

WATERSHED DEVELOPMENT IN THE DOON VALLEY – A CASE STUDY

The IWDP has been launched since 1993-94 for the development of lower Himalayas covering States, namely; Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab and Uttaranchal. For the purpose of the case study of 'Land Classification in Sloping Upland Areas for Sustainable Production System' watershed development activity undertaken in the Doon Valley of Uttaranchal State is selected. Land use pattern of Uttaranchal State (total area 0.65 million ha) as per census of 1990-91 are given in Table 4.

Table 4. Land Use Pattern of Uttaranchal State

S.No.	Land Use	Percent
1.	Cultivated land	46.5
2.	Forest land	15.3
3.	Cultivable wasteland	25.2
4.	Not available for cultivation	13.0

Various activities are taken up, viz. (i) social forestry, (ii) livestock, (iii) horticulture, (iv) minor irrigation, (iv) agriculture, (v) soil conservation, (vi) energy conservation, and (vii) community participation, with a view to achieve the project objectives and the related goals in a direct or indirect manner.

Community Participation

The primary thrust of the project towards community involvement starts at the planning stage itself. Participative micro planning based on the perceptions and felt needs of the village community form the foundation of a long-term association of the project with the villagers. For this, participatory rural appraisal

(PRA) is used as a tool. PRA exercises are carried out over several rounds during the planning and implementation stage to ensure that people's perceptions are reflected in the village plans and they are actively involved in the implementation stage as well.

Women Motivators

Constant interaction with the target groups is the crux of the strategies adopted for ensuring involvement of the people. Since women are the major and most important section of the village population, their participation in the project is of utmost importance. However, a meaningful communication with them by a work force, which is predominantly male, is often found less effective. To facilitate a two-way communication between the project team and the womenfolk, women motivators have been engaged by the project. They support the project team in getting effective involvement of the women in the project activities and to inculcate a sense of belonging amongst them towards the assets developed through project's interventions so that their participation is ensured.

Institutional Aspects

Self-help groups (SHGs), gaon resource management associations (GAREMAs), women groups, etc. are formed in the villages to strengthen the institutional aspect of people's participation. These local level organizations become the moving force to involve local population and get their active participation in the management of their natural resources.

Involvement of the Local People

The project activities are being implemented in consultation with the village level committees. A component of 'community participation' has been identified in the project document to provide the much-needed focus for unified sectoral actions in the villages through active involvement of the villagers in general and women in particular. In a number of villages, villagers have come forward to voluntarily provide labor for different field activities as a result of efforts made by the project team towards community participation.

Capacity Building through Training

The practitioners of PRA methods stress the need for training to the project staff to bring about an appreciation that the rural people possess the knowledge of the causes of the problems and can identify and suggest practical, workable solutions to these problems. Thus investigation and analysis need not be done by the 'outsiders' posing as the 'know-all experts'. It has to be carried out by the local inhabitants themselves and the project team should act as a facilitator in this exercise.

Participatory methodologies, therefore, require a change in the attitudes both in the project team as well as the villagers. It also requires learning of new skills and methods related to group dynamics by the project team, which would reflect in their behavioral pattern while interacting with the villagers. The project has been able to identify the needs of training to the staff in this regard. The need for upgrading the technical skills has also been appreciated to enhance the quality of technical inputs and to improve the delivery system. Similarly, the requirement of training to villagers in general, and women in particular, has also been appreciated. Empowerment of women is an area, which could bring about a sea change in their attitude from a passive resignation to an active participation in activities, which would enhance the quality of life in their village.

Training to the Villagers

The exploratory discussions with the villagers followed by the PRA exercises highlighted the felt needs of the villagers/womenfolk for training. The project utilized the information so gathered in chalking out the training program for the village women as 'entry point'. These trainings generated confidence amongst the women and the villagers and were instrumental in rapport building.

Sustainability

The major weakness of the projects taken up in the past has been the lack of proper attention towards development of local level institutions. Doon Valley Project has been able to initiate action in this direction and work out strategies for the project period and, to some extent for the post-project period as well. Though the outcome of the efforts made so far indicates that the project is on right direction, the ultimate test, of course, would be the post-project scenario.

Sustainability in the Post-Project Period

The linkage with *Gram Panchayat*, which is the statutory body at the village level, would be crucial for GAREMA. Section 29(6) of the U.P. Panchayat Raj Act provides that a *Gram Panchayat* may establish other committees to assist it in the discharge of any other function. GAREMA could become a legally constituted committee of the *Gram Panchayat* under this provision with *Gram Pradhan* as its patron. With its experience in the planning and implementation of development activities, it would benefit from the development programs to be taken up by the *Gram Panchayat* at the micro level.

Withdrawal Policy

To make the local level institutions aware of their role in the post-project period, a policy for withdrawal from those areas where the project interventions are over has been proposed. The policy proposed that the individual assets, which have been developed through project inventions, would be maintained by the beneficiaries who would continue to derive benefits from them. The common property resources and the group-oriented activities would need backstopping. Hence, these assets would bee handed over to the concerned GAREMA or the users group with the consent of the *Gram Pradhan*. Forestry activity carried out in the village community lands or the forest area is the most critical area are to be maintained through village institution such as GAREMA and forestland under Joint Forest Management Rules, 1997.

Policies for Appropriate Use of Land for Agriculture

The land is State subject, however, Government of India, Ministry of Agriculture provides necessary policy directives for effective utilization of different kinds of land for enhancing the agricultural production on sustainable basis. Following are the main policies suggested by Government of India:

1. ***National Agriculture Policy***

The National Agriculture Policy seeks to promote technically sound, economically viable, environmentally non-degrading, and socially acceptable use of country's natural resources such as land, water and genetic resources endowment to promote sustainable development of agriculture. According to the policies the measures are to be taken **to contain biotic pressures on land and to control indiscriminate diversion of agricultural lands for non-agricultural purposes**. The unutilized wastelands are to be used for agriculture and afforestation. Attention is focused for increasing cropping intensification through multiple-cropping and inter-cropping. Over the next two decades, it aims to attain:

- a growth area in excess of 4 percent per annum in the agriculture sector;
- growth that is based on efficient use of resources and conserves soil, water and bio-diversity;
- growth with equity, i.e., growth which is widespread across regions and farmers;
- growth that is demand-driven and caters to domestic markets and maximize benefits from exports of agricultural products in the face of the challenges arising from economic liberalization and globalization; and
- growth that is sustainable technologically, environmentally and economically.

2. ***Planning Commission – Approach Paper***

The Planning Commission, Government of India has prepared an approach paper for the X Five-Year Plan (2002-07) for effective utilization of land for sustaining the production. Paper stresses that every effort needs to be made to bring presently uncultivated land into productive use, whether in agriculture or in forestry. For this, it will be essential to evolve a comprehensive land-use policy which will lay out the contours of the ownership and institutional framework that will encourage the productive utilization of such lands.

3. ***Working Group Report for X Five-Year Plan***

The Working Group report for X Five-Year Plan on Watershed Development, Rainfed Farming and Natural Resource Management constituted by Planning Commission has recommended the development of 88.5 million ha through Watershed Development Programme by 2020, at total estimated cost of Rs.727.5

billion (US$1.52 billion). In the X Plan, the report envisages treatment of 15 million ha at estimated cost of Rs.90 billion (US$187.5 million). It has also recommended that a comprehensive soil survey is taken up in hand, and mapping of landmass in the country is completed in a time-bound period, so as to develop and utilize this vital resource for productive purposes.

4. ***National Land Use Policy Outlines***

In February1985, the Land Use Policy Outlines (NLPO) was prepared and circulated to the State governments for adoption. As per NLPO effective measures are to be taken to contain biotic pressures on land and to control indiscriminate diversion of agricultural lands for non-agricultural uses. The policy emphasizes appropriate use of the unutilized wastelands for agriculture and afforestation. Particular attention is to be given for increasing cropping intensification through multiple-cropping and inter-cropping. The NLPO is being adopted by the State governments for the sustainable management of the land in the country.

MAIN ISSUES AND PROBLEMS IN UPLAND CLASSIFICATION

The classification of upland has been made based on its use, types of wastelands, and various problems/degraded lands, etc. The different institutions and organizations have adopted different criteria for classifying the lands under different categories. There are large variations from one estimate to another while classifying the land under different categories. There is lack of uniform and scientific approach for this purpose. There is urgent need to survey and classify the land with a common and scientific approach on uniform scale.

In context of land classification for sloping uplands areas, there is no specific survey on scientific basis. The information is mixed up with other categories of land classification. Since the problems and remedial measures for uplands of sloping hills are different, there is need for a separate survey, mapping and land classification for sloping uplands. Also before the actual task is undertaken, a pilot project need to be undertaken for standardizing methodology for classification of sloping uplands.

5. INDONESIA

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INTRODUCTION

Agriculture remains a key sector to the economy of Indonesia. At present this sector contributes about 20 percent of GDP, providing employment for 55 percent of labor force and generating 26 percent of non-oil export. Total arable land is about 55.8 million ha (Census, 1993), which is about 17.2 percent of the total land resources. Out of this about 22.3 million ha comprise upland area and 12 million ha are estate crops.

Land resources availability is a determining factor for the production process. The quality and quantity of resources determine the pattern, directions and sustainability of the agriculture. At present, the upland resources are only receiving low attention from the government. During past 30 years, development efforts were focused on the development of wetland in order to strengthen national policy on food security. As a result, a significant and remarkable progress in the area of wetlands development has been achieved. This is indicated by the achievement of national rice security in 1986. On the other hand, progress on upland development was relatively very slowly.

As Indonesia is suffering from economical crisis in the recent years, the government shifted attention to wetland development, as well as to the other types of land (upland, swamp, etc). However, due to improper management, agricultural production system in the uplands – particularly in the mountainous area is suffering and becoming unsustainable.

LAND CLASSIFICATION IN INDONESIA

Classification Based on Physical Characteristics

In general land classification is determined based on its physical characteristics. In Indonesia land is classified into 11 categories (Table 1).

Classification Based on Land Use

In 1992 the Government of Indonesia released National Law No. 24/1992 about land use. This Law regulates and classifies the land resources in two categories, viz. conservation area and development area. Classification is based on slope and specific characteristics of the area. According to this Law the area with less than 25 percent slope can be categorized as development area and the area between 25-40 percent slope can be developed as productive forest area. Meanwhile, the area with slope greater than 40 percent must be determined as conservation area.

The development area is further classified into three categories. The area with 0-8 percent slope is determined for food crops farming, 8-15 percent for horticulture and secondary crop farming, and 15-25 percent is determined for estate crops. This classification system is now widely used for developing land use planning, which is compulsory for the local governments.

Classification Based on Agro-ecological Zoning (AEZ)

This system of classification was developed by the Ministry of Agriculture as a pragmatic tool for directing appropriate approach and strategy for agricultural development. Initially, the classification system is determined based on hydrology condition, climate and type of soils. Further, the criteria for classification were developed by adding social and economic parameters as well as available infrastructure. Based on this system land resources in Indonesia can be classified into several categories. These include wetland/irrigated land, dry climate upland, wet climate upland, coastal, and swamp/tidal land.

Table 1. Land Resource in Indonesia

S.No.	Land Classification	Total Area (km^2)	Possible/Existing Land Use
1.	Snow covered area	4,075	Conservation
2.	Sloping land		
	– Mountainous area	217,658	Estate crops, hydrology conservation, agro-forestry
	– Low slope area	302,407	
	– High slope area/steepland	361,474	Conservation
3.	Karst and shallow soils layer	28,344	Forest, estate crops, savanna
4.	Ill drainage area	220,373	Swamp, wetland, conservation, fisheries
5.	Coarse texture soils (sandy soild)	18,379	Forest, conservation
6.	Aluvio/coluvial (clay)	8,416	Wetland, upland
7.	Low fertile soils (acid soils)	426,468	Estate crops, mixed farming
8.	Saline soils	21,730	Mangrove, fisheries
9.	Sulfide acid soils	41,095	Wetland
10.	Peat soils	160,826	Conservation, wetland, estate crops, horticulture
11.	Alluvial with light constraint	93,947	Various farming

Source: Regional report of Indonesia Center for Soils and Agro-climatic Research (ICSAR), 1992.

CHALLENGES TO UPLAND DEVELOPMENT

The importance of uplands is reflected by the fact that 17.2 million ha of upland is contributing to tree crops production, providing significant amount of food crops and most of the country's fodder. Most of the upland area is non-irrigated and has been ignored by the development efforts for many years. As a result poverty in the upland area is still quite high. It is estimated that at present about 65 percent of poor people are living in the upland areas, of which about 50 million people are living under poverty line (Dimyati and Bahrein, 1998).

Because of the occurrence of steep slopes agriculture in the uplands differs significantly from the lowlands. In view of the impact of the intense tropical rains typical of Indonesia, the threat of soil erosion and soil degradation is far more severe in the uplands, which is exacerbated by the generally poor, shallow soils particularly those of non-volcanic origin. Upland agriculture is dependent on rainfall, which restricts cropping options, shortens the safe growing season particularly in dry areas, and increases risk. Land use mainly consists of forest, now threatened by illegal logging, shifting cultivation, and dryland food crops and tree crops production. Because of the inherent ecological constraints of these areas combined with the increasing population, which has to subsist on a declining natural resource base pressure is being placed on forest leading to an increasing rate of resource degradation mainly through deforestation and soil erosion. Disruption of traditional tenure systems has also played a role.

As pressure on land has increased in the upland areas, the extent of poverty and environmental degradation has grown and farmers have moved into unsustainable farming systems. Large number of permanent farmers at or below the poverty line can be found in all islands, whereas farmers practicing shifting cultivation are found in Kalimantan and Sumatra. This practice has led to more unsustainable production systems.

GOVERNMENT APPROACH AND STRATEGY

Recognizing the extent of poverty and the impending environmental problems in the upland area the Government of Indonesia has been promoting sustainable land use patterns. Program focusing on structural and vegetative soil and moisture conservation activities, in combination with sustainable food and tree crops and forestry production has been introduced. This program follows the watershed approach, which considers watershed as the basic physico-biological and socio-economic unit for planning and management. With the existence of great ecological diversity in the rainfed areas, the main challenge is to ensure that the investment of resources are focused on locally suitable and economically viable land use and farming systems that are derived from a participatory decision-making process.

EXPERIENCE IN UPLAND DEVELOPMENT: THE NATIONAL REGREENING PROGRAM

Concern in the development of upland areas has grown significantly. The government has launched various projects that aim to improve and sustain upland production system. One of the famous programs launched by government is the Re-greening Program. Launched in 1976 under special presidential instructions (INPRES), the program approach for upland development is through:

i) controlling erosion and floods;
ii) improving land productivity and farmer income; and
iii) increasing people's participation in preserving land productivity and farmer's income.

One component of the program also focuses on physical engineering/technological improvement of the uplands integrated with institutional and community development program. This component of upland physical engineering is composed of activities related to the improvement of upland through development of vegetation cover and civil works activity. The choice of activity is determined based on physical assessment of land considering various factors including land slope, land cover, elevation and so on. Activities related to the development of vegetation cover include establishment of soil conservation demonstration unit, reforestation, estate crop development, and sedentary farming demonstration unit for shifting cultivation areas. The civil work activities principally are related to construction of waterways control to reduce soil erosion. The typical structures that have been developed in sloping upland areas involve check dams, gully plug, ponds, terracing, etc. Practically, approach on physical engineering is simplified. In general, the typical activities are given in Table 2.

Table 2. Activities to Control Soil Erosion on the Upland Areas

Land Slope (percent)	Activities Involving the Use of Vegetative Cover	Involving Civil Works (physical activities)
0-8	Food crops mixed with tree crops	-
8-15	Tree crops and food crops	Terracing, gully plug, check
15-25	Estate crops, fruit crops, food crops (limited)	Terracing (limited)
25-40	Farm forestry (tree crops)	-

Lesson Learnt 1: Key to Success

Since its implementation the re-greening program has widely gained success in improving and conserving upland production system. In various locations re-greening program has significantly improved farmers' income and agricultural productivity (e.g., in Java) and improved hydrology characteristic (e.g., in Java, Lombok island and Nusa Tenggara). In-depth investigation shows that the underlining reason for success of the program was laid on the strategy and approach undertaken for the implementation of the program. National re-greening program was well accepted by villagers as it applied participatory approach in its implementation. In addition, the program was also successful in drawing involvement from stakeholders from other sectors including the local/district government. In this regard, even the program planning was delegated to the local government with assistance from regional technical institute (Institute for Land Rehabilitation and Conservation/BRLKT).

In practice the management of the program was carried out in a participatory way. At the early stage, BRLKT carried out the assessment of upland area and based on the assessment formulated the strategy and direction for upland farming and conservation (Technical Plan/RTP). The RTP was further accounted into village conservation plan (RKTD) with full participation of the villagers in its formulation. RKTD, which actually is a detailed plan for upland farming and conservation, can then be referred by the local government to implement the program on improvement of upland. Furthermore, the implementation of the program should also be conducted with full participation of the villagers. In this case, villagers act as collaborating beneficiaries by following/implementing directed upland conservation farming. On the other hand, however, villagers receive various incentives from the government such as free tree crop seeds and agro-inputs, micro finance, technological assistance, etc. In summary it can be said that the key to success of the program is in the adoption of participatory approach at all stages of process in combination with close technological assistance (Adiningsih, *et al*., 1998).

Lesson Learnt 2: Factors for the Failure

Not all the programs have success stories. In some places the re-greening program shows unsatisfactory outcomes. Problems that were responsible for such failures laid on the inconsistency to keep the program revolving. The main cause of failure was related to growing demand on woods in many areas, which resulted in the increased harvesting of wood and illegal logging. Unfortunately, after harvesting the wood, many farmers did not have the willingness to replant their land with new tree crops as the incentives from the government were shifted to other locations. As a result farmers were back to the unsustainable farming practice, which was focused only on the food crops farming. Ironically most cases of failure occurred in poor areas only as the poor farmers usually practice extractive farming without any capability to conserve the environment.

The second cause of the failure was the lack of enforcement of the Law No.: 24/1992 on the part of the government institutions. However, the regulation cannot be rigidly enforced due to the lack of government ability to provide alternative production systems for the sloping upland areas.

SUSTAINABLE UPLAND PRODUCTION SYSTEM IN INDONESIA

The unsustainability of upland production system is because of the low organic matter content in the soil, deteriorating physical condition and poor water-holding capacity of the upland soils. Another problem is the high use of inorganic fertilizers in the upland areas. The problem is increased by soil erosion, however, the farmers cannot realize the impact of erosion because the process of decreasing land fertility is slow (Latief, 1996). Generally upland farmers find that the productivity remains the same from year to year while the amount of inputs goes on increasing. The government is promoting several actions to sustain agricultural production in upland areas. These are as follows.

- The use of organic matter (compost, bio fertilizers, etc.)
- Recycling organic matter and minerals by adding the agricultural waste to the land
- Minimizing the use of inorganic fertilizers and other chemicals
- Applying conservation farming in the sloping upland areas
- Increasing water-holding capacity of the upland area and developing rain-harvesting technology. This effort is carried out by reducing flow of surface water, terracing, making on farm ponds, etc.

APPROPRIATE FARMING TECHNOLOGIES IN INDONESIA

Alley Cropping

Alley cropping is vegetative conservation technology by mixing food crops, which are grown in between the hedge crops. A hedge crop, usually legume crop, is grown following elevation contour. Moreover, alley cropping system can also be mixed with livestock farming by selecting the hedge crops that produce adequate fodder. The key to success of alley cropping that promotes sustainable upland farming includes the use of bio-fertilizers, crop rotation, minimum tillage and integrated pest management.

Agro-forestry

Agro-forestry is a kind of farming system in uplands, which mixes tree crops and food crops, and livestock/pastures. Agro-forestry has double benefit – as a production system as well as a conservation system. Land fertility usually increases as some tree crops have the capability to fix atmospheric nitrogen to the soils. Root system also improves soil physical structure. There are three types of applied agroforestry practices in Indonesia: (i) agro-silvicultural, i.e., the mixing of tree crops and food crops; (ii) silvo-pastoral, i.e., mixing of grass, livestock and tree crops; and (iii) agro-silvo-pastoral, i.e., the mixing of livestock, food crops and tree crops (Sumarno and Suyamto, 1998).

Some key strategies for sustainable agricultural production are given in the following Box 1.

Box 1. Key Strategies for Agricultural Sustainability

- To acquire sustainable farming does not necessarily mean to go back to nature or traditional system. Instead, we have to take the wisdom of the nature.
- There is no uniform technology/approach for maintaining sustainability of farming; instead, specific location may need specific technology and approach.
- Success of sustainable farming is closely related to poverty. Therefore, poverty alleviation should be carried out as parallel effort to promoting sustainable farming.

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6. ISLAMIC REPUBLIC OF IRAN

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INTRODUCTION

The average annual precipitation throughout the country is about 250 mm, with only 8 percent of the country receiving between 500-1,000 mm of precipitation annually. The maximum temperature during summer ranges from 34ºC in the north to 50ºC in the south. Most parts of the north and west of Iran receive snow during winter and temperature drops below freezing point. The southern part of the country, the north coast of the Persian Gulf and the Gulf of Oman do not usually experience freezing point.

Although agriculture and land use in Iran have a long history – about 5000 years B.C. and despite huge deterioration caused by soil erosion and flood, there are some documents showing that increasing soil erosion is an outcome of the recent century. The first comprehensive report of soil erosion, water and soil conservation in English was prepared by the two FAO experts – Dauan and Robin in 1958.

Climatic Zones

Three main climatic zones of Iran are:

- *Caspian Zone* has causian affinities with mediterranean influences on the coast. Precipitation increases from east to west from 500-1,900 mm with the greatest amount of rainfall on the west shore of the sea where the Alborz Mountain moves northward; snow is not common in this area especially in the lower Caspian.
- *Baluchi Zone* with high humidity (60-80 percent) due to the proximity of the Indian Ocean, saharo-sindian subtropical influences, and annual precipitation of less than 200 mm at sea level. The summer is long and hot with mean temperatures of 34ºC in July and 15ºC in January.
- *Irano-Turanian Zone* with dry summer and temperate continental climate. It covers more than 90 percent of the country's area. Precipitation varies between 100 and 500 mm with a long dry summer and the lowest humidity among the three major zones (20-40 percent in summer and 65-85 percent in winter).

Soils

According to exiting classification system, seven main geological units are distinguished in Iran. They include:

- *Khuzestan Plain* with deltas and floodplains of Karun and Karkheh rivers.
- Folded Zone includes series of gypsum, salt, marl, silt, sandstone, etc. and *Bakhtiari series* of conglomerates.
- *Iranides* formed of serpentines, thick massive limestones and dark phyllites, chlorites and chists.
- *Central Plateau* formed by gypsiferous and saline series of Eocene and Miocene Age.
- *Albors Mountains* with thick stratigraphic sequence of limestone.
- *Turkeman-Khorassan Mountains* composed of limestone and mails.
- *Caspian Littoral* with loess deposits, alluvial material and younger tertiary.

INAPPROPRIATE LAND USE AND CONSEQUENT FALL IN PRODUCTION

Lands have different and particular uses based on their location, type of soil and the material therein.

As shown in Table 1, total area under rangelands has been reduced by 20 million ha, i.e., from 110 million ha to 90 million ha and forage production declined by 50 percent. Similarly, the amount of biomass in Iran's forests have fallen by 40 times (Table 2).

Table 1. Rangelands Area and Forage Production in Iran

Type of Rangeland	Area (million ha)		Forage Production (000 mt)	
	Past	Present	Past	Present
Good	30	14	9,000	4,060
Fair	70	16	10,500	5,520
Deserted	10	16	500	420
Total	110	46	20,000	10,000

Source: *Iran Statistical Yearbook, March 1999.*

Table 2. Forest Area and Biomass Production in Iran

Forest	Area (million ha)		Amount of Biomass (/ha)	
	Past	Present	Past	Present
Kazari (north)	3,600	1,200	300	100
Arasbaran	500	60	140	30
Zagros (west)	12,000	1,500	125	8
Irano-Tourani	3,600	500	80	2

Source: *Iran Statistical Yearbook, March 1999.*

LAND CLASSIFICATION

Land Classes of the USBR (U.S. Bureau of Reclamation) System

Based on production economics six land classes are normally recognized. These include:

- Class 1: Arable lands that are highly suitable for irrigated farming.
- Class 2: Arable lands that have a moderate suitability for irrigated farming.
- Class 3: Arable lands that have a marginal suitability for irrigated farming.
- Class 4: Special use lands that is suited to certain special uses (e.g., rice, pasture or fruit) only.
- Class 5: Non-arable land that is temporarily considered as non-arable because of some specific deficiency such as excessive salinity, drainage, flooding, or other deficiency.
- Class 6: Non-arable land that is not being used under the existing conditions.

Land Suitability Classes

Though the framework at its origin permits complete freedom in determining the number of classes within each order. However, it has been recommended to use only three classes within order S and two classes within order N. The class is indicated by an Arabic number in sequence of decreasing suitability within the order; and therefore reflects degrees of suitability within orders.

- S_1: Suitable
- S_2: Moderately suitable
- S_3: Marginally suitable
- N_1: Actually unsuitable but potentially suitable
- N_2: Actually and potentially unsuitable.

NECESSITY FOR WATERSHED MANAGEMENT IN IRAN

Just taking a look at rangeland and farm products, increasing soil erosion, sedimentation in reservoirs of dams and emigration of the less-earning villagers to the big cities, is enough to indicate the strong need to initiate programs on integrated water and soil conservation. Soil erosion just by runoff, throughout the country, has been estimated at 1 billion mt per year in 1970 and 1.5 billion mt per year in 1980. At present the soil erosion rate is between 2.5 to 3 billion mt per year.

The erosion during the next two decades possibly will be 4.5 billion mt per year while in the European countries and the United States, soil erosion rate is less than 1 mt per ha, and in Africa, it is less than 7 mt per ha per year. But in Iran, the soil erosion rate is now approximately 15-20 mt per ha, which is a threat to the country's future. In addition to this, economic damage of more than US$120,000 results from soil erosion and floods every year. However, this damage is not so destructive as the socio-political damage of irregular emigration from villages to the cities. These processes threaten the country's economy and will result in Iran's dependence for food on other countries.

Goals and General Policy

The main goal of the Watershed Management Department is to apply integrated watershed management approach in all catchments in the country, in order to reduce water loss and soil erosion, and promote, as much as possible, rational use of land and natural resources. Basic methods to achieve these goals are as follows:

- Promoting public awareness about watershed management activities
- Executing the projects based on studies and designing
- Institutional capacity building, i.e., developing scientific and executive capacity of the implementing institution/organizations about watershed management plans in the country
- Ensuring participation of the residents of catchments in planning, deciding and executing of soil and water conservation activities.

General methods for continuing the above policies include:

- raising the awareness among the responsible agencies in the country about the importance of watershed management and priority in execution of integrated watershed management activities.
- promoting rational use of lands by farmers and others.
- training farmers/residents in sustainable farming.
- formulating and enforcing essential laws and regulations as executive guarantees for watershed management.
- developing integrated watershed management plans with participatory approach.
- organizing workshops/meetings/seminars for exchanging information on natural resources and agricultural systems.
- building skilled manpower in the country by organizing both in-country and outside trainings.
- conducting comprehensive studies and serious research to develop appropriate watershed management plans.

Potential Capacity of Watershed Management

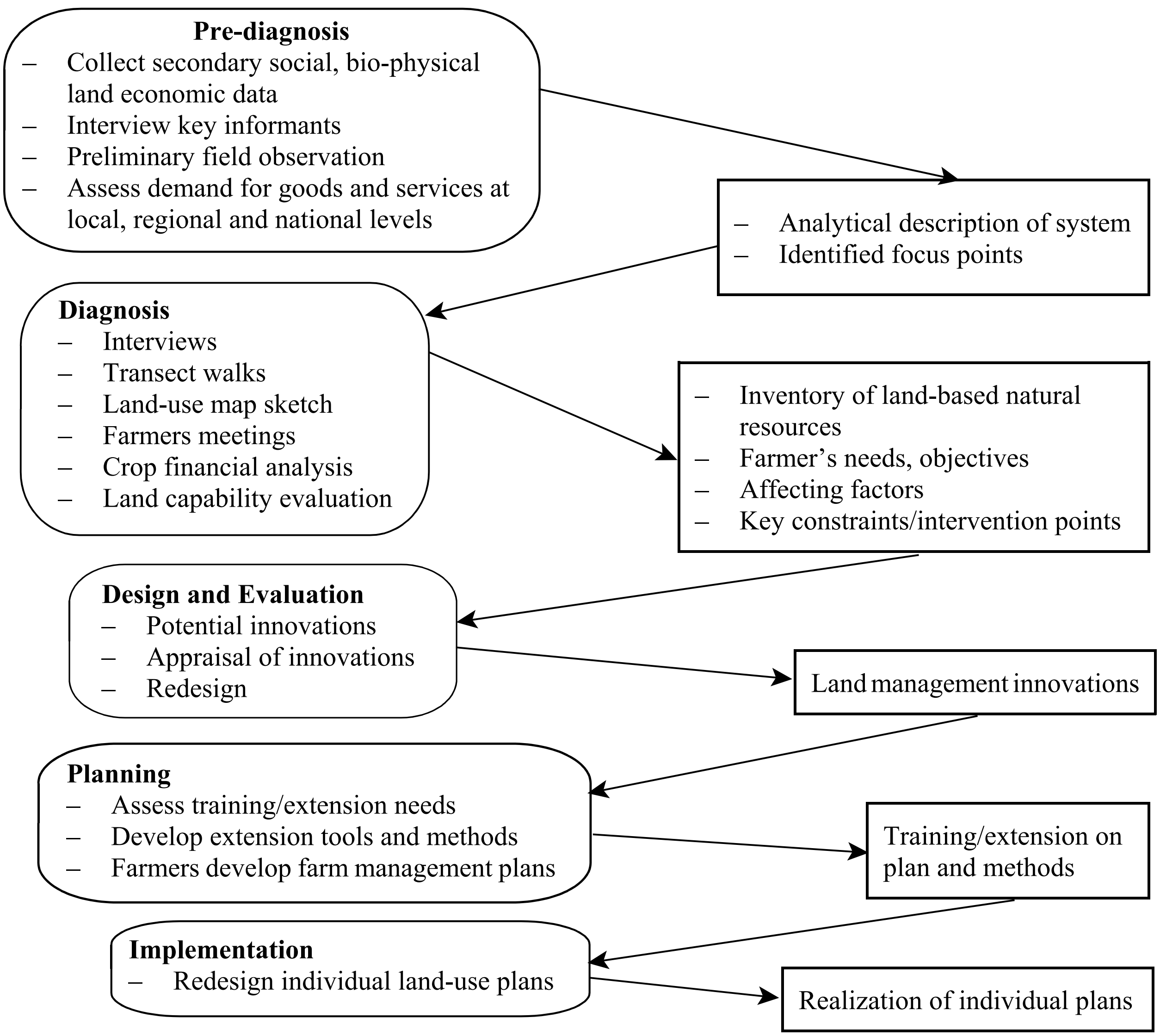
Statistical information on the potential capacity of watershed management in Iran is given in Table 3.

Table 3. Scope for Integrated Watershed Management in Iran

S.No.	Type of Area	Area (million ha)
1.	Whole area of watersheds in the country	105
2.	Area of watersheds suffering from increasing soil erosion	78
3.	Area of reservoir dam's catchments	30
	Area good for integrated watershed management programs	56
4.	Area of cultivable lands in reservoir dam's catchments that is potentially exposed to damage	8
5.	Cropland area of Iran under threat of damage	18
6.	Area of woodlands and rangelands that is exposed to erosion and damage	60
7.	Area of woodlands and rangelands in reservoir dams that is exposed to erosion and damage	13

INTEGRATED LAND-USE PLANNING IN UPLAND AREAS: THE FRAMEWORK BEING USED IN IRAN

Planning Process



Considerations

C Land use according to its capacity.
C Production needs must have a balance with environmental conservation needs.
C Promote efficiency and long-term stability of land use.
C Plans must be sensitive to local culture.
C The complex upland situation requires an integrated approach.
C Dialogue between farmers and extension workers is necessary for viable solutions.
C Soil and water conservation measures need time to be effective. Therefore, long-term solution must be linked to the solution of the farmer's immediate priorities.

A Case Study Revealing Use of the Framework

Location:	North of Iran
Name:	Sheikh Abad village
City:	Amol district
Distance to sea:	15 km
Distance to Tehran:	170 km
Precipitation of the area:	600 mm

<***Condition of Village***>

Land use:	Pasture
Product:	Fodder
Use of product:	Grazing by cattle
Quality of soil:	Poor
Cause of poor product:	Sandy land

Problems

– Increase in population
– Need to increase more production
– Need to earn more money
– Hard work
– Out-migration from village

Important

An interdisciplinary and participatory process helps avoid treating symptoms rather than actual causes.

Activities in Phase 1

– Discussion with old people
– Understanding about the basic problems in the village
– Participation of the residents in the project

Result 1

* Harvesting 22 ha suitable land

Activities in Phase 2

– Established a local community consisting of 60 persons
– Divided the group into two:
  Group A: Consisting of 40 people (30 years and older)
  Group B: Consisting of 20 persons (30 years and younger)
– Divided the land between the group:
  For group A each person got 4,000 m^2
  For group B each person got 3,000 m^2

Result 2

% Now each member has a land of his/her own

Activities in Phase 3

– Remove the unsuitable soil part of the land, e.g., sand
– Selling the sand
– Buying suitable agricultural soil for each part

– Spreading the soil in their lands
– Depth of spread soil is 10-20 cm
– Cultivating rice in each part.*

Result 3

& Total area is 22 ha
& Average product is 2.5 mt/ha
& Price of product is S$800/mt
& The total product is 55 mt
& The total price of product is US$44,000.
& Total funding was less than US$20,000.

<***Final Results of This Project***>

C Job opportunities for members
C Decrease in out-migration
C Longer life expectancy of members
C Increase in welfare

The most important difficulties in Iran especially in sloping upland areas include:

C division of land after many decades.
C growth of agricultural development in such areas is very low.
C lack of suitable roads in such areas.
C lack of suitable irrigation systems in sloping areas.
C limitation of government funds in the country.

* The rice is generally cultivated in the north of Iran.

7. REPUBLIC OF KOREA

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INTRODUCTION

Most Korean land is occupied by forest. Only 21 percent is cultivated land, which includes paddy and upland soils. Areas of paddy soils are larger than those of upland soils (Ministry of Agriculture and Forestry [MAF], 2001). Area of the uplands (740,000 ha) is just 7 percent of the total land of Korea, and about 62 percent of the uplands are located in the slopes higher than 7 percent (National Institute of Agricultural Science and Technology [NIAST], 1992). Due to this topographical distribution, most of the uplands are vulnerable to severe erosion. About 20 mt/ha of upland soils are estimated to erode every year in Korea (Yoo and Jung, 1999; Yang and Jung, 2000 and 2001; Jung, *et al*., 2001; and Jung, 2002). Soil erosion in the sloping uplands has deteriorated the soil productivity and water quality of the agricultural watersheds. The continuous and intensive cultivation of crops in these sloping uplands has caused severe soil erosion, and degraded soil quality, thus requiring more agrochemicals to maintain crop productivity. Therefore, a specific management strategy to conserve soil and water environment and maintain the sustainable productivity in the sloping upland is strongly required.

In Korea, the criteria for recommendation and classification of land use are suggested based on the soil survey data, such as properties of soils and factors limiting crop productivity. Recommended land use categories are upland, paddy, orchard, grassland, and forest. At each category land is classified into five suitability classes based on the above criteria. However, the guidelines on the site-specific management practices for sustainable production systems in the respective category are not specifically provided.

Until the mid-1980s, agriculture in Korea focused on increasing the crop productivity with using high levels of fertilizers and agrochemicals. However, this has caused a detrimental effect on soil and water quality. However, in 1997, Korean Government promulgated the Environmentally-sound Agriculture Promotion Law in order to implement sustainable production while minimizing the environmental deterioration. The major objective of this law is to produce safe food and conserve the environment by making proper use of chemical fertilizers and pesticides, adoption of integrated nutrient management (INM) and pest management (IPM), and recycling agricultural organic resources, etc. This goal can be achieved by the best management practices (BMP), which are site-specific. Many research efforts are being made recently by public and private sectors to develop the BMP for sustainable agriculture, especially in the sloping upland areas. It is expected that management strategy guidelines for sustainable land use will be suggested soon.

In this report, we will briefly discuss the status of upland agriculture, the land use classification system, the case study on the development of land classification and management practices, and the government policies and programs on the environmentally sound production system in the sloping uplands.

STATUS OF AGRICULTURE AND SLOPING UPLANDS IN KOREA

Selected Agricultural Indices

Table 1 summarizes the trend of agriculture in Korea in the last decade. With industrial and economic development, total GNP increased sharply, but the ratio of agricultural input to GNP decreased from 8.5 to 4.6 percent (MAF, 2001). The agricultural population decreased from 15.5 to 8.6 percent as of 2000 even though the total population is still increasing. Arable land is only about 21 percent of the total land and about

65 percent of the land is occupied by forest. Arable land is mostly upland and paddy soils, but both areas are decreasing due to the land being converted into industrial and public facilities, etc. Paddy areas are still larger than upland areas. Growth in income and assets of the farm households doubled in the last decade but the debts increased about four-fold mainly due to the increase in labor and production costs (MAF, 2001).

Table 1. Change in the Selected Agricultural Indices in Korea during the Last Decade

Parameter	Index	Unit	1990	1995	2000
GNP	Total	₩ billion	178,797	377,350	517,097
	Agricultural	₩ billion	15,212 (8.5)*	23,354 (6.2)	23,868 (4.6)
Population	Total	000	42,869	45,093	47,008
	Agricultural	000	6,661 (15.5)	4,851 (10.8)	4,031 (8.6)
Land area	Total	000 ha	9,926	9,927	9,946
	Agricultural	000 ha	2,109 (21.2)	1,985 (20.0)	1,889 (19.0)
Of which:	Paddy	000 ha	1,345	1,206	1,149
	Upland	000 ha	764	779	740
	Per farm household	ha	1.19	1.32	1.37
Farm household income		₩ thousand	11,206	21,803	23,072
Farm household asset		₩ thousand	79,352	158,171	159,957
Farm household debt		₩ thousand	4,734	9,163	20,207

Source: MAF, 2001.
Note: Numbers in parentheses indicate the percentage of the total.

Cultivated Area and Production of Crops

Table 2 compares the changes in cultivated areas and production of major upland crops in the last eight years. Area and production of vegetables and orchard crops showed an increasing trend but those of other upland crops are decreasing. The corresponding parameters for rice were slightly decreased.

Table 2. Changes in Cultivated Areas and Production of Major Upland Crops

Parameter		Area (ha)			Production (000 mt)		
		1992	1997	2000	1992	1997	2000
Food crops:	Rice	1,157	1,052	1,072	5,331	5,476	5,291
	Barley	103	70	68	315	292	163
	Pulses	135	122	107	212	189	134
	Potato	33	30	25	105	86	75
	Misc. crops	50	41	46	243	213	248
Sub-total		1,478	1,315	1,318	6,206	6,256	5,911
Vegetable crops		356	364	386	8,276	9,685	10,483
Oilseed and other cash crops		129	108	92	88	79	64
Orchard crops		147	176	173	2,090	2,300	2,429

Source: MAF, 2001.

Topography

Most of the upland soils are located in the sloping fans, valleys, mountain foot and hilly areas as shown in Tables 3 and 4 (NIAST, 1992). About 62 percent of the uplands are located at slopes greater than 7 percent. Table 5 shows that higher than 20 percent of upland uses are subject to soil erosion in the ranges from Class II (eroded) to Class III (severely eroded). A similar trend is revealed for the orchard and grassland uses. Thus, land use to produce the conventional food crops, vegetables, and potato, etc. in this topography requires labor-intensive management with higher input of agrochemicals and less dependence on agricultural machinery. This results in higher costs in agricultural production as well as higher risks of water pollution in the watershed due to erosion. Thus, a site-specific management practice for the sustainable production system is required in the sloping upland areas.

Table 3. Topographical Distribution of the Korean Soils

(Unit: ha)

Soil Type	Upland	Paddy	Orchard	Grassland	Forest
Sand dune	1,075	1,979	2	262	738
Plain	73,954	507,493	16,337	2,892	10,679
Alluvial fan	65,922	39,608	8,168	425	8,255
Valley	284,800	590,889	28,174	1,658	48,169
Diluvium terrace	18,658	51,028	2,323	176	18,855
Mountain foot	214,869	88,902	21,503	7,977	260,828
Rolling to hilly	145,326	2,148	27,839	12,588	1,504,558
Mountain	34,268	57	5,812	12,532	4,528,345
Volcanic ash	39,587	6,145	8,663	63,999	24,758
Others	42	0	190	337	20,042
Total	878,501	1,288,249	119,011	102,846	6,425,227

Source: NIAST, 1992.

Table 4. Distribution Areas of the Korean Soils Based on the Slopes

(Unit: ha)

Slope (percent)	Upland	Paddy	Orchard	Grassland	Forest
0-2	77,896	550,332	17,891	3,326	10,854
2-7	259,730	477,677	28,534	23,495	44,033
7-15	339,586	215,479	42,246	39,579	205,501
15-30	175,508	44,726	25,815	20,736	571,062
30-60	23,181	34	3,809	14,146	2,106,288
60-100	2,600	1	716	1,564	3,487,489
Total	878,501	1,288,249	119,011	102,846	6,425,227

Source: NIAST, 1992.

Table 5. Distribution of the Korean Soils Based on the Degree of Surface Soil Erosion

(Unit: ha)

Land Use	Erosion Classes				Total
	None to Slightly Eroded (I)	Eroded (II)	Severely Eroded (III)	Gullied (IV)	
Upland	700,327	171,228	6,798	148	878,501
Orchard	84,113	33,230	1,626	42	119,011
Grassland	84,672	17,313	746	115	102,846
Forest	853,639	5,305,349	227,484	38,755	6,425,227

Source: NIAST, 1991.

Soil Resources

1. ***Soil Taxonomy***

Up to 1985, the detailed soil surveys were completed on 65 percent of the total land area including all arable land and some mountainous areas. Based on soil taxonomy, 390 soil series are recognized in Korea. Because of a warm climate with moderately high rainfall in summer with an average of 1,275 mm, most of the Korean soils in the coastal plain, alluvium plain, terraces, hilly land and low mountains are relatively deep and well oxidized. Two-thirds of parent materials of Korean soils are mostly granites and granite gneisses. Due to these parent materials the Korean soils are generally acidic in nature and coarse-textured. This nature under the thermic temperature regime with high precipitation resulted in highly weathered and leached soils of acidic, low organic matter content and low cation exchange capacity (CEC).

Table 6 summarizes the areas of the major soil orders and suborders. The dominant soils in Korea are inceptisols and entisols. The alfisols, ultisols, histosols, mollisols and andisols are recognized, but are less predominant. Table 7 shows the distribution of soil orders for the major land classification categories. Inceptisols, entisols, alfisols, and ultisols are the major soil orders used for upland and paddy soils. Andisols developed on volcanic ash materials are mostly in Jeju and Ulreung Islands.

Table 6. Soil Orders and Suborders of Korean Soils

Orders	Extent (ha)	Suborders	Extent (ha)
Alfisols	313,683	Aqualfs	37,580
		Udalfs	276,103
Entisols	2,849,102	Psamments	657,124
		Aquents	46,896
		Fluvents	103,730
		Orthents	2,041,352
Inceptisols	5,810,441	Andepts	92,064
		Aquepts	786,848
		Ochrepts	4,060,307
		Umbrepts	871,222
Histosols	384	Saprists	46
		Hemists	338
Ultisols	309,677	Udults	309,677
Mollisols	5,866	Udolls	5,866
Andisols	110,009	Udnads, udivitrands	110,009
Others	503,082	Rock outcrop	503,082
Total	9,902,244		9,902,244

Source: NIAST, 1992 and 2000.

Table 7. Distribution of the Soil Orders at Each of Land Use Classification Category

(Unit: ha)

Soil Orders	Upland	Paddy	Orchard	Grassland
Inceptisol	531,949	1,077,950	69,578	62,198
Entisol	115,472	115,312	20,658	26,454
Alfisol	118,509	92,742	15,418	2,202
Ultisol	107,693	1,801	13,057	11,654
Histosol	0	384	0	0
Mollisol	4,861	60	110	1
Others	17	0	190	337
Total	878,501	1,288,249	119,011	102,846

Source: NIAST, 1992.

2. ***Soil Catena***

The complicated geographic nature, climate and vegetation have brought about wide ranges of soils. Hilly topography and heavy monsoon rain cause a considerable movement of fine particles from the land directly into the water body. As a result, soils on sloping areas are shallow and very coarse. The textures of the soils in the river basins are also coarse due to flooding.

Figures 1 and 2 are the typical patterns of the soil catena developed on the high mountainous sloping land in Pyeongchang county and on the hilly and plain land in the western coastal area, respectively. In the high mountains the soils are acid forest soils of haplumbrepts. The Odae soil series is a member of the coarse loamy mesic family of the humic lithic dystrudepts. These soils are shallow with very dark brown A horizons, and thin yellowish brown gravelly and stony sandy loam B horizons overlying hard bedrocks within 50 cm of the surface (NIAST, 2000). On the soil surface thin to moderately thin Odae layer is accumulated.

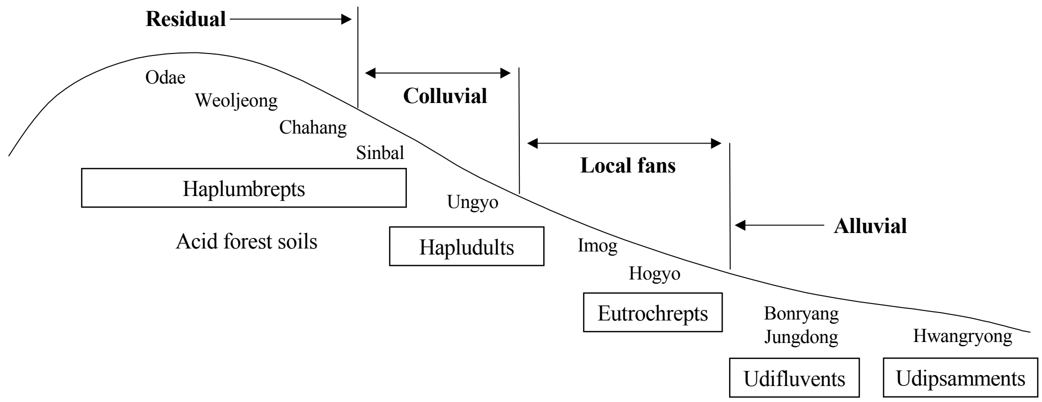


Figure 1. Typical Soil Catena of the Sloping Alpine Upland in Pyeongchang County, Kangwon Province

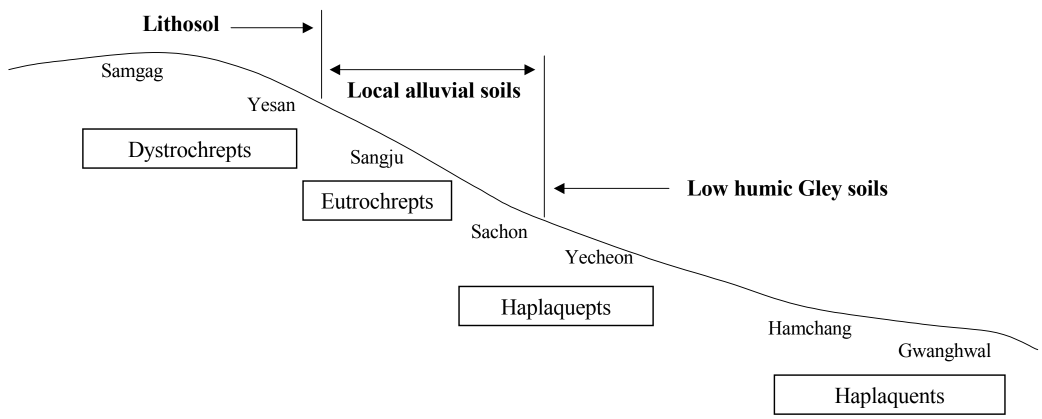


Figure 2. Typical Soil Catena of the Hilly and Plain Land in the Western Coastal Areas

Weoljeong, Chahang and Sinbul series are the humic dystrudepts of which organic matter contents in A horizon are 4-8 percent. In the hilly area of the western coastal region, the hilly soils are dystrochrepts with pale brown soil color. For example, the Samgag series is a member of the coarse loamy, mesic family of typic dystrudepts. These soils have pale brown loamy A horizon and moderately thick brown to yellowish brown sandy loam cambic B horizon. The organic matter content of A horizon is less than 1 percent. Soil organic matters in local alluvial fans or alluvial positions are less than 3 percent.

3. ***Chemical Characteristics of Upland Soils***

Table 8 shows the chemical properties of the upland soils, the suggested optimum ranges of the respective parameters for crop cultivation, and the comparative ratios between the two parameters. The ratios are classified into 'insufficient' when the analyzed soil properties are lower than the optimum ranges recommended by Rural Development Agency (RDA), 'optimum' when soil properties fit into the optimum ranges, and 'excess' when data exceed the recommendation.

In Korea, upland use is generally categorized into the general upland for food crop production, orchard, grassland, and plastic film house. The plastic film house is a recent development in farming systems in Korea. The land is covered with plastic film over an iron-constructed frame and in this way intensive cultivation of mostly vegetable crops is possible because of the higher ambient temperature of the constructed facilities than outside. This type of farming is taking place to a large extent in the suburban areas in order to supply vegetables to the cities. Usually, farmers can harvest vegetables three or four times a year continuously, thus, they rely on the high input of agrochemicals into their land.

Table 8. The Selected Chemical Properties of the Upland and Plastic Film House Soils

Land Use/Year		pH (1:5)	OM (g/kg)	Available P_2O_5 (mg/kg)	Exc. K ($cmol_c$/kg)	Exc. Ca ($cmol_c$/kg)	Ex.s Mg ($cmol_c$/kg)
Upland Soils							
1964-68		5.7	20	114	0.32	4.2	1.2
1976-80		5.9	20	195	0.47	5.0	1.9
1985-88		5.8	19	231	0.59	4.6	1.4
1997		5.6	24	577	0.80	4.5	1.4
Optimum ranges		6.0-6.5	20-30	300-500	0.5-0.6	5.0-6.0	1.5-2.0
Ratio (percent)*:	Insufficient	76.9	33.0	21.0	30.9	63.9	64.5
	Optimum	13.4	46.7	27.4	10.7	15.8	18.3
	Excess	9.7	20.3	51.6	58.4	20.3	17.2
Plastic Film House Soils							
1976-80		5.8	22	811	1.08	6.0	2.5
1980-89		5.8	26	945	1.01	6.4	2.3
1991-93		6.0	31	861	1.07	5.9	1.9
1998		6.0	35	1,092	1.27	6.0	2.5
Optimum ranges		6.0-6.5	20-30	350-500	0.7-0.8	5.0-6.0	1.5-2.5
Ratio (percent)*:	Insufficient	46.4	20.7	12.7	23.4	29.8	27.9
	Optimum	29.8	24.5	7.4	6.0	17.8	18.9
	Excess	26.8	54.8	79.9	70.6	52.4	53.2

Source: Park, 2001.

Note: Ratios were calculated based on the 1997 and 1998 data for upland soils and plastic film house soils, respectively, as compared to the optimum ranges for crop growth in the respective land use. Data shown in the Table are average data over at least several hundreds samples.

As shown in Table 8, upland soils are acidic and low in organic matter. Contents of the available phosphate are, however, increasing constantly with time and exceeding the optimum ranges. This might have been contributed to the retention of phosphate in the soils due to the continuous and over application of fertilizers.

Over the years, the chemical parameters of the plastic film house soils show a more drastic change than those of the upland soils and chemical parameters except pH are to a larger extent in 'excess' ranges. Accumulation of salts especially phosphate is of primary concern. Frequently reported are physical and chemical problems inherent from salt accumulation and management, such as drainage, water use, higher bulk density due to machinery operation, and high salinity, etc.

LAND CLASSIFICATION SYSTEMS IN KOREA

Land Use Classification and Recommendation

In Korea, the principle of land use classification is based on the soil survey data, which provide soil characteristics, soil maps, and views on the soil management, etc. Decisions on the effective land use classification depend not only on the physical and chemical properties of soil but also on other factors, such as farming technology of the landowner, capitals, and socio-economic conditions. However, the primary factor in deciding land use classification is the soil characteristics, the suitability of soils for the proposed classes and management strategies. Even though lands have similar conditions, yields can vary with management practices, thus including proper management practices are also critical in land classification. This corresponds to the goal of the soil survey.

Recommendation, adaptability, limitation, and interference for land use classification for each land category should be proved through the research trials, along with the soil survey data. The more research data, the better predictability for land use recommendation, but the research data are not always enough to solve the problems. In addition, the farmers experience of cultivation and management is a very valuable asset to be added to the land use classification.

Criteria for Upland Use: Recommendations

Decisions on land use and the corresponding crop's adaptability rely on soil characteristics and many other factors such as climate, socio-economic merit, capital, and farmer's capability. However, recommendations for land use cannot consider all of these important parameters. Thus, in Korea, physical and chemical characteristics, along with soil factors limiting and/or interfering crop growth in that land, are primarily considered as criteria for land use recommendation (NIAST, 1992). Whether the land use is upland or other, the suitability is evaluated based on the soil characteristics, and the upper and lower limits for the soil properties in respective land use are provided. This is intended to help farmers or the landowners decide the effective management practices based on the recommendations.

Table 9 shows the selected chemical and physical parameters, which can be used as bases for characterizing and classifying the soil characteristics and subsequently for suggesting land management in the soil survey. Each parameter is classified into several levels, which can be used for characterizing the status and suitability of land use.

Using the above soil characteristics, criteria for land use recommendation are suggested separately for upland, paddy, orchard, grassland, and forest areas. Table 10 shows the criteria for upland use recommendation in Korea and Table 11 reveals the difference between the current land use and the recommended land use based on the soil survey data. Except for paddy and forest uses, the recommended upland uses could be expanded from 1.4 to 22.2 percent as compared to the current land use. In some sense, this indicates that the criteria recommended for land use based on soil survey data are somewhat reasonable. About 27 percent of forests can be exploited as arable land or grassland.

Table 9. Selected Parameters and Classification Criteria Adopted in the Soil Survey for Characterizing Soil Properties and Land Management in Korea

Parameter	Classification Criteria or Description
Slope (percent)	A (level to nearly level: 0-2); B (gently sloping: 2-7); C (sloping: 7-15); D (moderately steep: 15-30); E (steep: 30-60); and F (very steep: 60-100)
Drainage	Very poorly drained; poorly drained; somewhat poorly drained; imperfectly drained; moderately well drained; well drained; somewhat excessively drained; and excessively drained
Soil reaction (pH)	Extremely acid (<4.5); very strongly acid (4.5-5.0); strongly acid (5.1-5.5); medium acid (5.6-6.0); slightly acid (6.1-6.5); neutral (6.6-7.3); mildly alkaline (7.4-7.8); moderately alkaline (7.9-8.4); strongly alkaline (8.5-9.0); and very strongly alkaline (>9.0)
Erosion class	Slightly eroded (Class I); eroded (Class II); severely eroded (Class III); and gully (Class IV)
Permeability (cm/hour)	Very slow (<0.1); slow (0.1-0.5); moderately slow (0.5-2.0); moderate (2.0-6.0); moderately rapid (6.0-12.0); rapid (12.0-25.0); and very rapid (>25.0)
Runoff	Ponded; very slow; slow; medium; rapid; and very rapid
Soil depth (cm)	Very shallow (0-20); shallow (20-50); moderately deep or shallow (50-100); deep (100-150); and very deep (>150)
Organic matter (percent)	Low (<1.0); moderately low (1.0-2.0); medium (2.0-3.0); moderately high (3.0-5.0); and high (>20)
CEC (cmol/kg)	Low (<5); moderately low (5-10); medium (10-15); moderately high (15-20); and high (>20)
Management problem	Salts; flood hazard; high water table; drought; permeability; soil structure; and slope
Fertility status	Low; moderately low; moderate; moderately high; and high
Land use	P (irrigated rice); C (cultivated upland crops); O (orchard and mulberry); G (grassland); F (forest); U (urban); and X (not suitable for agriculture)

Source: NIAST, 1992.

Table 10. Criteria for the Upland Use Recommendation

Characteristic	Classification Criteria or Description
Topography	Flat land, terrace, local valley, hill, and mountain foot slope with slopes less than 15 percent.
Soil drainage	"Moderately well drained" to "well drained" ranges. However, lands in plains can include "somewhat excessively drained" or "excessively drained" soils.
Soil texture	"Clay loam", "sand loam", "silty sand loam", "silt loam" ranges. But "well drained" clayey soil and "moderately well drained" sandy soils can be included.
Soil depth	>50 cm when rocky fragments or hardpans exit; however, in case stone or sandy layers exist, depth should be higher than 25 cm.
Rock fragments in surface soil	No or less of rocky fragments on surface soil or in soil profile.
Erosion status	Slightly eroded (Class I) or eroded (Class II); however, lands should not expose to severe erosion.

Source: NIAST, 1992.

Table 11. Difference between the Current Land Use and the Recommended Land Use

Land Use	Current Land Use Status		Recommended Land Use		Difference	
	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)
Upland	878,501	9.2	1,017,358	10.6	138,857	1.4
Paddy	1,288,249	13.4	1,257,352	13.1	-30,897	-0.3
Orchard	119,011	1.2	444,700	4.6	325,689	3.4
Grassland	102,846	1.1	2,226,826	23.3	2,123,977	22.2
Forest	6,425,227	67.1	3,867,598	40.4	-2,557,629	-26.7
Others	763,533	8.0	763,533	8.0	-	-
Total	9,577,367	100.0	9,577,367	100.0	-	-

Source: NIAST, 1992.

Suitability Class of Land Use Classification

The suitability class of land use describes the degree of the potential production and the limitation of crop production when the landowner uses his land for a certain land use category. However, the landowner should make the final decisions on land use and crop selection. Thus, even in the same type of soils, land use pattern and cultivating crops can be different from landowner to landowner. Therefore, it is necessary to define concisely, the suitability class of land use and the degree of difficulty in land management in each land category.

The suitability class is the classification of land use based on the inherent soil characteristics, topography and many other environmental factors limiting land uses, in which data are provided from the scientific soil survey. Characterizing the degree and extent of limitation to crop production by environmental factors can on the other hand suggest the management strategy of land and crop selection criteria.

In general, nearly every country adopts the suitability class for land use classification based on criteria derived from the soil conditions and environmental factors. Soil Conservation Services (SCS) of the United States Department of Agriculture (USDA) groups the lands as I-VIII categories, rather than adopting the suitability class: Lands I-IV categories are possible for crop cultivation, and lands V-VIII categories are not recommended as arable lands, but as grassland, forest, and recreation area, etc.

In Korea, the suitability class of land uses is divided into five Classes (I-V) for each of the land classification categories (upland, paddy, orchard and mulberry, grassland and forest), based on the adaptability of soil conditions, superiority or inferiority of crop productivity, and degree of difficulty in land management. Classes I-IV can be applied to the respective land category, but Class V is the inappropriate soil for land use at each category.

Crop productivity is highest in Class I land and lowest in Class IV (Table 12). However, the practical productivity is not proportional to the suitability classes. In a certain case, for example, productivity in Class II is higher than that in Class I. Simply, Class I is easier than Class II in soil management both practically and economically in order to achieve the yield goals. In suitability Classes II-IV, since soil of each class contains limiting factors in land use and management. These limiting factors are listed in the suitability class. It is possible that certain soils have more than two limiting factors in each class, but only the most influential factor is listed. An explanation for each suitability class is summarized as follows:

* ***Class I***: High soil productivity; possible for the intensive cultivation; no limitation in soil management
* ***Class II***: Moderate soil productivity; possible for intensive cultivation but some limitation is expected in soil management
* ***Class III***: Low soil productivity; severe limitations in soil management and crop cultivation
* ***Class IV***: Very low soil productivity; very severe limitations in soil management and crop cultivation, thus this class is not economically viable for crop production
* ***Class V***: Below the Classes I-IV.

Table 12. The Recommended Criteria for the Suitability Class for Upland Use in Korea Based on the Soil Conditions

Parameter		Classes for the Degree of Suitability as Upland Use			
		I	II	III	IV
Definition and Requirements	Productivity	High	Medium	Low	Very low
	Management options for cultivation	Easy for IC and no limit for CS and SM[a]	Possible for IC but slight limit for CS and SM	Special techniques are needed for soil and crop management due to severe limitation as upland use	Same as Class III but an economic net return might be impossible
Selected Soil Conditions as Limiting Factor	Drainage	Well and moderately well drained	Same as Class I plus imperfectly drained	Same as Class II plus excessively drained	Same as Class III plus poorly drained
	Texture[b]	CL; SiL; SL; SiSL	C; CL; SiCL; SL; SiSL	C; CL; SiL; SL; SiSL; S	C; CL; SiL; SL; SiSL; S
	Effective soil depth (cm)	>100	50-100	20-50	20-50
	Slopes (percent)	<2	2-7	7-15	15-30
	Erosion class	None to slightly eroded (Class I)	Eroded (Class II)	Eroded to severely eroded (Class III)	Severely eroded
	Layer of sand or stoniness	>50	25-50	10-25	10-25
	Rock fragments	None	None	Gravel	Stone

Source: NIAST, 1992.
Notes: [a] IC, CS and SM: Intensive cropping, crop selection and soil management, respectively;
[b] CL, SiL, SL, SiSL, C and S: clay loam, silt loam, sand loam, silty sand loam, clay and sand, respectively.

Limiting factors commonly used in defining the suitability Class II-IV are as follows: slope, water-logged condition, stoniness, sandiness, heavy clayey soil, salt, acid sulfate soil due to presence of sulfate salts within 100 cm of soil profile, immature soil, hardpan, rocky fragments, and erosion, etc. Table 12 summarizes the recommended criteria for the suitability class for upland use in Korea based on the soil conditions (NIAST, 1992).

Table 13 shows the distribution areas of each suitability class for land use classification category. The majority of the uplands and others are in Classes II-IV, indicating the existence of many limiting factors in soils for crop productivity.

Table 13. Distribution Areas of the Korean Soils based on the Land Use Suitability

(Unit: ha)

Land Use	Areas of Suitability Classes for Land Use					Total
	Class I	Class II	Class III	Class IV	Class V	
Upland	45,073	238,983	321,887	206,080	66,478	878,501
Paddy	183,037	368,391	487,938	217,201	31,682	1,288,249
Orchard	23,869	39,561	28,482	21,449	5,650	119,011
Grassland	5,532	17,460	28,713	33,620	17,521	102,846
Forest	123,759	576,149	1,614,680	2,539,942	1,560,697	6,415,227

Government Policies and Programs for Sustainable Agriculture Development

In Korea, the MAF is responsible for formulating policies and programs on sustainable agriculture and rural development. To achieve the goals of sustainable agriculture, many policies, plans and strategies have been proposed. However, few specific policies or strategies are made on sustainable development in the sloping uplands in the context of land classification. Here, a brief summary of the government report on the policies and programs for sustainable development in agriculture is provided. This was added to the 5th and 8th Sessions of the United Nations Commission on Sustainable Development (1999) as part of the fulfillment for Agenda 21.

Until 1990, agricultural policy focused on increasing crop production through development of high-yielding varieties and the application of high amounts of fertilizers and pesticides. As a result, such new problems as increasing instances of plant diseases and environmental contamination emerged.

In July 1996, the MAF established its "Environmental Policy in Agriculture, Forestry and Fisheries for the 21st Century". The main emphasis of the policy is placed on reducing pollution and other environmentally harmful effects of agriculture, conserving and improving the agro-environment, and encouraging environment-friendly farming systems such as organic farming and low input sustainable agriculture. Specific targets have been set to develop technologies for reducing pesticide use and chemical fertilizer use by 2004.

The MAF established a law of sustainable agriculture promotion in 1998. In order to use farmland for purposes other than agricultural production or farmland improvement, one must receive permission from the Minister of Agriculture and Forestry, and permission must be granted after considering the value of farmland conservation and effects on other farmland. In agricultural promotion zones, government restricts the construction of any facilities except those for processing agricultural and marine products, agricultural research and testing institutions, community facilities, farmers' houses, agricultural and livestock raising facilities, military facilities, rivers, dikes, roads, and railroads.

Major policy instruments and activities to promote sustainable agriculture management in Korea include the following:

* Promotion of model projects for environment-friendly agriculture by adjusting integrated plant nutrient management
* Promotion of environment-friendly agriculture projects
* Selection of environment-friendly agriculture promotion areas; 28 such places were selected by the year 2001.
* Construction of 16 environment-friendly agricultural model villages nationwide
* Promotion of environmental agriculture that requires the application of fertilizers on the basis of soil tests

* Provision of subsidies on drinking water preservation, nature protection, and tourist agriculture
* Compensation for decreases in farmers' income due to the application of chemical and organic fertilizers on the basis of soil tests.

To prevent the wastage of resources and energy, deterioration of the quality of agricultural products, and environmental contamination a new fertilization system that determines fertilizer application rates based on soil testing was established in 1992. The system determined the following: 1) to readjust fertilizer application rates for 73 crops to lower levels to preserve the environment; 2) to establish fertilizer systems for each crop through soil testing; and 3) to study fertilizer application management with bulk blending fertilizers through soil testing.

The Korean Government has adopted methods of maintaining and improving the basic agricultural environment, such as soil and water, emphasized measures to maximize the positive effects of agriculture on the environment and to develop agriculture as a pollution-filtering industry, and has restricted the diversion of agricultural land to other purposes. Major policies to accomplish agricultural sustainability include the following: 1) promoting proper use of chemical fertilizers and pesticides, in accordance with soil characteristics and pest intensity; 2) supporting farmers in fostering environment-friendly farming, such as organic farming and low input sustainable agriculture (LISA); 3) improving the productivity of sustainable agriculture through new environment-friendly technologies; 4) supporting the recycling of agricultural byproducts like straw, livestock wastes, etc., and return them to agricultural fields for use as organic fertilizers; and 5) expanding direct payment policies for environment-friendly agriculture.

The government has many programs to train farmers in IPM and to assist environment-friendly agricultural groups in training farmers who are willing to learn organic farming and LISA techniques. Soil conditioners are distributed periodically to the farmers to improve soil conditions. Loans and subsidies are given to entitled farmers for certain projects, which are designed to develop sustainable agriculture.

The government usually adopts education and mass media measures to inform the public, especially farmers of sustainable agriculture. It focuses on why environment-friendly farming is important and necessary, and how it is done. Consumers' role in developing sustainable agriculture is not neglected either. Recently, the government developed a new project through which farmers, consumers, and policy makers cooperate and support each other for sustainable agricultural development.

With a view to achieving multiple objectives, such as increasing forage production, preventing soil erosion, improving soil fertility, preserving landscape features, and capitalizing on eco-tourism resources, the government, in close cooperation with farmer's organizations, is conducting a nationwide campaign to foster the cultivation of winter feed crops and green manure crops, including Chinese milk-vetch, rye, and Italian ryegrass. It is called the "Green Field Movement". For the optimal use of plant nutrients, county governments do precise soil tests. Farmers use fertilizers in accordance with the soil test results, whether they are organic or inorganic. The IPM training program and education programs for the safe use of pesticides by farmers are supported, too. The Korean Government initiated direct subsidies for environment-friendly farming beginning in 1999. Direct subsidies are granted to those farmers in environment protection areas who are willing to exercise environment-friendly farming practices. To maintain and improve soil productivity, soil conditioners like lime and silicate fertilizers are distributed to the nutrition deficient areas, and loans are granted to farmers in order to reclaim soil.

The government initiated to construct the soil environment information system from 1998, by employing the GIS (Geographical Information System) tool. The detailed soil survey database was created for each lot. This computerized information system can provide users with soil characteristics, soil taxonomy, topography, the current land use, the recommended land use classification and suitability class, soil management strategies, and the suitable cropping system, etc. Parts of this project are finished and available for users. This project will be finished within few years, and users can access this at URL http://soils.niast.go.kr/gishome/theme/, http://soils.niast.go.kr/gishome/land/, http://soils.niast.go.kr/gishome/chart/, and http://soils.niast.go.kr/gishome/search/(Korean).

A research system was established to develop sustainable technologies and to monitor the status of the agricultural environment in terms of soil quality, water quality, and the quality of agricultural products. The government has been modeling INM and studying nutrient balancing in crop cultivation since 1998. The relationship between the farming area, the kind of crop and fertilizer, and the amount of chemical and organic fertilizers applied were investigated. The amounts of nutrient input, plant uptake, residues in soil, volatilization, etc. were also studied.

SUSTAINABLE PRODUCTION SYSTEMS IN THE ALPINE SLOPING UPLANDS: CASE STUDIES

Adoption of the sustainable production systems and natural resource conservation in the sloping uplands is critically needed to meet the goals for productivity enhancement and environmental conservation in Korea. Numerous research and administrative efforts have been made on this aspect, but the specific research on the use of land classification as a tool for sustainable agriculture is very scarce. This is because land uses are classified into the pertinent category and suitability classes in each category are provided based on soil properties and limiting factors for production. Also, current land uses somewhat coincide with the land classification recommendation as shown in Table 11. Rather, authors have conducted a series of research experiments on the BMP in the sloping uplands in line with sustainable agriculture. Some of the results from case studies are presented below:

Alpine Agriculture in Kangwon Province

Lands located at elevation higher than 600 m and 400-600 m are defined as 'alpine' (highland or mountainous) and 'semi-alpine', respectively in Korea. Climate in the alpine lands is cool in summer, cold in winter and high in precipitation. Due to the advantage of cool temperature during summer, potato and vegetables such as Chinese cabbage and radish are mostly cultivated as cash crops in the alpine regions. Farmers make a high level of profits from alpine agriculture, thus area and production of vegetables are constantly increasing. In the alpine regions, many lands are reclaimed from the forest. About 20 percent of the total arable lands are located at elevation higher than 200 m (NIAST, 1992). In Kangwon province, northeastern part of the Rep. of Korea, the alpine land area is 16,301 ha and this is equivalent to 98 percent of the total alpine lands in Korea (Jung, *et al*., 2001 and 2002). Higher than 70 percent of the alpine lands have slopes greater than 7 percent (NIAST, 1992). Due to the topography and site-specificity of the alpine lands, many managerial and environmental problems occur, which include severe erosion, low productivity, intensive land use with high inputs of agrochemicals, shallow surface soils exposed with rocky fragments, difficulty in tillage, and loadings of non-point source (NPS) contaminants into the watershed, etc. Development of management strategies towards the sustainable production systems in the alpine sloping land are, therefore, urgently needed.

Land Classification in the Alpine Sloping Lands: Pyeongchang-gun Case

Most of the lands in Pyeongchang-gun, Kangwon province, are located at an elevation higher than 600 m, representing the typical alpine agricultural areas. There exist 25 soil series according to the soil taxonomy. Based on the criteria shown in Tables 9, 10 and 12, land use recommendation and the suitability class for the upland area of Pyeongchang-gun are summarized in Table 14, along with limiting factors for crop production.

Most of the sloping uplands are classified as Classes III-V, indicating there are severe limitations in crop productivity in upland areas (Table 14). The major limiting factors are slope, rock fragments, sand, and heavy clay, of which slope and rock fragments are the most important factors. Only two soil series out of 25 are classified as Suitability Class I. Most of the lands are located at slopes greater than 7 percent. This topography is subject to severe soil erosion, which results in high extent of rock fragment exposures on the surface soil, resulting in a lower holding capacity for water and nutrients. The typical soil catena in this county is shown in Figure 1.

Land Classification and Soil Erosion

Using the Universal Soil Loss Equation (USLE) and the information in the detailed soil map, Jung, *et al*. (2002) estimated the amount of soil loss at each category of the total land classification in Korea. They intended to construct a soil erosion map for each city and county and proposed the degree of erosion based on the amounts of soil eroded. The rainfall (R) factor in USLE was obtained from the iso-erodent map, soil erosion (K) and slope and slope length (K and S-L) factors from the detailed soil map, and cropping (C) and soil management (P) factors from the field trial research data collected over the last 30 years in Korea.

All of the factors in USLE were data-based and soil erosion maps for several counties were constructed. Table 15 shows the amount of soil erosion at the selected provinces based on the proposed classification criteria for the erosive degrees.

Table 14. Distribution of Soil Series at Each Category of Land Classification in Pyeongchang-gun

Land Use	Suitability Classes					
	Class I	Limiting Factors	Class II	Class III	Class IV	Class V
Upland	Anmi; Jungdong	Slopes	Anmi (B)*; Imog (B)	Gaghwa (C); Bancheon (C); Anmi (C, D); Ungyo (C); Imog (C); Chahang (C); Pyeongan (C)	Gaghwa (D); Maji (C); Mui (C); Mitan (C); Bancheon (D); Songjeong (D, E); Sinbul (C); Ungyo (D); Chahang (D); Pyeongan (D); Hogye (C)	Gaghwa (E, E); Gwanag (E, F); Mui (D, F); Mitan (D, E); Sinbul (D, E); Odae (D, E, F); Oesan (E, F); Ungyo (D, E); Weoljeong (E, F); Imog (C); Jangseong (E, F); Chahang (C, D, E); Cheongsim (E, F); Pyeongan (D, E); Pyeongchang (D, E); Hogye (C); Hwangryong; Rocky land; River land
		Rock fragments		Maji; Hogye (B)	Maji (B)	
		Sand	Bonryang			
		Heavy clay	Bancheon (B); Wangsan (B)			

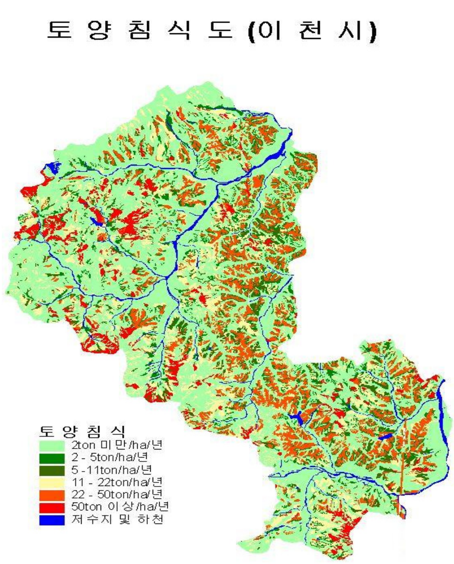
Source: NIAST, 1993 and 2000; and Jung, *et al*., 2001 and 2002.
Note: * Letters from B to F in parenthesis indicate the degree of slopes, as specified in Table 9.

Table 15. Soil Erosion at Selected Provinces Based on Proposed Classification

Classification	Amount of Soil Erosion (mt/ha/year)					
	<2	2-5	5-11	11-12	22-50	>50
Current criteria by NIAST (1992)	Slightly eroded (Class I)		Eroded (Class II)	Severely eroded (Class III)		Gully (Class V)
Proposed Criteria by Jung, *et al*. (2002)	Very low	Low	Moderate	Slightly severe	Severe	Very severe
OECD Criteria	Tolerable and low			Moderate	High and severe	
Upland areas in selected provinces (km^2)						
Kangwon	285.6	152.2	168.0	136.9	146.4	99.4
Kyunggi	268.5	207.1	216.5	234.1	115.0	47.6
Chungbuk	189.9	149.1	143.3	134.3	91.6	77.0
Chungnam	50.2	191.0	221.2	198.6	134.1	79.0
Chonnam	105.3	195.9	244.7	308.3	345.3	239.7
Chonbuk	126.0	122.6	158.0	140.1	98.2	119.0
Kyungbuk	428.7	239.0	215.4	202.3	271.7	86.2
Kyungnam	94.0	93.1	108.1	129.2	182.0	238.0
Cheju	10.4	56.8	169.8	86.7	51.2	23.7
Seoul	9.2	8.9	4.2	4.4	0.5	1.1
Total	1,567.8	1,415.7	1,649.2	1,574.9	1,436.0	1,010.7

Source: Jung, *et al*., 2002.

Figure 3 shows the examples of the soil erosion maps for Icheon city, Kyunggi province (left) and Jincheon-gun, Chungbuk province (right). These maps provide the basis for sustainable production systems in the sloping lands subjected to erosion and will help farmers select the proper land use, cropping system, and management practices in the specific region.



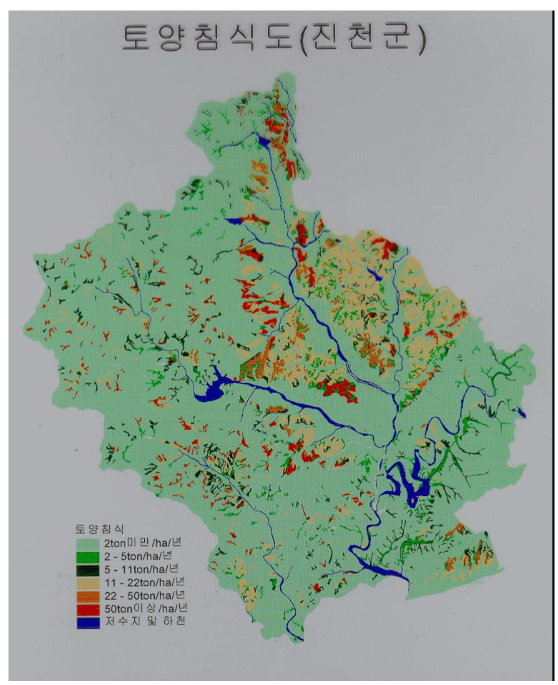


Figure 3. Soil Erosion Maps in Ichon City (left) and Jincheon-gun (right)

Source: Jung, *et al*., 2002.

Land Classification and Fertilizer Management

In the sloping alpine uplands, land is more susceptible to erosion resulting in a lot of rock fragment exposure on the surface soils. The sloping alpine uplands can be classified as Suitability Classes III-IV based on the contents of rock fragments. Fertilizer recommendations in all counties are made on the basis of surface soil per unit area. If the rock fragments in soil are more and the amount of soil is less, the amount of fertilizer applied should be less. However, farmers in the sloping alpine regions apply the mixed fertilizers more than the recommended (NIAST, 1999; and Jung, *et al.*, 2001), based on their experience rather than soil testing. Soil testing considers even only soil particles passing through 2 mm sieve, but not rock fragments.

Jung (2002) conducted pot experiments by making the artificial gravel contents of soils from 0 to 70 percent. Chinese cabbages were grown in the pot, and nitrogen fertilizers were applied with 60, 120, and 240 kg/ha rates. The N recommended rate for Chinese cabbage in the sloping alpine upland is 240 kg/ha. The bottom of the pot hole was connected to bottles to collect the leachate. Table 16 shows the soil characteristics after experiments, and chemical composition of leachates analyzed right after the collection. pH, NH_4-N and NO_3-N of the control experimental soil were 6.5, 28.0 and 16.8 mg/kg, respectively.

The pH of the soils was slightly decreased with increasing N fertilizer rates, irrespective of gravel contents. At each N rate, the pH of the soil was slightly increased also with increasing gravel contents. Electrical conductivity (EC) of soils was increased with both N rates and gravel contents. Changes of soil NO_3-N were greater than those of NH_4-N with N fertilizers and gravel contents. Contents of NO_3-N were sharply increased with increasing N rates, but those at each N rate were increased with increasing gravel contents. The leaf length (cm) of cabbage measured after 60 days was decreased with N rates at each of the gravel contents. The yield of cabbages as fresh weight was significantly decreased with increasing gravel contents (data not shown). At high levels of N and gravel, cabbages wilted due to the excessive N in the soils.

The pH of leachate did not change significantly with N rates and gravel contents. However, EC increased with N rates and was at least one thousand times higher than values reported in the freshwater. Gravel contents seemed to increase the EC of the leachates. Contents of NH_4-N in leachates were sharply increased with gravel contents and N rates, and those of NO_3-N showed a similar trend, but with lower extents. Amounts of N leached from the pot proportionally increased as increasing gravel contents and N rates. When the sloping alpine lands are eroded and have enough gravel contents on the surface, so-called classified as the Suitability Classes III-IV in land classification, soils are over-fertilized with N even at the recommendation rate. With this, soil qualities can be degraded and N loss to either groundwater or surface water can cause environmental problems such as eutrophication. The results clearly demonstrate that fertilizer management in the sloping land should be different from that in flat land and the characteristics of land classification need to be considered.

Best Management Practices in the Sloping Alpine Uplands

Soil survey data can provide the basis for land use recommendation and classification, and give a perspective on soil management methods. Even though farmers follow the guidelines on land classification, management and crop selection, yield prediction in the field is erratic in many cases. Thus, the site-specific management strategies should be developed *in situ.* The BMP is the best tool for accomplishing the goals of the sustainable agriculture especially in the sloping uplands. BMP is a practice or combination of practices that is determined by a state (or designated area-wide planning agency), after problem assessment, examination of alternative practices and appropriate public participation, and is the most effective practical (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by NPS to a level compatible with water quality goals (Bailey and Waddell, 1979). Thus BMP should be agronomically and environmentally effective, economically feasible, socially acceptable and technically implementable in any type of field. Also BMP is site-specific.

Our research group conducted various field studies to develop the BMP in the sloping alpine uplands and agricultural watersheds in the last several years (Jung, *et al.*, 1997, 1998, 2001, and 2002; Choi, *et al.*, 1998 and 2000; Yang and Jung, 2000 and 2001; and Choi and Yang, 2002). Field trial plots were installed in the sloping uplands as shown in Figure 4. Each plot was located at slopes greater than 7 percent and was separated from the neighboring one by dividers to prevent the water intervention between the plots. At the lower end, flumes, gutters, water level gauze, and water tanks were set to collect effluents and sediments.

Table 16. Effects of Gravel Content and N Fertilizers on Soil and Leachate Qualities

	Gravel (%)	Nitrogen Fertilizer Rate (kg/ha)																	
		60	120	240	60	120	240	60	120	240	60	120	240	60	120	240	60	120	240
		pH			EC (dS/m)			NH_4-N (mmol/kg)			NO_3-N (mmol/kg)			Leaf Length (cm)			N Leach (g/pot)		
Soil property	0	7.5	7.2	6.8	0.06	0.14	0.34	10.0	5.6	5.6	4.4	7.5	18.8	33	30	31			
	10	7.5	7.2	7.1	0.05	0.15	0.35	6.9	6.3	6.3	3.1	13.1	30.0	32	30	30			
	30	7.7	7.4	7.4	0.10	0.18	0.37	7.5	6.3	6.9	6.9	15.6	35.6	33	32	31			
	50	7.6	7.5	7.3	0.12	0.16	0.36	6.3	5.0	6.3	9.4	11.9	33.1	30	33	30			
	70	7.7	7.5	7.4	0.09	0.23	0.24	8.1	6.9	6.9	4.4	10.0	28.8	31	32	27			
Leachate property	0	7.5	7.7	7.6	13.5	17.1	25.0	15.4	18.2	74.2	32.2	32.2	37.8				0.05	0.07	0.17
	10	7.6	7.8	7.8	16.9	18.7	19.4	11.2	28.0	144.0	37.8	23.8	39.2				0.08	0.06	0.26
	30	7.8	7.6	7.6	12.7	20.5	20.2	15.4	88.2	139.0	21.0	35.0	42.0				0.08	0.23	0.44
	50	7.6	7.6	7.6	12.0	16.3	17.8	46.2	138.0	183.0	35.0	23.8	18.2				0.25	0.49	0.59
	70	7.7	7.7	7.4	12.1	11.2	16.0	92.4	277.0	338.0	29.4	51.8	28.0				0.41	1.08	1.53

Source: Jung, 2002.

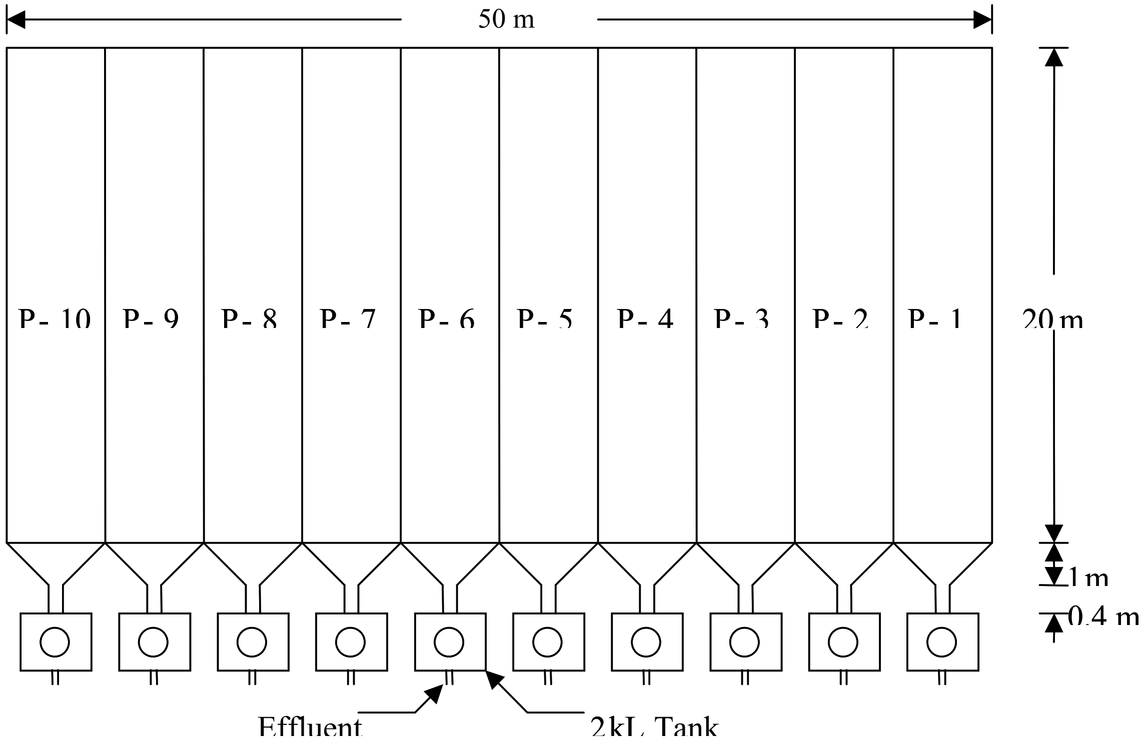


Figure 4. Schematic of Field Plot Experiment to Develop the BMP
in the Sloping Alpine Uplands

Each plot received different combinations of treatments as can be seen below:

- ***Land Use***: upland, paddy, bare soil, grassland, and forest
- ***Tillage Methods***: no-till, up-down, contour, and slant
- ***Crops***: potato, corn, and grapes
- ***Conservation Management***: grass way, mulching with minimum straw, vinyl, and mini gravel bags, bare fallow, and top-dressing
- ***Fertilizer***: chemical and organic fertilizers
- ***Winter Cover Crop***: no-cover and rye.

The amount of soil erosion, crop yields, soil properties, runoff and loading of NPS pollutants such as N and P into the watershed were assessed, and the management practices in the sloping alpine upland toward the sustainable production systems were drawn by integrating various results. The major results on management, vegetative, and structural options obtained from these studies and others are integrated as in Tables 17 and 18.

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Table 17. Land Use Classification and Management Options in the Sloping Uplands for the Sustainable Production Systems

<table>
<tr><td rowspan="2"></td><td colspan="4">Slope (percent)</td></tr>
<tr><td>2-7</td><td>7-15</td><td>15-30</td><td>30-60</td></tr>
<tr><td rowspan="3">Land Use</td><td colspan="2">General upland crop or vegetables</td><td></td><td rowspan="2"></td></tr>
<tr><td colspan="3">Orchard, mulberry, or intensive sowing grassland</td></tr>
<tr><td></td><td colspan="3">Surface sowing grasslands or fruit cropping trees</td></tr>
<tr><td rowspan="3">Land Conservation Management</td><td rowspan="2">Crop cultivation with contour and diversion ditch</td><td>Installment of diversion ditch (40×40 cm) at every 15-20 m</td><td>Installment of diversion ditch (50×50 cm) at every 10-15 m</td><td rowspan="2">Reclamation and cultivation with terrace methods</td></tr>
<tr><td colspan="2">Installment of back slopes and diversion ditch; grass covering on slopes</td></tr>
<tr><td colspan="4">Mulching with grass or others (e.g., vinyl) after seeding and transplanting: fresh grass (6,000 kg/ha), rice or barley straw (3,000-4,000 kg/ha)</td></tr>
</table>

Note: Interval of diversion ditch (m) = {surface area of diversion ditch (cm^2)} *5/{maximum annual average precipitation (mm)}.

Table 18. Proposed Best Management Practices to Reduce Soil Erosion and Conserve Water Quality in the Sloping Alpine Uplands

Best Management	Implementation	Conservation Effects
Buffer strips along edge of fields and streams	Cover with weeping love grass, etc.	Reduces flow velocity, runoff and sediment loss
Contour farming	Contour strip cropping	Decreases runoff velocity and transport capacity; reduce rill erosion
Mulching farming	Mulching with vinyl, straw, mini gravel bags, and weeds, etc.	Decreases raindrop impact; decrease runoff and increase surface storage
Diversion drains	Diversion ditch at upland and forest border using rock and pipes	Reduces runoff velocity and capacity; reduce rill and gully erosion
Detention weir or pond	Small-scaled detention ponds in the waterway	Captures sediment, suspended solid, and adsorbed pollutants
Grassed waterway	Natural vegetation in the waterway	Decreases runoff velocity and gully erosion
Drainage	Subsurface drainage with rocks and pipes, etc.	Decreases rill and gully erosion
Cover crop	Winter cover crops using rye and hairy vetch, etc.	Minimizes the periods of bare soil, decrease raindrop impact and rill erosion, improve soil structure
Slope arrangement	Slope arrangement at upland border with rocks or concrete	Decreases landslide and erosion

Source: Jung, *et al*., 2001 and 2002; and Yang and Jung, 2000 and 2001.

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8. MALAYSIA

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INTRODUCTION

Malaysia is a relatively small country with a total land area of about 33 million ha. However, in geographical terms, it is made up of three distinct regions; namely, Peninsular Malaysia, Sarawak and Sabah. Peninsular Malaysia, which has a land area of about 13 million ha, is situated at the southern end of the Asian mainland, while Sarawak, with more than 12 million ha of land, and Sabah, with 8 million ha, occupy the northern part of the island of Borneo. All three regions have small patches of low-lying alluvial plains and substantial areas of uplands. The term 'upland' is used in a general sense to describe land that is outside the coastal alluvial plains, river floodplains and adjacent low-lying areas. A wide range of agricultural activities is carried out in these uplands.

A large percentage of land is considered as unsuitable for agriculture (Table 1). This includes the steep uplands, peat lands and areas with acid sulphate and sandy soils. However, in all three regions, uplands constitute more than 80 percent of the unsuitable areas.

Table 1. Distribution of Different Types of Land in Malaysia

Category of Land	Peninsular Malaysia	Sarawak	Sabah
Total area (million ha)	13.16	12.24	7.63
Total area suitable for agriculture (million ha)	6.19	1.81	2.31
Total area unsuitable for agriculture (million ha)	6.97	10.43	5.32
Total unsuitable area as percentage of total area (percent)	53	85	70
Total area of uplands unsuitable for agriculture (million ha)	5.61	8.57	4.49
Unsuitable upland as percentage of total unsuitable area (percent)	80	82	84
Steepland (percent of total area)	42	70	58

Source: Aminuddin, *et al*., 1990.

Slope characteristics (gradient, length, form) vary widely throughout the uplands in all the three regions. In addition, a wide range of soil types has been mapped, with a large percentage being acidic and highly weathered soils belonging to the ultisol and oxisol orders of soil taxonomy. Slope steepness, soil erosion and nutrient depletion are some of the constraints faced in crop production. In certain areas, the other major problems faced are shallowness of the soil profiles and poor accessibility due to rugged topography.

Many physical characteristics of uplands in Malaysia are known although no comprehensive classification system has been developed. The objective of this paper is to discuss information related to land classification problems in the upland areas in the context of sustainable crop production.

STATUS OF UPLAND AGRICULTURE IN MALAYSIA

Malaysia has about 70 percent sloping uplands. Many parts of this land, except where the gradient is very steep, are being used for agricultural production. The agricultural land use in parts of the sloping uplands that are below 300 m are dominated by palm oil, rubber, cocoa and tropical fruit farming. Until recently, rubber used to be the major crop, occupying around 2 million ha. Many stands of rubber in the sloping uplands have now been replaced with oil palm. In addition, a range of tropical fruits are being grown in small orchards. Fruit production is still relatively small, but it is being vigorously encouraged, both for local consumption and for export. In the recent past, several orchards of relatively large size have been developed. The total area under fruit production may increase further in the sloping uplands. Table 2 shows the area under agricultural production in 1995 and the projected areas in 2000 and 2005. The actual cropped areas in sloping uplands are, therefore, smaller than those shown in Table 2. The declining trend in rubber production and the expected increase in fruit and vegetable production are clearly viable.

Table 2. Agricultural Land Use in Malaysia, 1995-2005

(Unit: ha)

Crop	1995	2000	2005
Rubber	1,727,000	1,430,700	1,301,500
Oil palm	2,507,611	3,460,000	3,100,000
Cocoa	243,538	105,000	105,000
Pepper	8,600	11,480	12,500
Pineapple	9,081	10,233	16,000
Vegetables	42,000	51,420	77,290
Fruits	244,471	297,436	379,613

Source: Government of Malaysia, 2000.

Soil erosion and nutrient depletion are important issues in the context of upland agriculture. In many plantations, some form of soil and water conservation is practiced. The common approaches include terracing, cover cropping and mulching using materials available locally.

Apart from soil erosion and nutrient depletion, other issues that have cropped up in recent years include the need to increase mechanization to overcome expected labor shortages and the feasibility of adopting mixed farming, especially in combining the production of food items with industrial products. Integrated farming, especially production of beef, mutton or poultry in combination with palm oil or rubber, has been proposed as another way of increasing the productivity of sloping uplands.

"Highlands" are an important part of sloping uplands. Although the total area under production is small, agricultural activities in that environment are associated with high levels of soil erosion, runoff and the transport of nutrients and chemicals. A district where intensive agricultural activities have been carried out for many years is Cameron Highlands, located in the Main Range, in the central part of Peninsular Malaysia. The lessons learnt here might be applicable to other highland areas.

The district is spread over an area of 712 km^2 with elevations ranging from 900 to 1,800 m. At these high altitudes, temperatures are distinctly lower than in the lowlands. The mean daily minimum and maximum temperatures are 14.8 and 21.1ºC, respectively. These conditions and the abundant rainfall encouraged the cultivation of a range of crops that favor relatively low temperatures (Table 3).

Table 3. Major Crops Grown in the Cameron Highlands

(Unit: ha)

Crop	Area[a]	Estimated Area[b]
Tea	2,500	2,300
Vegetables	2,140	2,500
Flowers	200	600
Fruits	250	50
Others	63	80

Sources: [a] Ko, *et al*., 1987; and [b] G. M. Hashim, 2000 (unpublished data).

Tea occupies the largest tracts of land although the area has declined slightly over the years. Tea land is characterized by slope gradients of over 30º, with some fields having slopes as high as 60º. This, coupled with the 'erodible' nature of the soil and the existence of 'empty rows' aligned in a longitudinal direction, increases the risk of soil erosion and the associated nutrient transport. A tea stand has several soil-conserving features. These include the closed canopy associated with well-maintained mature tea bushes and the large amount of leaf litter that cover the soil surface. Tea plantations also have wide contour terraces separating tea fields. During large rainstorms, soil erosion processes take place within tea fields, as evidenced by field erosion features such as flow pathways and numerous miniature deposition sites. A large proportion of the eroded soil is eventually deposited in the wide terraces after overland flows associated with large rainstorms have moved sediment, including previously deposited ones, downhill as shown in Figure 1 (Hashim and Wan Abdullah, 2001).

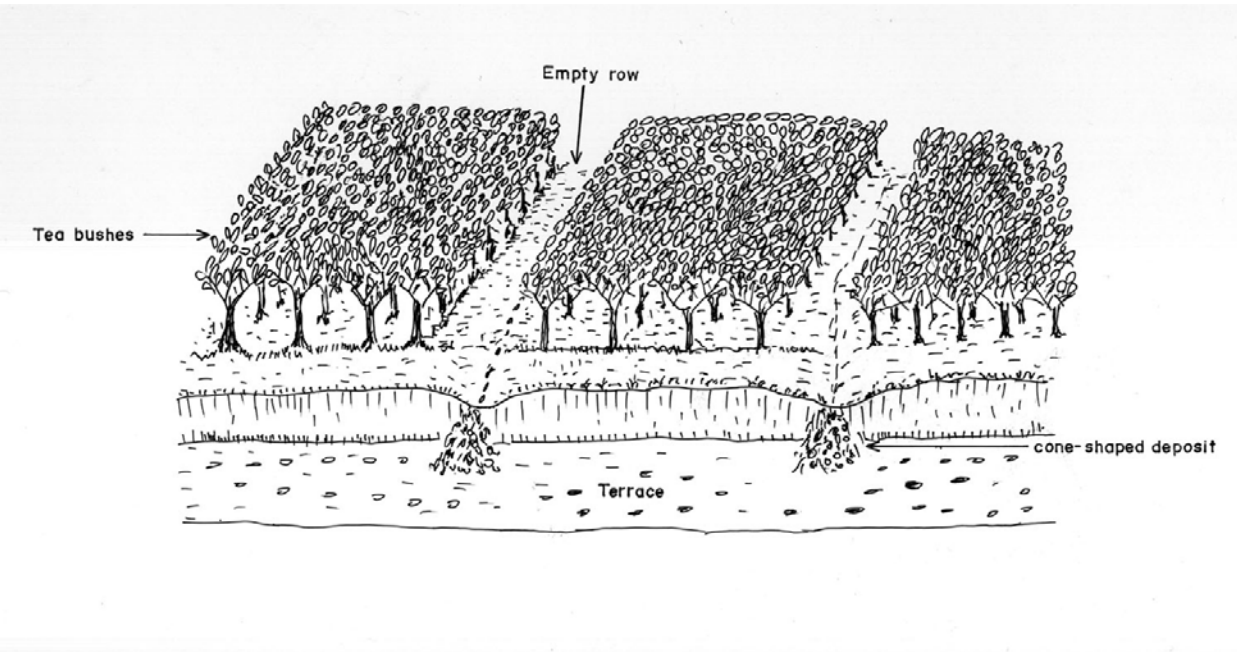

Figure 1. Cone-shaped Sediment Deposits on a Wide Terrace of a Tea Plantation

Vegetable cultivation is the most important economic activity in terms of number of families involved. The vegetables are grown on hillside terraces, on flattened hilltops and in valley floors. The establishment of vegetable farms is associated with high rates of soil erosion and nutrient transport. The consequent losses of topsoil and plant nutrients necessitated the use of high amounts of chicken manure, in the range of 10-20 mt/ha, in addition to inorganic fertilizers. However, as vegetable cultivation exposes a large part of the soil surface and involves frequent reworking of the soil, high rates of erosion and transport of nutrients and chemicals take place continuously.

Another important form of highland farming is floriculture under plastic rain-shelters, in which natural rainfall is excluded completely to maintain the quality of flowers. Therefore, soil erosion, runoff and transport of nutrients and chemicals within the farm is very low (Wan Abdullah, *et al*., 2001). However, the complete exclusion of rainfall tends to reduce leaching and encourage the accumulation of salts, leading to soil salinization (Wong, *et al*., 2002). During the establishment phase, land-shaping activities and shelter construction cause severe soil erosion, while during the life of the farm, large amounts of runoff are generated.

Shifting cultivation is still an important form of farming in sloping uplands, especially in Sarawak and Sabah. Land degradation problems such as soil erosion and nutrient depletion are worsened by the general decrease in fallow periods from the traditional 10 years or more to 3-4 years (Sinajin, 1987; and Teng, 1990).

PRESENT STATUS OF LAND CLASSIFICATION IN SLOPING UPLANDS

Although the bases for classification in the three regions are slope gradient, topographic features and elevation, there are slight differences in the systems of classification. In Peninsular Malaysia, the most important classification is the differentiation between 'agriculture land' and 'steepland'. Steeplands are those with average slope gradients >20º (36.4 percent). Such lands are considered as not suitable for agriculture unlike those with gradients <20º, which are termed agriculture lands. The 20º gradient is used because it marks an abrupt break between gentle and steep topography. Land with gradients of less than 20º are characterized by undulating and rolling terrain merging into almost level coastal plains. Land with gradients of more than 20º is mountainous and rugged. Above the steepland boundary, the slopes tend to be long, normally extending to the tops of ridges (Lim and Chan, 1993).

In Sarawak, the 33º (60 percent) slope gradient is the boundary separating 'agriculture land' from 'steepland'. Steeplands are more extensive in Sarawak, a region that is generally very hilly and dissected, than in Peninsular Malaysia. Similarly, Sabah has substantial areas of steep uplands. In Sabah, land with a slope gradient >25º (47 percent) is classified as 'steepland'.

Land classification is also based on elevation. In Peninsular Malaysia, 'lowland' is separated from 'highland' by the 300-m asl contour line (Nieuwolt, *et al*., 1982). The 300-m altitude is an arbitrary boundary marking a transitional change in climatic conditions. Below 300 m, temperatures are more uniform and have little influence on crop selection. However, at higher elevations, the climate is cooler and temperature exerts an influence on crop performance.

Besides the above two important systems of classification, land is also characterized according to general physiography as a guide in broad land use planning. In Peninsular Malaysia, five physiographic regions are recognized, while Sarawak has three regions (Table 4).

Table 4. Physiographic Regions in Peninsular Malaysia and Sarawak

Peninsular Malaysia		Sarawak	
Physiographic Region	Elevation (m)	Physiographic Region	Elevation (m)
1. Coastal plains and low terraces	0-20	1. Coastal lowlands	
2. Floodplains and low terraces	0-80	2. Central lowlands	<500
3. Intermediate and higher terraces	10-80	3. Interior uplands	>500
4. Rolling and low hilly land	30-170		
5. Hills and mountains	>170		

Sources: For Peninsular Malaysia: Lim and Chan, 1993; and for Sarawak: Ng, 1993.

The classification in Peninsular Malaysia provides a general picture of the availability of land with different types of terrain, and their distribution. Regions that include plains with gentle slopes are regarded as more suitable for activities such as wetland rice cultivation and vegetable production, while others that comprise sloping uplands are more suitable for tree crops. The classification into physiographic regions also provides an idea of the extent of uplands that may be used for agricultural production, the level of land conservation required and the uplands that are unsuitable for cultivation.

The physiographic regions of Sarawak are defined in more general terms. Therefore, each region is further subdivided according to agro-ecological zones (Table 5).

GOVERNMENT POLICY

Government policy on the protection of sloping uplands is reflected on the enactment of several pieces of legislation relating to land management and conservation. One of these is the "Land Conservation Act, 1960". Among other things, this act states that any area, or class, or description of land can be declared as 'hill land'. Once so declared by state authorities, the said piece of land should remain under forest cover. Some other relevant pieces of legislation are:

- National Land Code, 1965, which, among other things, defines the terms 'land' and 'agriculture' as a guide for state governments and land administrators.
- Environmental Quality Act, 1974, which among other things, provides for the conduct of an "Environmental Impact Assessment" (EIA) for certain categories of land development and use.

- National Forestry Act, 1984, which, among other things, empowers the Department of Forestry to classify any permanent forest reserve under one or more of 11 categories, including 'soil protection forest' and 'soil reclamation forest'.

Table 5. Land Units In Sarawak and Their Agricultural Capability

Physiographic Region/ Agro-ecological Zone	Agricultural Capability Class[a]	Area (percent)
Coastal Lowlands		
Marine floodplains	5, (4)[b]	5.4
Coastal organic swamp	05	13.0
Residual landform	5	0.1
Central Lowlands		
Riverine alluvial plain	3, 2	3.8
Low hills	3	7.1
Dissected hills	4, (3)	8.3
Dissected hills and mountains	5, (3)	13.4
Landform complex	05, (4)	0.1
Interior Uplands		
Riverine alluvial plain	3	0.6
Dissected hills and mountains	5, (4)	46.9
Mountainous highlands	2, 3	0.3

Source: Teng, 1990; and Ng, 1993.

Notes: [a] Agricultural capability classes: 1 = highly suitable, 2 = suitable, 3 = moderately suitable, 4 = marginally suitable, 5 and 05 = unsuitable; and [b] figures shown in brackets are subordinate classes.

In the late 1990s, after a period in which agriculture took a back seat, the government re-emphasized its importance, especially in the context of food production. In the Eighth Malaysia Plan, 2001-05 (Government of Malaysia, 2000), one of the policy thrusts is to make agriculture modern and dynamic, and attract youths with good formal education to participate actively in the sector. One of the strategies in the plan is to increase food production. An important step is the creation of "*permanent food production zones*" in every state so as to reduce the rate of conversion of agricultural land to other economic uses. In rice production, one of the new policies is to encourage the cultivation of new varieties and increase the number of cropping seasons. Another strategy is to intensify agricultural land use. Some of the programs towards land use intensification are mixed farming, integrated farming and agro-forestry. When implemented, these practices should improve upland conservation and productivity.

USING LAND CLASSIFICATION IN LAND USE

Agricultural land in Peninsular Malaysia is further sub-divided into four terrain classes by the Department of Agriculture (DOA) (Lim and Chan, 1993). These classes were formulated from data routinely collected in the department's soil mapping program. Although based on slope gradient, these classes represent distinct physiographic units on the ground, influencing crop suitability. The classification provided convenient units of land to be used in comprehensive recommendations on land management and conservation measures (DOA and MARDI, 1993). Thus, in the nation-wide set of recommendations for steepland development, the conservation measures and crop choices were based on the terrain classes (Tables 6, 7 and 8). The number of suitable crops decreases as the slope gradient increases. At higher slope classes, only perennial crops are recommended. Similarly, the classification system facilitates the process of recommending the adoption of land conservation measures. The type and number of conservation measures recommended are in accordance with the type of crop and the slope class. This set of recommendations, formulated so as to guide policymakers, planners and land users on the sustainable use of sloping uplands, has been presented to high-level representatives of all state governments.

Table 6. Recommended Land Clearing Measures for Various Crops and Land Slopes

Slope Range	0-2º	2-6º	6-12º	12-20º	20-25º	25-30º	>30º
In Lowlands							
Annual	1, 2, 4b, 6, 7, 8*						
Perennial	1, 2/3, 4c, 5, 6, 7, 8					- - - ➤	
Grasses	1, 2, 4c, 5, 6, 7, 8						
Medium-term crops	1, 2/3, 4c, 5, 6, 7, 8						
Aquaculture	1, 2, 4c, 5, 6, 7, 8						
In Highlands							
Annual (vegetables, flowers)	1, 2, 4c, 5, 6, 7, 8		1, 4a, 5, 6			- - - ➤	
Perennial	1, 2/3, 4c, 5, 6, 8					4a - - - ➤	

Note: * No burning or replanting.

<Legend>
——— Recommendation for Peninsular Malaysia, Sabah and Sarawak
- - - ➤ Similar recommendation for Sabah and Sarawak only.

1 = in manageable stages; 2 = clean felling; 3 = selective felling; 4a = manual; 4b = mechanical; 4c = both; 5 = buffer zone wherever applicable; 6 = timeliness; 7 = de-stumping; and 8 = light burning.

Table 7. Recommended Conservation Structures/Measures for Various Crops and Land Slopes

Slope Range	0-2º	2-6º	6-12º	12-20º	20-25º	25-30º	>30º
In Lowlands							
Annual	4	4, 6					
Perennial	4	4, 6	1/2, 4, 5, 6, 7, 8			2, 4 - - - ➤	
Grasses	4	4, 6	4, 5, 6				
Medium-term crops	4	4, 6	1/2, 4, 5, 6, 8				
Aquaculture	4	4, 5					
In Highlands							
Annual (vegetables, flowers)	4	1, 4, 5, 6	1/3, 4, 5, 6, 8	1/3, 4, 5, 6, 8, 9, 10			
Perennial	4	4, 6	1/2, 4, 5, 6, 7, 8			2, 4 - - - ➤	

<Legend>
——— Recommendation for Peninsular Malaysia, Sabah and Sarawak
- - - ➤ Similar recommendation for Sabah and Sarawak only.

1 = bench terrace; 2 = platform/individual basin; 3 = plateau/broad bench; 4 = drain and waterways; 5 = silt pits/traps/contour ditches; 6 = hillside ditches; 7 = orchard terrace; 8 = check dams; 9 = culverts; and 10 = stone wall/retaining wall/gabions.

Table 8. Recommended Agronomic Measures for Various Crops and Land Slopes

Slope Range	0-2º	2-6º	6-12º	12-20º	20-25º	25-30º	>30º
In Lowlands							
Annual	3, 5, 6	2 to 10					
Perennial	3, 4, 5	7, 8				4	
Grasses	1, 3, 4, 5	1, 2, 3, 4, 5, 7*, 8*				- - - - ➤	
Medium-term crops	4						
Aquaculture	1, 3, 4, 5, 6, 7, 8, 10						
In Highlands							
Annual (vegetables, flowers)	3, 5, 6, 7, 10			- - - - -	- - - - - ➤		
Perennial	1, 2, 3, 4, 5, 7, 8, 9, 10						

Note: * Where applicable.

<Legend>
——— Recommendation for Peninsular Malaysia, Sabah and Sarawak
- - - -➤ Similar recommendation for Sabah and Sarawak only.

1 = ground; 2 = contour planting; 3 = mulching; 4 = minimum tillage; 5 = high density planting; 6 = crop rotation; 7 = intercropping; 8 = alley cropping; 9 = grass strips; and 10 = wind breakers.

CONCLUSION

Sloping uplands constitute a significant part of the agricultural land in Malaysia. To meet national food needs and to increase the production of agricultural commodities, upland agriculture is expected to expand further. To ensure sustainability, agricultural use of uplands must be planned properly on a scientific basis. Therefore, the classification of such lands needs to be further developed and refined. Besides slope gradient and elevation, other aspects of land quality such as soil properties (biological, chemical, physical) and microclimate should be incorporated into the system.

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9. MONGOLIA

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INTRODUCTION

The dominant economy of the country is agriculture with 48.5 percent of the total work force employed in this sector. The agriculture sector contributes almost 35.1 percent to the GDP. Animal husbandry is the dominant agricultural activity contributing approximately 90 percent of the total productivity of Mongolian agriculture (Batjargal, 2000). Hence the main land use and classification is related to the livestock husbandry especially in rangeland and its management. The other important economic sector of the country is heavy dependence on livestock husbandry. In 2000, the livestock reached 30.2 million heads from 25.9 million in 1990, thereby increasing the number of livestock heads by 4.3 million in 10 years. More than 2,600 species of plants are found in the Mongolian pastureland out of which 600 species provide good amount of forage and natural hay for the livestock every year.

Mongolia has steeplands and shallow soils, which are under forest if the climate is favorable. In the semiarid and arid parts of Mongolia, the steeper terrain and shallow soils are generally used for grazing of small ruminants.

There are four major land use constraints including continuous moisture stress, continuous low temperatures, steep slopes, and shallow soils, which cannot be corrected easily by technology. In Mongolia such lands have great difficulties supporting sustainable agriculture. The pastureland occupies more than 80 percent of total land of Mongolia and animal husbandry is the main economic activity of the country, which directly depends on nature and weather condition of the region. Much of the arid and semiarid land of Mongolia has been converted to raising domesticated or semi-domesticated animals in permanent open ranges or nomadic herding. Most of these areas do not support farming without irrigation but are suitable for livestock raising. Permanent ranges occur where rainfall is low but regular. Nomadic herders can utilize areas that have irregular, sparse rainfall. Within last several years the pastures' degradation was intensive due to harsh weather and increase in livestock population and concentration of people, especially around urban area due to the development of free marketing.

The challenges to sustainable agriculture in Mongolia have different dimensions than in other countries. The data reveal that Mongolia has relatively high per capita land (ha/person), but only 11 percent of it is used as cropland and 81 percent is used as pastureland (Avaadorj, *et al*., 2000).

ISSUES IN LAND MANAGEMENT

As mentioned above the pasturelands form about 80 percent of all land of Mongolia. Thus pastureland policies define the land policies of the country. Today, the issues relating to pastureland cannot be treated traditionally. More than 70 percent of soil cover of all land has been eroded and at least 8.6 million ha are suffering from overgrazing. In these degraded pasturelands the composition of plant species has changed because of the overgrazing. This tends to reduce certain species of plants and encourage others. The rangelands that spread throughout the mountainous regions and steeplands are suffering from erosion by water and wind. About 6.2 million ha of land has rocky surfaces and cannot be used as pastureland anymore. Approximately 3 million ha is covered by sand and 20.5 million ha is arid land.

In order to increase the productivity of rangeland, management techniques will have to be developed to specifically eliminate certain species of plants not useful for the grazing animals or to plant-specific grasses that are not native to the area or to introduce exotic species of grasses. If overgrazed, many plants die, and the loss of plant cover allows the soil to begin blowing, resulting in a loss of fertility, which further reduces the ability of land to support vegetation. This results in degradation of the land and its conversion to desertification.

During past 50 years, the yield of pasture has decreased by 2-3 times and the percentage of important grazing plants reduced by two times (Avaadorj, 1999). Under such conditions of reduction in the amount of pastureland and degradation of the quality of pasture it is difficult to increase the number of livestock. There are many, usually confounding reasons why land users allow their land to degrade. Many of the reasons are related to the perceptions of the society about land and the value they place on it. Degradation of pastureland is also a slow imperceptible process and many people are not aware of the fact that their land is degrading. Thus, creating awareness, building up the sense of stewardship, and research on traditional pastureland management are important challenges.

Another factor that prevents efficient use of land in Mongolia is their traditional nomadic lifestyle. The nomadic herders had different concept about the land. They lived in relatively large areas and used commonly pastures. However, they have no capital to invest on the pasture and were not given any incentives by the government. They have fewer facilities and an inadequate knowledge base to implement land management technologies. Thus, they cannot be expected to contribute much in pasture management. Sustainable and the efficient use of the land can only be possible through the appropriate application of modern knowledge. In rangeland management there is need to address issues and problems related to rangeland ecology.

Desertification is another problem related to natural resource management, which requires solutions that are holistic, technically sound, politically relevant, socially acceptable, and economically viable. Addressing this problem is important because desertification is closely linked with climate change, biodiversity, and food security.

USE AND MANAGEMENT OF SLOPING PASTURELAND

Soil Characteristics and Land Classification

Situated in the heart of Asia, Mongolia covers an estimated total area of 1,565,000 km^2 or about 156.65 million ha. The steeply sloping lands of Mongolia account for 34.7 percent of the total land area or about 54,305 million ha. Half of the land area of the country is 1,400 m above sea level. The lowest point is 560 m while the highest is 4,374 m. Mongolia is continental country with sharply defined seasons, high diurnal temperature fluctuations, and generally low precipitation. Because of the country's elevation, the climate is considerably colder than other countries with the same latitude. The average annual temperature is 2-4ºC in the southeast region and -7 and -5ºC in the northwest Mongolia. The climatic features of Mongolia include long winter from October to April. Growing season in the country is short, i.e., from May to September.

The most dominant land cover in Mongolia is grass and arid grassland with roughly 124 million ha or 79 percent of the total land cover. Data on some land use classes of the country are shown in Table 1. In 1975, the Research Institute for Land Policy began a major campaign to systematically map and survey the vegetation, soil, land use, and land productive capability of the country. The survey revealed that, 82.6 percent of the country's total land area is committed to agriculture, out of which approximately 97.5 percent is suitable as a rangeland for livestock production.

Mongolia's topography is generally mountainous and interspersed with broad areas of plains. In the north, the forests of taiga cover approximately 8 percent of the whole territory of the country. Taiga forest areas developed mountain taiga cryomorphic, mountain derno-taiga soils (Tables 2 and 3).

Pastureland Use and Management in Mongolia

Raising livestock is the only feasible agricultural activity for utilizing the extensive natural grasslands and sloping uplands. These are estimated to cover about 126.7 million ha, which form about 81 percent of all land resource of Mongolia. The steeply sloping lands consist of more than 50 percent of pastureland and occur in the mountainous region.

Table 1. Some Land Use Classes of Mongolia

(Unit: 000 ha)

Land Use Class	1990	1991	1992	1993
Farm land	121,584.0	122,102.2	119,565.3	116,248.5
Arable land (crop)	1,337.7	1,281.6	1,214.5	1,181.5
Cultivated fruit land	0.9	1.0	1.2	1.0
Hay making land	1,357.1	1,346.0	1,347.3	1,337.4
Pastureland	118,768.6	119,299.7	116,766.7	113,469.5
Agricultural facilities	89.6	89.5	89.5	88.1
Protected areas	5,614.3	5,614.3	8,429.2	12,617.2
Forestland	15,188.4	14,403.1	15,218.5	13,622.4
Natural forestland	11,431.9	12,039.9	11,356.8	10,393.6
Saxaul (*Haloxylon*)	3,755.6	2,362.2	3,860.7	3,227.6
Land under surface waters	1,624.6	1,630.6	1,632.3	1,631.4
Reserve land	9,570.0	9,581.3	9,617.6	8,852.5
Livestock tracking route	2,660.0	2,967.0	2,660.6	2,657.3
Hay production land for state emergency	632.9	632.6	630.2	631.5

Table 2. Major Soil Groups of Mongolia

S.No.	Types of Soil	Area (000 ha)	Percent
1.	Haplusols	3,112.4	1.99
2.	Chestnut: dark chestnut	8,488.3	5.43
	– Typical chestnut	49,201.3	31.46
	– Light chestnut	13,765.9	8.80
3.	Meadow chestnut	6,735.0	4.30
4.	Alluvial soil	3,029.6	1.94
5.	Brown desert steppe soil	21,907.7	14.01
6.	Grey brown desert soil	8,216.8	5.25
7.	Grey brown extra desert soil	4,308.1	2.75
8.	Saline soil	12,338.7	7.89
9.	Aeolic soil	2,988.2	1.91
10.	Litho soil and gully, gravel ravines	6,286.1	4.02
11.	Soil under water bodies	1,630.5	1.04
12.	Forest soil	14,403.1	9.21
Total		156,411.7	100.00

Table 3. Vertical Zones of Soils

S.No.	Types of Soil	Area (000 ha)	Percent
1.	Mountain forest soil	14,403.1	9.21
2.	Mountain other soil	53,188.1	34.01
3.	Valley, hollow, plains, and inter-zone soils	80,903.9	51.72
4.	Litho soil and gully, gravel ravines	6,286.1	4.02
5.	Underwater soil	1,630.5	1.04
Total		156,411.7	100.00

Pastures on the Sloping Lands of Mongolia

Mongolia has learned a lot from its efforts to better protect and preserve the rangeland resources. In Mongolia rangelands, as the experts say, are overstocked. One of the things Mongolia has learned is that land degradation occurs as a result of the mismatch between land use and land quality. According to the survey and the map generated by the Land Research and Policy Agency of Mongolia and Landsat data 50 percent of the total pastures are in mountainous area. Further, 19 percent of the pastures are located in the high mountain area with steep slope, which create difficulties in managing them. The study of Avaadorj (1999) reveals that the rangeland quality, management and use heavily depend on the steepness of the slope. The tested pasture area was Bayangol of the Sellenge province, Adaacag of the Dundgobi province and Cogtcecii of the Southgobi province. These test range areas were chosen to represent various places of Mongolia. Data show that the elevation of the whole area of Adaacag, 80 percent of the Cogtcecii area, about 10 percent of the Bayangol area is 1,300 m above the mean sea level with the steep slope and that of 17 percent of the range of Cogtcecii and 21.8 percent of the Adaacag is 1,500 m above the sea level. These data reveal that pasturelands are mainly found in the mountainous area of Mongolia and have steep slopes. The pasturelands in about 14 percent of the Cogtcecii, 25.5 percent of the Bayangol and 11.4 percent of Adaacag have a slope more than 10º. Such pasturelands are located in the northern and western part of country. There is no reliable source of land degradation data because of the lack of an accepted method of data recording. According to some data sources about 70 percent of the pastureland of Mongolia are degraded to different degrees. The reason for this is overgrazing and increased number of livestock.

Livestock rearing, using transhumance production systems, is the main land use and source of livelihood in vast areas of the semiarid and arid zones of Asia, which indeed, is probably the only way of exploiting these seasonal pastures economically. Lack of feed during winter and early spring, a period of extremely low temperatures, when breeding stock are pregnant and most vulnerable is the major constraint to improving livestock production and family income.

Grazing Cycle

The grazing cycle for main pastoral zones in Mongolia is given below:

C ***A zone of alpine snow and rock***, above the summer pastures, is of little use for grazing. The snow line is at about 3,500 m. These pasturelands are usually found in the north and western regions of Mongolia.

C ***Summer grazing lands***, above 1,300 m, provide rich grazing for about three months per year. These are the fattening pastures constituting about 50 percent of the total pastureland of Mongolia. In summer, these are in good condition and their carrying capacity is high.

C ***Spring and autumn pastures*** are the transition routes, which are heavily grazed twice a year, largely owing to a lack of winter feed. These transitory spring and autumn grazing areas are also subjected to very high stocking pressures, as herds are forced to leave their winter grazing areas early and remain on the transitory grazing areas as long as possible in the autumn.

C ***Winter pastures*** consist of desert plains, low meadows and marshland, which are totally inadequate for the number of stock carried. Desert pastures are only used when there is snow for drinking needs. A sudden thaw or deep snow is highly disastrous to livestock. This occurred in last two years and approximately 7 million livestock died. In addition, another phenomenon called "*zud*", also occurs in which heavy snow, lack of food for cattle and freezing damage animal husbandry easily and the crop yield becomes less due to lower soil fertility. This transhumance route from the desert plains to the high mountain range is long and different. For example, the yak is mainly in the high mountain areas even in the summer and some kind of breed of sheep have 200-300 km.

Different parts of the country have different grazing cycles in order to effectively manage rangeland. To avoid rangeland degradation due to overgrazing, there is need to develop better management techniques, land classification system and land use policy. In case of Mongolia, rangeland management remains one of the most controversial issues facing livestock development.

CONCLUSION

Land use and management is the most controversial issue of Mongolian agriculture. The purpose of this paper is to present a brief overview of Mongolian land resources. Subsequently, the condition of the resource base has been analyzed by inferring from the extent of human impact on the resource base.

Rangeland is the most important land resource of Mongolia. Long periods of the mismanagement and misuse have degraded much of the soil resources. The challenge now is to improve the system again. This can be achieved by restoring the integrity of the agro-ecosystem especially by maintaining range-ecosystem's balance.

Although Mongolia is a country with rural economy, main rural sectors such as animal husbandry and plant crop growth are still unsustainable with high percentage of risk. In range-ecosystem close cycle is damaged by mismanagement of land. The basic question is how to incorporate a sustainability component in research and development programs.

Pasture use and management must be viewed as a challenge and a motivating force to guide future research and development efforts. Pastureland is heavily degrading, thus there is need to manage sloping upland areas for grazing. However, it creates many difficulties to manage and use it. Sustainability and the efficient use of the land can only be possible through appropriate application of modern technologies.

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10. NEPAL

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INTRODUCTION

The elevation of Nepal varies from 60-8,848 m with diversified climatic and agricultural zones. The total area of the country is 147,484 km^2 (14.75 million ha), out of which 2.97 million ha are cultivable. The rest of the area is covered with high mountains, snowy peaks, rocks and forest. The total population of the country is 23.21 million with the population growth rate of 2.27 percent per annum and the population density of 151.97/km^2. About 81.1 of the population is engaged in agriculture. Nepal has diversity of agro-ecological variations and agro-climatic conditions, which considerably contribute to the vastness of its bio-diversification and genetic potentials. Almost all types of crops are grown in Nepal.

STATUS OF UPLAND AGRICULTURE

Out of the total area of the country mid-mountains occupy 41.72 percent and high mountains and higher Himalayas occupy 35.16 percent. The net cultivated area is 2.64 million ha which is 17.91 percent of the total land area; out of which *tarai*, mid-mountain, and high mountain and higher Himalayas occupy 51.5, 39.9 and 8.6 percent, respectively. About 40 percent of its total population lives in *tarai* whereas 60 percent lives in the mountain areas and valleys.

The statistical data reveal that only 27.31 percent of rice, 43.78 percent of wheat and 78.92 percent maize is harvested in high mountain and mid-mountain regions (Table 1) which is not sufficient to meet the need of food grains for the people living in these regions. However, people living in these regions are planting other crops such as vegetables, fruit trees, cash crops, and spices as per their need and suitability to agro-climatic areas. Raising livestock is another alternative for generating income.

Table 1. Area, Production and Yield of Agricultural Crops (1999-2000)

	Paddy	Wheat	Maize
High Himalayas/High Mountains			
Area (ha)	46,286	47,362	74,714
Production (mt)	87,893	65,429	118,041
	(2.18)	(5.53)	(8.17)
Yield (kg/ha)	1,899	1,381	1,580
Mid-mountains			
Area (ha)	377,370	241,550	571,662
Production (mt)	906,806	383,078	997,948
	(22.50)	(32.37)	(69.04)
Yield (kg/ha)	2,403	1,586	1,746
Tarai			
Area (ha)	1,127,334	371,128	172,650
Production (mt)	3,035,401	735,023	329,461
	(75.32)	(62.10)	(22.79)
Yield (kg/ha)	2,693	1,981	1,908

Note: Figures in parentheses are percent.

THE PHYSIOGRAPHIC REGIONS

There are five physiographic regions in Nepal. These include: (1) *tarai*; (2) *siwaliks*; (3) middle mountains; (4) high mountains; and (5) high Himalayas. This paper is especially focused on the physiographic regions 3, 4 and 5, briefly described in Table 2.

Table 2. Characteristics of Physiographic Regions of Nepal with Special Reference to Sloping Uplands

Characteristics	Middle Mountain	High Mountain	High Himalayas
Elevation	800-2,400 m, relief 1,500 m with isolated peaks to 2,700 m	2,200-4,000 m, high relief 3,000 m from valley floors to ridges	4,000 m+
Climate	Warm temperate (but subtropical in lower river valleys and cool temperate on high ridges)	Warm to cool temperate	Alpine to arctic (snow 6-12 months)
Moisture regime	Sub-humid, humid above 2,000 m N-aspects and 2,000 m S-aspects	Sub-humid N-aspects, humid throughout the region below 3,600 m	
Rainfall intensity	Medium	Low	Low
Vegetation	Pine forest, mixed hardwood and oak forest	Fir, pine, birch and rhododendron	Open meadows + tundra vegetation
Soils	Ustochrepts, haplustalfs, rhodustalfs, haplumberepts, ustorthents and ustifluvents	Eutrochrepts, dystrochrepts, haplumbrepts, cryumbrepts, cryorthents and ustorthents	Cryumbrepts, cryorthents and rock
Crops	Rice, maize, wheat, millet, barley, pulses, sugarcane, radish, potato, ginger and cardamon	Oat, barley, wheat, potato, buck-wheat, yams, amaranths, medi-cinal herbs	Grazing (June-September)
Horticulture	Mango, papaya, banana, orange, lime, lemon, peach, plum, pome-granate	Chestnut, walnut, apple, peach, plum, apricot	

The combination of many ethnic groups and extreme differences in climate and physiography determine the great variations in the land use of the country. The public forest and grazing lands are a vital part of the integrated agriculture farming systems of Nepal. However, the growing human and livestock populations are putting severe pressure on the existing public lands. Even at present, farmers are forced to turn agricultural land with low soil fertility into temporary pastures.

Although the *tarai* represents only 14 percent of the total area of Nepal, it contains about 42 percent of the total cultivated land of the country. The *tarai* forests consist mainly of high value *sal* (*Shorea robusta*) and a mix of tropical and subtropical species.

The *siwaliks* has very little agricultural land and this is predominantly on the valley floors. The main crops are maize, millet, wheat and mustard. Some rice is found where irrigation water is available. The Doon valleys resemble the *tarai* more than they resemble other areas within the *siwaliks*. The forests are mainly mixed hardwoods and pine.

The middle mountains are intensively cultivated. Existing pastureland is heavily overgrazed and forests are stripped for fodder and fuel wood. Most slopes are terraced and support maize, millet, rice, wheat or potatoes as dominant crops. About 85 percent of the cultivated land of the middle mountains consists of some form of hill slope cultivation. The badly degraded forests of the middle mountains consist mostly of hardwood with some conifers mainly pines.

In the high mountains, upper limits of agriculture were found at about 4,200 m elevation. In these high regions fields can support only one crop of buckwheat, barley or potatoes once a year or once every two years. The high mountain forests contain a higher proportion of different conifers and in general are in better condition than forest elsewhere in the country.

LAND CLASSIFICATION

In Nepal, there are many systems of land classification based on: (A) land taxation purposes; (B) cultivation practices; (C) irrigation purposes; and (D) forestry and conservation practices. Here, I would like to give the example of land classification based on land taxation purposes in Nepal, and detailed discussion would be made based on the land system approach.

Land Taxation Classification

The Act of 1962, with third and fifth amendments (1975 and 1979) outlines a land classification, which deals with agricultural lands only. At the first level, lands in the *tarai* are separated from all other lands. Next, *khet* (lowland, rice cultivation) is separated from *pakho* (upland, i.e., maize cultivation). Four sub-divisions are then applied to the *khet* and five to *pakho* lands:

C *Khet Awal* – Year-round irrigation
C *Khet Doyam* – Supplemented monsoon irrigation (5-6 months)
C *Khet Sim* – Supplemented monsoon irrigation (less than 2 months)
C *Khet Chahar* – Paddy production only in certain year.

Five sub-divisions of *pakho* land include:

C *Pakho Awal* – No soil limitations
C *Pakho Doyam* – Minor soil limitations
C *Pakho Sim* – Major soil limitations (sandy, stony or gravelly soils)
C *Pakho Chahar* – Severe soil limitations
C *Pakho* Fifth Level – Land above 2,438 m.

In addition lands are also downgraded in use value because of elevation aspect, steepness and flood hazard.

The classification system does not deal with pasture, fuel and fodder production, forestry or other purposes. Climatic limitations are applied by increasing altitude ranges, however, it appears that lands are downgraded more than necessary. There is considerable evidence indicating that climatically adapted crops have similar productivity up to an altitude of about 2,500 m.

The land classification of the Land Assessment Act is applied at a more detailed level than that of our current mapping. The former maps are based on intensive field inspection and plain table surveying, and serve as a land registry as well as for the assessment and determination of tenancy rates.

THE LAND SYSTEM APPROACH

Nepal is a land of extremes: climate ranges from subtropical to arctic and physiography encompasses vast alluvial plains to very rugged, permanently snow covered peaks. In the mountainous terrain, variability of soil types is so great that meaningful reconnaissance mapping based on soil series or even associations of soil series is not possible. In such a landscape, any attempt to classify the soils without a well-defined arrangement upon which to base lower categories results in a jumble of unconnected data, and therefore no possibility to transfer soil information from one region to another. If strictly genetic approach to land classification is attempted, one ends up with an academic exercise of little use in addressing pressing land use planning questions. On the other hand, if one's approach is strictly pragmatic (based on arbitrary criteria established from the state of knowledge of one point in time), then the information is immediately outdated and not responsive to future technological innovations. The land systems approach provides a methodology flexible enough to employ both genetic and existing pragmatic criteria in delineating map units. Where very important or well-defined genetic breaks are found, they are mapped, as are pragmatic limits such as agro-climate and slope. Landscape descriptions should be specific enough to provide a meaningful framework for detailed studies, and general enough to be of use in regional planning. The land systems approach, utilizing the physiographic land region to the site-specific land type, provides such a framework and permits levels of generalization appropriate to any level of survey intensity. Soils, physiography, climate, geology, geomorphology, and vegetation have been integrated into the framework of land systems mapping, and in doing so provide a natural base for the capability classification.

The Land System Mapping Framework

1. ***Physiographic Regions***

The recent Landsat Mapping Project by Nelson (F.A.) 1981 was chosen as the initial framework for delineating physiographic regions. These physiographic regions (*tarai, siwaliks*, middle mountains, high mountains, and high Himalayas) are well recognized by all Nepalese geographers, geologists, foresters, soil scientists and agronomist alike. They represent well-defined geographical areas with distinctive physiography, bedrock geology, geomorphology, and climate.

2. ***Land Systems***

Within these physiographic regions, mutually exclusive land systems are defined according to recurrent patterns of land forms, geological materials, slopes, and arable agricultural limits which are readily observable on 1:50,000 aerial photographs. These criteria are both genetic and pragmatic in nature, and they separate important land capability differences.

3. ***Land Units***

Within land systems, map-base land surfaces, which are significant from some user-oriented point of view, are delineated. These are called land units. The land units are differentiated by landscape characteristics such as position, slope, surface dissection, and flooding frequency, and by soil characteristics such as drainage, depth, texture, profile development and pH.

4. ***Land Types***

Within land systems or land units there is a complex of land types that are either too small or too complex to be mapped on 1:50,000 aerial photographs. They are, however, readily recognized in the field and have important physical characteristics for determining land capabilities. These land types are noted where they occur and are described within a schematic cross section of the land system.

Land Systems Descriptions

Seventeen land systems were described. Brief descriptions of these systems and the associated land units are provided in Table 3 as they are listed in the mapping legend. In addition, the complete map legend provides information on dominant soils, slope, soil texture, oil depth and drainage.

Table 3. Land System Descriptions

Land System	Land Form	Land Unit	
***Tarai* Region**			
1.	Active alluvial plain (depositional)	1a	present river channel
		1b	sand and gravel bars
		1c	frequently flooded
		1d	occasionally flooded
2.	Recent alluvial plain lower piedmont (depositional and erosional)	2a	depressional
		2b	intermediate position; level
		2c	intermediate position; undulating
		2d	high position
3.	Alluvial fan, apron complex upper piedmont (erosional)	3a	very gentle slope
		3b	gentle slopes
		3c	gentle rolling
		3d	highly dissected

... To be continued

Table 3. Continuation

Land System	Land Form	Land Unit
***Siwalik* Region**		
4.	Active and recent alluvial plains	4a sand and gravel bars 4b flooded frequently or occasionally 4c rarely flooded
5.	Fans, aprons and ancient river terraces (tars)	5a very gentle slopes 5b gentle slopes 5c undulating 5d rolling
6.	Depositional basins (Duns)	6a depressional 6b non-dissected high position 6c gentle rolling 6d highly dissected
7.	Moderately to steeply sloping hilly and mountainous terrain	
8.	Steeply to very steeply sloping hilly and mountainous terrain	
Middle Mountain Region		
9.	Alluvial plains and fans	9a river channel 9b alluvial plains 9c alluvial fans
10.	Ancient river terraces (tars)	10a non-dissected 10b dissected
11.	Moderately to steeply sloping mountainous terrain	
12.	Steeply to very steeply sloping mountainous terrain	
High Mountain Region		
13.	Alluvial plains fans	13a active alluvial plain 13b recent alluvial plain 13c fans 13d ancient alluvial terraces
14.	Past glaciated mountainous terrain below upper altitudinal limit of arable agriculture	14a moderate to steep slopes 14b steep to very steep slopes
15.	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture	15a moderate to steep slopes 15b very steep slopes
High Himalayan Region		
16.	Alluvial, colluvial and morainal depositional surfaces	16a glacio alluvial plains 16b morainal deposits 16c alluvial colluvial fans 16d colluvial slopes (talus)
17.	Steeply to very steeply sloping mountainous terrain	17a shallow till or colluvium over bedrock 17b rock head walls

THE LAND CAPABILITY MAPPING SYSTEM

Lands are grouped into seven classes, five subclasses and three subdivisions according to their opportunities, limitations and hazards for different sustainable areas (Table 4). Emphasis is on arable agriculture. However, the lands are also evaluated for other uses including perennial cropping, fuel and fodder production, timber extraction, grazing, and watershed protection. The arrangement of classes reflects decreasing opportunities for use as well as decreasing intensity of use. Erosion hazard generally increases from class I to VI, but erosion can be kept within tolerable limits by the prescribed land management. Subclasses are closely correlated with elevation, and subdivisions represent estimates of yearly soil moisture averages based on the limited information available.

Table 4. The Land Capability Classes in Nepal

Class I	Lands are nearly levels (slopes 1º) and soils are deep. There are few limitations for arable agriculture or forestry.
Class II	Lands are gently sloping (slopes 1-5º), and soils are deep and well-drained. Terracing or contouring is necessary to control erosion when used for arable agriculture, and maintenance of ground cover is required for sustained forestry-related usage.
Class III	Lands are moderately to strongly sloping (slopes 5-30º), and soils are 50-100 cm deep and well-drained. There are few limitations to traditional forest use, provided adequate ground cover is maintained. Terracing is mandatory to control erosion when used for arable agriculture. Under the existing agri-cultural system a large portion of Class III land is required for fodder pro-duction and grazing in order to maintain the productivity of the cultivated lands.
Class IV	Lands are either too steep to be terraced and cultivated (30º slope), or are above the altitudinal limit of arable agriculture. Soils are more than 20 cm deep and well to imperfectly drained. These lands are suitable for fuel wood, fodder, and timber production provided a good, permanent vegetative cover is maintained to minimize erosion.
Class V	Soils are more than 20 cm deep and slopes are less than 30º, on lands, which are alpine (above tree line), or are river terraces that are frequently flooded. These lands will not support tree growth but have few limitations when used for fodder collection or grazing.
Class VI	These lands include areas with slopes of 40-50º, or gentle slopes with soils less than 20 cm deep. The lands are considered fragile because of extreme erosion hazard and/or poor regeneration potential.
Class VII	This class consists of rock and ice.

The five subclasses differentiated represent major climatic temperature regimes; namely, subtropical, warm temperate, cool temperate, alpine, and arctic. The subdivisions represent major climatic moisture regimes. These include semiarid (s), sub-humid (u), humid (h), and per-humid (p).

This land capability classification is qualitative, based mainly on the physical productive potential of the land, with economics presented only as a background. Guidelines for placing lands in different categories based on slope limits, soil depths, altitudinal ranges, rainfall, erosion control requirements, and opportunities for different kinds of land use are provided in the Land Capability Report. The distribution of land area in Nepal under different land capability classes is given in Table 5.

Table 5. Distribution of Land in Nepal by Capability Class

Class I	10 percent	Class V	4 percent
Class II	4 percent	Class VI	22 percent
Class III	17 percent	Class VII	7 percent
Class IV	35 percent	Rock, ice and unclassified	1 percent

MAIN ISSUES AND PROBLEMS

There might be many problems regarding the utilization of sloping uplands. Some of these are listed here as follows:

- Soil erosion (due to rain and animal raising)
- Landslide
- Less accessibility
- Low literacy
- Less input supply
- Inadequately managed irrigation system
- Overpopulation
- Increasing number of unproductive domestic animals
- Non-availability of credit in time.

SUGGESTED STRATEGY

- In order to optimize the benefit from agricultural land use and development of the land and water resources with minimum damage to the ecology, it would be necessary to make a comprehensive survey of the resources of the country and their present condition and utilization.
- Bringing the present public lands under administrative control, preferably at the lowest possible local level, so they can be managed to meet the requirements of the local population.
- Bringing extensive areas of degraded forest and shrub lands under local management and making it more productive. The highest priority can be given to those lands closest to regions where the ratio of forestland to cultivated land is the lowest.
- Providing training in managing fragile areas to gain maximum amounts of fuel wood and fodder while still maintaining watershed protection.
- Encouraging on-farm forestry for fodder and fuel wood production, to the extent that it is compatible with or complementary to food crop production.
- The revision of any policies, which may currently be hampering food production on existing agricultural land, in view of the conclusion, that deforestation is caused primarily by lack of food. Immediate increase in food production or the provision of food from outside sources will be necessary to relieve pressure on public lands while long-range management plans are implemented.
- Decreasing the number of domestic animals while increasing their productivity and control, which implies the eventual elimination of free grazing.
- Decreasing the rate of population growth and/or providing education/training and credit for better utilization of such sloping lands.
- Construction of agricultural roads (may be without hampering environment and ecology) so that the high value crops growing in such regions can be transported and marketed easily.

GOVERNMENT POLICIES AND PROGRAMS FOR SUSTAINABLE DEVELOPMENT

Policies of the government for the acceleration of development in the sloping uplands as envisioned in the 10th Five-Year Plan are given below.

Soil Management

There is considerable loss in soil fertility due to soil erosion and unbalance use of fertilizer, etc. Therefore, the soil management program would be extended as per the requirement.

Land Use

Due to the lack of concrete land use plan, fertile agricultural land is being used for non-agricultural purposes. Therefore, the long-term land use plan will be formulated and implemented in order to check the environmental problems so that scarce agricultural land resources are optimally utilized.

Priority Crops

Priority would be given for the production of high value crops such as apple plantation in the high mountain areas, citrus cultivation in the middle mountain, suitable fresh vegetables and vegetable seeds, ginger, cardamom and other spice crops' cultivation are being followed in such sloping lands.

Livestock Raising

There are ample areas for grazing especially in the high mountains. Priority would be given for animal raising in such areas by which the people can raise their income by selling animal products.

Delineation of Production Areas

Special production program would be launched in the selected districts of backward areas of high and middle mountain areas. The production and productivity of millet, barley and buckwheat would be raised by using selected seeds of local varieties.

Services

The farmers of these regions will be provided land management training with special reference to production optimization. Extension and research services and agricultural credit facilities would be extended to the farmers and farming communities for the better utilization of their cultivated land.

11. PAKISTAN

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INTRODUCTION

Total geographical areas of Pakistan is 79.61 million ha, out of which 21.49 million ha are cultivated, 3.66 million ha are under forest, 24.50 million ha are not available for cultivation and 9.13 million ha are culturable waste (Government of Pakistan [GOP], 2000). There has been an increase of 5.36, 0.81, 4.59 and 1.69 million ha in the reported area, forest area, area not available for cultivation and cultivated area, respectively and decrease of 1.73 million ha in culturable waste (Table 1).

Table 1. Land Utilization Statistics of Pakistan

(Unit: Million ha)

Land Use	1980-81	1999-2000	Increase/Decrease Compared with 1980-81
Geographical area	79.61	79.61	
Total area (reported)	53.92	59.28	+5.36
Forest area	2.85	3.66	+0.81
Area not available for cultivation	19.91	24.50	+4.59
Culturable waste	10.86	9.13	-1.73
Cultivated area	20.30	21.99	+1.69

Source: GOP, 2000.

Pakistan is an agricultural country wherein agriculture contributes 24 percent of GDP of Pakistan, employs about 49 percent of the labor force, provides raw material to most of the industries and is a source of foreign exchange earning in addition to meeting the food and other requirements of the inhabitants. In order to meet the basic needs of the burgeoning population, the role of agriculture is getting more importance especially under the circumstances when the resources are degrading and climate is becoming more unfavorable.

Out of the 21.99 million ha cultivated area of Pakistan, 17.32 million ha are irrigated by canals, tube-wells and other sources while 4.67 million ha are rainfed. The irrigated areas are level to nearly level which are faced with the problems of inadequate plant nutrient supply, salinity, water-logging and sodicity, etc. Rainfed agriculture solely depends on moisture received from precipitation but these areas are subject to various degrees of erosion by wind and water. Consequently the natural resources are on severe decline. Because of uneven terrain and erratic rains about 6 million acre feet (maf) of water is lost annually (Chaudhry, 1996).

CLIMATE

Climate of Pakistan ranges from arid subtropical to sub-humid subtropical. The average annual rainfall varies from less than 100 mm to more than 1,000 mm having a bimodal pattern. About 70 percent of the total rainfall is received in summer during July-September in the form of heavy down pours and 30 percent in winter during November-March. Summer temperatures in south and southwestern areas are very harsh as compared to north and northeastern parts of the country. The latter are colder during winter.

AGRO-ECOLOGICAL REGIONS OF PAKISTAN

Based on physiography, geology and climate, Pakistan has been categorized into the following regions (Pakistan Agricultural Research Council [PARC], 1980).

Indus Delta

It represents the deltaic region of the Indus, having arid tropical marine climate. Mean daily maximum summer temperature ranges between 34 and 40ºC and winter temperature between 19 and 20ºC and mean annual rainfall is less than 100 mm. Two types of soils are encountered in the region. The clayey soils are found in the shallow basins and silty soils in the nearly level flat areas. Parts of the clayey soils are under cultivation with rice, sugarcane, pulses and banana whereas strongly saline alkali soils are barren.

Southern Irrigated Plains

The region has been formed by the meandering of the Indus river emerging as lower Indus plain. The climate is arid subtropical continental with hot summer and mild winter having mean maximum and minimum temperature 40-45ºC and 8.5ºC, respectively in the northern areas, and 38-43ºC and 8-12ºC in the southern areas. Mean annual rainfall is about 150 mm, which is received during summer whereas winter is practically dry. Silty and sandy loam soils are predominantly found in the area with active flood plain as the main landform. Upper areas of the flood plains have calcareous loamy and clayey soils. Cotton, wheat, mustard, sugarcane and berseem are grown at the left bank of the Indus whereas rice, wheat, gram and berseem are the main crops on the right bank.

Sandy Desert

The region has xerophytic vegetation and the central part is occupied by salt lakes. Various forms of sand ridges, moving sand dunes and sand sheets with profuse short trees are found in the area. The soils are mostly sandy but at places fine sandy soils are also encountered. Western part has strips of clayey soils, moderately calcareous to strongly calcareous and locally saline sodic, which are used for grazing.

Northern Irrigated Plains

The region constitutes the areas between the Sutlej and Jhelum rivers in the form of different floodplains and bars. The climate is semiarid to arid subtropical continental. Mean daily maximum and minimum temperatures are 39.5 and 6.2ºC, respectively. Mean annual rainfall varies from 300-500 mm in the east and 200-300 mm in the southwest.

The soils of the southern part are sandy loam to clay loam, which are calcareous. The northern part has silty clay and clay loam soils, which are moderately calcareous with minor salinity and sodicity. The sloping sides of the valleys are non-calcareous to moderately calcareous loams. The area is canal irrigated having wheat, rice, sugarcane, oil seeds, cotton and maize crops. Citrus and mangoes are major fruit trees in the central and southern part. Tobacco, sugarcane, sugar beet, legumes and oranges are major crops in the northern part of the region.

Barani (Rainfed) Lands

It covers the salt range, Potwar plateau and Himalayan piedmont plains. A narrow belt stretches along with foot of the mountains, which is sub-humid. Mean monthly maximum and minimum daily temperatures are 38.5ºC and 3.6ºC, respectively. Mean annual rainfall varies from 750 to 950 mm. Southern part is semiarid and hot where the annual rainfall varies from 375 to 500 mm. There is great heterogeneity in the soils and land forms which vary from sandy loam to silty clay loam. Ridge and trough uplands, piedmont plains, alluvial deposits, loess plains and dissected loess plains are major land forms of the region. Wheat, millets, maize, peanut and oil seeds are mainly grown.

Wet Mountains

It covers high mountains intervened by wide and narrow valley plains and plateaus. Eastern part is humid with mild summers and cold winters where mean daily maximum and minimum temperatures are 35ºC and 0-4ºC, respectively on the mountain tops. The annual rainfall exceeds 1,000 mm with snow during winters. Western part is sub-humid Mediterranean with dry summers and rainfall is confined to winters only.

The soils are silty loam to silty clays, non-calcareous to slightly calcareous. The organic matter is about 1 percent in the cultivated soils and 2-4 percent in the forestlands. About 25 percent of the area is under agriculture and the remaining is under forest. Wheat and maize are major crops. Rice and tobacco are grown where spring water is available for irrigation. Apple, pears and peaches are main fruit trees. Conifer vegetation is predominantly present at higher altitudes whereas scrub vegetation is prevalent in the semiarid region. Northeastern part at 5,000 m altitude is under permanent snow.

Western Dry Mountains

It comprises barren hills (1,000-3,000 m) with steep slopes. The climate of the greater part of the region is semiarid highlands with mild summers and cold winters. The annual rainfall varies from 250 to 450 mm. The soils in the valleys are deep loamy, strongly calcareous and shallow on hill slopes. Major land use is grazing. Part of the soils is grown to wheat and a very small portion is irrigated where apples, peaches, plums, apricot, grapes, wheat and maize are grown.

Dry Western Plateau

Mountainous areas have inter-mountain basins and plateaus. Hills are generally steep and rugged with narrow valleys in-between. The climate is arid tropical. Mean annual rainfall ranges from 250 to 375 mm, coastal belt receives sea breeze.

Soils in the plains are silt loam deep, calcareous and shallow in the hill slopes. The lower regions have xerophytic vegetation and grasses; at higher altitudes have juniper forests and wild olives.

Land use is mainly grazing. Melons and sorghum are more extensively grown. Fruits, maize and wheat are cultivated where irrigation water is available.

Suleiman Piedmont

The region comprises the piedmont plains of the Suleiman range and alluvial fans. The climate is arid and hot subtropical continental. The soils are loamy in the gently sloping areas and clayey further away, which are strongly calcareous with narrow strips of salinity/sodicity at the junction of piedmont plain and river floodplains. Torrent watered cultivation is the main land use. Wheat, millets, chickpea and rice are main crops in the region.

LAND CAPABILITY CLASSES

The land capability classes are described by the degree of the limitations and potentialities whereas the subclass is based upon the type of limitation. The limitations are expressed by small letters as below:

- e Erosion
- r Irregular relief, making irrigation difficult
- w Wetness drainage problem or flooding hazard
- s Soil limitation: shallow, sandy, clayey or stony soil science
- a Salinity and/or sodicity: saline or saline-sodic soils
- x River erosion, burial by river, or wind deposits
- c Unfavorable climate.

The extent and distribution of these factors is given in Table 2. This table indicates that coarse textured soils, erosion salinity and sodicity are important factors affecting the soil productivity. Sloping lands have a major threat of erosion problem. Classes and subclasses encountered in Pakistan were described by Mian and Javed (1989), Rafique (1990), and Ashraf, *et al*. (1970). Irrigated and dry farmed lands are being discussed separately.

Table 2. Major Limiting Factors

S.No.	Nature of Limiting Factors	Percent TGA*
1.	i. Soil texture unfavorable (sandy, gravely, stony, shallow, bed rock)	37.9
	ii. Clayey, less permeable, dense layers, clayey impermeable, bed rock	
2.	Erosion limitation prevailing water/wind erosion and past adverse effects	25.5
3.	Climatic limitation (too high/too low temperatures, too low/too erratic rains)	14.3
4.	Sodicity/salinity hazard	11.2
5.	Wetness, water-logging, ponding/flooding	3.3
6.	Frozen soil, snow and ice cover most part of the year	2.2

Sources: Mian and Javed, 1989; and Rafique, 1990.
Note: * TGA = Total geographical area.

Irrigated Lands

Total irrigated area in Pakistan is 17.34 million ha but keeping in view the scope of the workshop the details of the irrigated land classes are not mentioned in the paper as it emphasizes on the sloping lands. However, the extent of the various classes under irrigated lands has been shown in Table 3. These soils are nearly level and have the problems of salinity, water-logging, sodicity, dense soil texture and imperfect drainage. The system originally developed by the U.S. Soil Conservation Service is applicable to dry land conditions. However, it has been modified to suit our irrigated and rainfed conditions. The classes and subclasses are preceded by the letters "ir" and "d" for irrigated and rainfed lands, respectively.

Table 3. Extent and Distributions of Land Capability Classes in the Irrigated Area
(Unit: Million ha)

Class	Land Type	Area
Class ir I land	Very good cropland	5.2
Class ir II land	Good cropland	6.92
ir II s	With heavy clay	4.9
ir II s	With somewhat sandy and somewhat shallow soils	0.8
ir II a	With slightly saline sodic soils	0.6
	Saline gypsiferous soils	0.1
ir II w	Imperfectly drained soils	0.32
ir II e and ir II r	With gently sloping and high lying	0.2
ir III land	Moderate cropland	3.60
ir III a	With porous saline sodic or saline gypsiferous soils	2.44
ir III w	Moderately water-logged soils	0.47
ir III s	With sandy or shallow soils	0.57
ir III e	With sloping soils	0.12
ir IV land	Poor/marginal cropland	1.62
ir IV a	With dense saline sodic soils	0.47
ir IV s	With sandy or very shallow soils	0.54
ir IV w	With severely water-logged soils	0.61

Sources: Mian and Javed, 1989; and Rafique, 1990.

Dry Farmed Land

Area totaling about 4.67 million ha in Pakistan is dry farmed which is dependent upon rains, river flooding, and torrent flood irrigation. Land capability classes and subclasses of the dry farmed area are given in Table 4 and discussed in the following paragraphs:

1. ***Class d II Land (0.23 million ha)***

These have only minor limitations, the lands occur in sub-humid areas. Its subclasses are as follows:

Subclass d II e The problem is due to gentle slopes and is vulnerable to erosion. Bench terracing, contour cropping (especially during summer), and other soil conservation measures are necessary.

Subclass d II c Moisture shortage due to irregular rainfall is the main problem, which necessitates the adoption of the short duration varieties.

2. ***Class d III Land (2.07 million ha)***

This land has moderate potential for agriculture. The subclasses are as follows:

Subclass d III e-with Sloping Soils (0.42 million ha) – The soils are loams, silt loams, or clay loams, with gentle to moderate slopes and a moderate erosion hazard. Low organic matter and high intensity summer rains cause a high rate of runoff and water erosion. Their management involves the construction and improvement of bench terraces, together with water disposal systems, emphasis on summer crops, and other soil conservation measures. Deep tillage/chiseling to about 20 cm depth helps to increase the water intake rate and crop yields.

Subclass d III c-Inadequate Rainfall (0.79 million ha) – The soils are mainly rainfed but it includes some torrent-watered land. Chiseling to about 20 cm depth helps to increase water infiltration into the soil, and provision of a suitable water disposal system is adopted to check soil erosion. A shift to summer cropping, e.g., groundnuts, mung beans, and sorghum, from the present emphasis on wheat would be helpful in increasing agricultural production and in decreasing erosion hazard but this change is not easily acceptable to the farmers.

Subclass d III w-Flood Watered Land (0.86 million ha) – These soils are moderately deep to deep (underlain by sand) loams, silt loams, or silty clay loams, located in active floodplains of rivers and subject to flooding in summer. They are used for growing winter crops of wheat, mustard, and gram. The incidence of flooding has decreased since the construction of Mangla and Tarbela dams, making it possible to develop tube-well irrigation in the higher parts of the land, but summer crops are sometimes damaged due to flooding.

Table 4. Extent and Distribution of Land Capability Classes of Dry Farmed Lands

(Unit: Million ha)

Class	Land Type	Area
Class d II land	Cropland with minor limitations	0.23
d II c	Moisture shortage due to irregular rainfall, low duration	
d II e	Sloping land, vulnerable to erosion	
Class d III land	Cropland with moderate potentials	2.07
d III e	With sloping soils	0.42
d III c	Inadequate rainfall	0.79
e III w	Flood watered land	0.86
Class d IV land	Poorly dry farmed, economically marginal	2.37
d IV c	With severe moisture shortage	1.65
d IV s	Sandy/gravelly or shallow soils	0.48
d IV e	Sloping soils	0.09
d IV x	Unstable soils	0.08
d IV w	Flood watered land	0.07

Sources: Mian and Javed, 1989; and Rafique, 1990.

3. ***Class d IV (2.37 million ha)***

This is a poor dry farmed land, which is economically marginal. Various subclasses are as follows:

d IV e-with Sloping Soils under Semiarid Subclass d IV c-Land with Severe Moisture Shortage (1.65 million ha) – The soils are deep, loamy or silty, and are nearly level. Irregular and uncertain rains cause moisture shortage which limits both choice of crops which can be improved by chiseling to about 20 cm depth. A shift to drought-tolerant crops like groundnut, gram, and mustards would be useful. Growing of agricultural crops along with animal production is an economical and appropriate land use.

Subclass d IV s-Sandy/Gravely and Shallow Soils (0.48 million ha) – The main problems are low water-holding capacity; low rooting depth and low soil fertility. This subclass includes the areas of rainfed, flood watered, and torrent-watered land. Farmers' community tends to level their land, which damages shallow soils instead of improving the land, so it should not be practiced indiscriminately in rainfed or riverine areas. Adoption of drought-tolerant crops like *taramira* (*Eruca sativa* Lamb.) and mustard is only way to get some production from this land, but putting it under grasses and shrubs and use as rangeland is more beneficial.

Subclass Climate (0.09 million ha) – These have loamy and silty soils with moderate slopes. This land has a severe hazard of water erosion which is aggravated by leaving the land fallow in summer and exclusive emphasis on wheat growing. Proper bench terracing and water disposal structures, together with a shift to drought-resistant crops like groundnut and mustards would be useful. These are marginal lands. Their use for grasses and shrubs is beneficial.

Subclass d IV x-with Unstable Soils (0.08 million ha) – These soils are subject to washing away by rivers and streams or burying by infertile material such as sand or fresh river sediment. Such land is located on the bank of rivers/streams or near active sand dunes. Improvement of the soils is usually uneconomical, but stabilizing stream banks and active sand dues helps the protection of the adjoining good cultivated land.

Subclass d IV w-Flood-watered Land (0.07 million ha) – It is located in active floodplains and has sandy soils, which are subject to flooding in summer. Poor crops of gram, mustard, and wheat are grown with residual flood moisture but their use, as forestland is appropriate.

Non-agricultural Lands

These lands are not used for agriculture but can be appropriately used, for grazing and forestland and unclassified land (Table 5).

Table 5. Extent and Distribution of Land Capability Classes of Non-agricultural Lands
(Unit: Million ha)

Class	Land Type	Area
a. Grazing and Forestland		16.86
Class V	Good forest or grazing land	0.17
Class VI	Moderate forest or rangeland	1.26
VI e	Sloping land, erosion problem	0.61
VI w	Wetland	0.03
VI s	Undulating, steep, sandy, gravely or stony	0.45
VI c	Moisture shortage	0.17
Class VII	Poor forest or rangeland	15.43
VII e	With sloping soils	4.5
VII w		0.06
VII s		5.0
VII a		1.2
VII x		0.05
VII c		4.62
b. Class VIII		23.5
c. Unclassified land (riverbed, marshland, towns and others)		1.90

Sources: Mian and Javed, 1989; and Rafique, 1990.

<Grazing and Forest Land>

An area of 16.86 million ha is used for grazing and forest. Further description of classes and sub classes is as below:

1. ***Class V – Good Forest or Grazing Land (0.17 million ha)***

The soils are nearly level, deep but stony, and at some places somewhat imperfectly drained.

2. ***Class VI – Moderate Forest or Range Land (1.27 million ha)***

   The subclasses are as follows:

   Subclass VI e (0.61 million ha) – The soils are moderately steep to steep, and deep but usually stony and are subject to erosion hazard. Proper forest management is needed.

   Subclass VI w (0.03 million ha) – These are wetlands and lack aeration as a moderate problem. The soils are nearly level, moderately deep or deep, but imperfectly drained. Suitable range management is needed.

   Subclass VI s (0.45 million ha) – The soils occur on nearly level, undulating, or steepland. They are very sandy, gravelly, or stony, and thus have low water-holding capacity and fertility. Planting suitable grasses, shrubs, or trees is appropriate land use.

   Subclass VI c (0.17 million ha) – Moisture shortage due to irregular and inadequate rainfall is the main limitation. The soils are nearly level, deep, and well drained.

3. ***Class VII – Poor Forest or Rangeland***

   An area of 15.4 million ha is under poor forest and rangeland which is described hereunder:

   Subclass VII e (4.5 million ha) – This land has a moderate erosion hazard. The soils are shallow or somewhat shallow and stony or gravelly, with steep slopes. Rotational grazing and other range management practices are useful.

   Subclass VII w (0.06 million ha) – Severely water-logged land, and have problem of aeration in the root zone. Marshlands and open water areas are also included. The soils are sandy to clayey, and usually deep. These areas are mostly difficult and un-economical to drain, but may be used as fishpond.

   Subclass VII s (5.0 million ha) – These are very shallow, very sandy, or very gravelly soils, with severe problems of low water-holding capacity, causing drought.

   Subclass VII a (1.20 million ha) – These are severely saline sodic and saline gypsiferous soils. Some parts also have high water table (within 1.5 m depth). The soils are loamy to clayey, but dense and nearly impervious to water or very strongly saline.

   Subclass VIII x (0.05 million ha) – Unstable soils, occurring along active river or streambed and subject to erosion or burial by infertile sediments.

   Subclass VII c (4.62 million ha) – The soils are loamy to clayey. Low moisture availability because of semiarid and arid climate is the main problem.

4. ***Non-arable, Non-grazing and Non-forest Land***

   Class VIII (23.5 million ha) – This land has no potential for cultivation, forestry, or grazing because of very severe limitations imposed by soil erosion, excessive wetness, and lack of porosity, unstable soils, very arid climate, or ice/glacier cover.

5. ***Unclassified Land***

About 1.9 million ha are in the form of unclassified land in Pakistan, which include riverbeds, marshlands, towns and other miscellaneous.

GOVERNMENT POLICIES AND PROGRAMS FOR SUSTAINABLE DEVELOPMENT OF SLOPING UPLAND AREAS

Sloping upland areas are subject to water erosion and government has been trying to address the issues of these areas and to reduce the pace of the problem since 1951. There are a number of agencies/ organizations like Soil Conservation Directorate, Watershed Management Projects, Water and Power Development Authority, Murree Kahuta Development Authority, Agency for Barani Areas Development and lot of NGOs, which are involved in it. The Federal Government has already established Soil Survey of Pakistan. The organization has completed reconnaissance soil survey of almost all the areas of Pakistan and the detailed soil survey of some of the selected areas wherein the soil classification has been made into soil series, associations and orders. For this purpose a comprehensive soil taxonomic system developed by U.S. Department of Agriculture Soil Survey has been adopted (USDA, 1975). Soil properties, which can be measured and verified, are considered as basic and fundamental criteria for soil classification. In addition to the description of the soil characteristics, the limitations and the potentials of soils have also been identified.

There is no legal binding for the landholders to use it for a specific purpose. This is the reason that misuse of land, mismanagement of land and indiscriminate felling of trees and irregular grazing are the main causes in accelerating the erosion problem. However, the focus of the government policies has been on the following perspectives:

- Use and management of sloping lands in accordance with the land capability classification (limitations and potentials).
- Reducing the length and steepness of slopes for arable farming, which is achieved by terracing.
- Trapping the rainwater where it falls or just close to it. This is achieved by retaining major proportion of the precipitation in the soil and reducing runoff through appropriate soil management and crop management practices.
- Safe disposal of surplus rainwater without causing damage to the land surface.
- Collection of surplus water in the water storage reservoirs and facilitate its recycling for domestic and agricultural uses.
- Planting trees and grasses on the non-arable lands and reduction in the indiscriminate felling of trees and overgrazing of rangelands.
- Rehabilitation and management of degraded lands through various measures.

ISSUES AND PROBLEMS

The government has launched different programs for sustainable development of the sloping areas and there are a number of government/non-government agencies engaged in carrying out various activities. There are three types of lands in Pakistan; namely, government lands, crown lands (*Shamlats* – communal properties) and private lands. The extent of government lands in these areas is very small. However, the crown lands are quite common in each village. The following issues and problems are involved in the sustainable development and management of the sloping lands.

- There is sufficient information about lands pertaining to soil characteristics, classification, potentials and limitations but there is no legal framework for enforcing the farmers to use the land in accordance with the capability classes (potentials and the limitations).
- Steeper slopes are cultivated, as every farming community desires to produce food crops for their families. This improper land use and mismanagement is leading to the degradation of natural resources.
- Small and fragmented holdings: The landholdings are very small and these are located in the form of small parcels at different places. Hence their management involves more input and most of these holdings are uneconomical and are not being managed properly.
- Poor economic conditions of the farmers: The farming communities in these fragile areas are very poor because of low productivity of the soils. Hence they do not posses sufficient funds to invest in land husbandry.
- Exodus of farm families: Because of the low productivity level and less return, most of the farm families have migrated to the urban areas. The farms have been abandoned and have led to further degradation of the natural resources.
- Shortage of forage and fuel: There is an acute shortage of forage and fuel in the area. For this purpose the trees are being felled and grasslands are overgrazed which is leading to degradation in biodiversity and denudation of the land resources.
- Costly soil and water conservation measures: Some of the soil conservation measures are costly and beyond the reach of the common farmers unless these are carried out at government expenses or these are subsidized.
- Lack of linkage between research, education and extension services: These organizations are operating independently. Most of the research activities are not problem-oriented and extension agents are not well acquainted with the latest technological developments.

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12. PHILIPPINES

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OVERVIEW OF THE UPLAND AGRICULTURE

Upland agriculture contributes significantly to the socio-economic conditions of the Philippines. Apparently, agricultural activities are concentrated in the highland region of the Cordilleras situated in the northern part of the Philippine archipelago.

The Cordillera Administrative Region is composed of six provinces – Abra, Apayao, Benguet, Ifugao, Kalinga and Mountain province. It has 75 municipalities and one chartered city – Baguio – referred to as the "summer capital of the Philippines".

Inhabited by the indigenous people, the region's population increased to 1,525,000 with a growth rate of 63.82 percent from 1985 to year 2000. The region has a total area of 1,829,368 ha, of which only 18.6 percent are certified alienable and disposable, while the remaining 81.4 percent are considered forestlands and unclassified public forest. Based on existing vegetation and cover, lands are classified as: agricultural areas, brush lands, grasslands, built-up areas, mossy forest, old-growth forest, other land uses, pine forest, residual forest, and river beds/water bodies.

Predominantly, very steep slopes to nearly level slopes in areas towards the lowlands characterize the region. More than one-half of the total land area has a slope of 50 percent and above. Thus, there is a very limited area for intensive agricultural production. Elevation ranges from 5 m to around 3,000 m above sea level. Nevertheless, the region is famous for its rich cultural heritage and ethnic diversity. The indigenous people are known to have built their scenic rice and vegetable terraces, not only as their land use systems and way of life, but also for tourism.

More significantly, the Cordillera is considered as the locus of vegetable production in the Philippines. Capable of producing about a million tons of vegetables and crops, it sufficiently supplies to about 70 percent of the Philippine markets and even exports to other countries. Rice production in these areas, however, cannot satisfy the needs of the populace. This is probably because traditional rice varieties are grown and produced like the glutinous or fancy rice due to its adaptability to the low temperature in these highland areas.

The indigenous farmers in the region have also a common system of land resource management. Although their landholdings are small and fragmented, they follow simple strategies to promote sustainable agriculture in their own way.

LAND CLASSIFICATION AND ITS EFFECTS

The chronological records reveal that the colonizers and local ruling elite made attempts to encroach on the ancestral lands of the indigenous people in the Cordilleras and displace them from their lands. History had been replete with bitter experiences of displacement and disposition over these ancestral lands in the Cordillera. This particular region, being rich in natural resources like minerals, forests, hydropower, and other uses, has always been looked upon by the colonizers and subsequent governments as a principal resource area.

Ultimately, another crucial issue compounded the situation in the Cordillera region. The Bureau of Forest Development (BFD) of the Department of Environment and Natural Resource (DENR) outlined only 18.6 percent of the Cordillera region as alienable and disposable (A&D). The greater portion of 81.4 percent is still classified as forest reserves, timberlands, national parks, watershed reserves, and military and civil reservations.

Further, the current tension surrounding land tenure makes the issue of resource access and control over the land prevalent in the Cordillera. The incongruence between land use and land classification creates tension between the government and the indigenous people. These government issuances are unfavorable to the Cordillerans since most of these lands are actually occupied for many years. With the indigenous farming systems of the people, these lands are even agriculturally improved and developed. Hence, the people considered this land classification biased and discriminatory especially when the small farmers and inhabitants were considered as 'squatters on their own land'.

Evidently, there do exist agricultural lands over the lands still classified as forests/timberlands but are not yet A&D. Of course, the perfection of ownership over these lands is impossible because of such land classifications. This affected the security of tenure of the farmers, as well as the agricultural productivity of these lands. Obviously, the other adverse effects of not owning the land include the improper use of the natural resources, and fast expansion or encroachment towards the forest reserves.

GOVERNMENT POLICIES AND PROGRAMS ON SUSTAINABLE DEVELOPMENT

All legislations and issuances on resource management and sustainable development are based on the Philippines Constitution, which is the basic law in the country. For the past decades, several legislations and legal issuances have been passed. These specific legislations provided the proper implementation of programs and projects geared towards sustainable development. At this standpoint, government interventions are expected to play a significant role for the realization of the vision for development that is laid down by the laws enacted. The following are the major policies and programs on sustainable development practicable in the sloping uplands of the Cordilleras.

National Integrated Protected Area System (NIPAS)

Established by Republic Act (RA) No. 7586, the NIPAS Act provides the establishment and management of integrated protected areas system, defining its scope and coverage. Further, this policy refers to the classification and administration of all designated protected areas to maintain essential ecological processes and life support systems, preserve genetic diversity, ensure sustainable use of resources found therein, and to maintain their natural conditions to the greatest possible extent. The lead implementing agency is the DENR.

Community-based Forest Management (CBFM)

Under Executive Order 263, CBFM is adopted as the national strategy for achieving people-centered development. The locus of decision-making with regard to the sustainable use of resources lies with the communities of that area. Being implemented by the DENR, the communities are organized to manage and preserve their own resources for the future generations. Community concerns are brought into play through participatory process.

Local Government Code of 1991

This code mandates each local government unit (LGU), in conformity with existing laws, continues to prepare their respective comprehensive land use plans enacted through zoning ordinances, which are the primary and dominant bases for the future use of land resources and maintaining ecological balance. Through this RA No. 7160, power is given to the local governments to reclassify land according to its use and suitability. However, this is not meant for them to allow the conversion of agricultural lands to other non-agricultural purposes.

Agriculture and Fisheries Modernization Act (RA 8435)

This is an act prescribing urgent measures to modernize the agriculture and fishery sectors of the country in order to enhance their profitability, and prepare these sectors for the challenges of globalization through an adequate, focused and rational delivery of necessary services, appropriating funds for these purposes. This defines the creation of the strategic agriculture and fisheries development zones (SAFDZs) as center or convergence of development.

Comprehensive Agrarian Reform Program (RA No. 6657)

Land reform or agrarian reform is not a new program in the country. The Comprehensive Agrarian Reform Law was signed on 10 June 1988 instituting the agrarian reform program, which was the core program strategy of the government under the reign of President Corazon C. Aquino. RA No. 7905 was again issued to strengthen the implementation of the Comprehensive Agrarian Reform Program. Comprehensive as it is, the coverage of land acquisition and distribution became wider to include all agricultural lands of the public domain regardless of what crop is produced. Aside from land distribution, program-beneficiaries development is another major program of this department. Under this program, creation of viable and self-sustaining Agrarian Reform Communities (ARCs) is a special strategy of modernization and industrialization.

Official Development Assistance (ODA)/Foreign-assisted Projects (FAPs)

The government through its departments is tasked to mobilize resources from any outside sources. However, their resource mobilization efforts are hardly felt by the upland Cordillera region. There are limited special projects or FAPs related to sustainable development in the region. Some of the special projects being implemented in the region are:

- Central Cordillera Assistance Program (CECAP-ADB [Asia Development Bank]);
- Cordillera Highland Agriculture and Resources Management Program (CHARM-ADB);
- Agrarian Reform Infrastructure Support Project (ARISP-OECF [Japanese Overseas Economic Cooperation Fund]); and
- Cooperative Development Authority-JICA (Japan International Cooperation Agency).

ISSUES AND PROBLEMS FOR SUSTAINABLE AGRICULTURE

It is a reality that despite the efforts of various sectors of society for a socio-economic growth especially in the uplands, many issues and impediments, which must be carefully addressed to, have always been cropping. However, it is accepted that nobody can solve national problems properly and effectively without first understanding the nature of the problem.

Nonetheless, the basic problems of the upland areas are linked with other problems, and the other problems are related still to other problems until they boil down into one: the land problem. Notwithstanding, the major problems, issues and development concerns of the upland Cordillera are enumerated and discussed as follows:

Low Productivity and Income

The stability and sustainability of the agricultural production systems in the Cordillera is a paramount concern of the rice and vegetable producing provinces of the region. The high cost of inputs and the lack of adequate capital for production are frequently mentioned as the cause of low productivity and income of the farmers.

However, at some points, low productivity is also due to soil depletion and soil erosion making the soil infertile for vegetable and crop production.

Improper Use or Unregulated Use of Fertilizers and Pesticides

The use of fertilizers and pesticides was a little bit reduced when the integrated pest management (IPM) technologies were inculcated to most of the vegetable producers. But, due to high incidence of hard-to-control pests and diseases, the farmers are forced to go back using even the branded pesticides and fertilizers.

Again, the ill effects of this problem would be polluted environment, health hazards, high erosion and slow rate of reforestation.

Inadequate Infrastructures and Basic Services

Geographic location, topography and slope of the Cordillera affected the infrastructure development of the region. Till now there are still other municipalities in the provinces that are not reached by farm-to-market roads, pre- and postharvest facilities, and other infrastructures. More than that, irrigation as a factor in the production systems in the region is very inadequate. These significantly affect the level of living and life expectancy of people in the highlands. Basic services delivery is likewise hampered by lack of infrastructures and lack of funds.

The Marketing System and Its Price Mechanism

The problem in marketing has been a perennial problem in the upland vegetable industry. The upland farms are able to produce millions of tons of crops like potatoes, cabbages, carrots and other perishable vegetables. However, marketing systems are defective. Middlemen and other unscrupulous businessmen control the prices of these perishable products such that the farmers get a little or no profit.

Evidently, there is high cost of inputs while the prices of the farm produce are low. Most of all, the "supply system" in the region is very disadvantageous and discriminatory towards the farmers.

Land Tenure Security

Land security implies a guarantee for those who invest today, that they will get the benefits of that investment tomorrow. Farmers will generally take the responsibility and the risk of long-term investment at the cost of immediate sacrifices, only if they have a guarantee that the land and the resources they have invested in will not be taken away. But, with this outdated land classification in the sloping uplands and the perplexed laws affecting the ownership of lands, the farmers are hindered to perfectly own these agriculturally developed lands. Hence, the cry of the indigenous people to own their ancestral lands is still in flame.

Forest Denudation and Environmental Stress

Deforestation and forest degradation caused by uncontrollable forest fires, as well as illegal harvesting of forest products and biodiversity have reduced the region's forest cover. As a consequence, there has been accelerated soil erosion, siltation of water reservoirs, rivers and waterways, shortage of wood and other forest products, and even extinction of unquantifiable number of plant and animal species. And, with fewer trees to soak up carbon dioxide from the atmosphere, the risk of global warming has been increased.

Decreased Carrying Capacity

The rate of extraction of resources seems to exceed the rate of resource generation. This issue is primarily attributed to the population pressure due to displacement and encroachment over the forest areas. For most, the genetic diversity of indigenous species (flora and fauna) is continuously declining. And, the danger is that when the carrying capacity is exceeded, nature is said to compensate by reducing the population in one way or the other and this has happened in many parts of the country.

Siltation and Human Encroachment

Mining and resource exploration as well as the traditional farming systems cause soil erosion of the upstream ecosystems resulting in severe siltation in the low-lying areas. In addition, freshwaters and irrigation became infested. This has critically been seen in the hydroelectric dams in the region that are highly silted. Eventually, this siltation affects the efficiency and affectivity of these dams to generate power as expected. Again, agricultural production in the sloping areas is affected.

Lack of Funds for Development Programs and Projects in the Uplands

Several sound plans and proposals for development to combat the complicated problems, issues and concerns in the sloping lands of the Cordillera have been conceptualized, written and proposed. However, the limiting factor is the lack of government funds. Participatory development approach had been advocated in the rural communities. Nevertheless, these communities need to mobilize outside resources to assist them in development.

CONCLUSIONS AND RECOMMENDATIONS

Based on the foregoing discussion, the following conclusions, recommendations and plans of action are drawn:

- Agricultural productivity improvement should be given emphasis considering the present contributions of upland agriculture to the country's economy. Application of appropriate farming technologies should be enhanced through continuous research and diffusion of technologies in the upland areas. Promotion of sustainable agriculture and continuous provision of the needed support mechanisms should be given emphasis by the national leaders and policymakers in order to sustain the gains of agricultural development in the Cordilleras.
- People participation should be encouraged in all development activities affecting their lives. Frequent consultations and massive information drives can increase their awareness on the proper management of the natural and environmental resources around them. Hand-in-hand, the effects of the improper use of fertilizers and pesticides should be ingrained to the farmer users.
- Infrastructure development is much needed in the sloping areas in the Cordilleras. Without infrastructure development, all other development initiatives will be hampered. Provision of support infrastructures will lead to the solution of the many problems besetting the region.
- Marketing system should be addressed. Without efficient marketing system in place everything that the farmers are able to produce goes waste.
- Land ownership problems in the Cordilleras can be lessened through reclassification of land. On one hand, the comprehensive agrarian reform law should be implemented in close coordination with the other project stakeholders and line agencies. The provisions in the law that agriculturally developed lands will be covered should be implemented so that farmers in these areas are secured. At the same time, the immediate implementation of the Indigenous People's Right Act covering the ancestral lands will solve some of the ownership problems in the highlands.
- The intensification of reforestation programs and agro-forestry projects in the Cordillera mountains will greatly help in minimizing the environmental stress and thus, regeneration of lost resources will occur. Apart from these, awareness program on resource management and its effects on livelihoods should immediately be undertaken.
- Institutional development in the upland communities is very vital in sustainable development. This is because man is the center of development and that the people should be organized and empowered. In the end, they would be having equal access to the resources and a fair share of the benefits thereof.

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13. SRI LANKA

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INTRODUCTION

Prior to the advent of plantation agriculture, especially tea, the residual uplands in the mid and up country of Sri Lanka were under the natural forest or else under home gardens that carried an assortment of tree crops. There was no real need for soil conservation under that system of land use. The introduction of tea plantation however, has entered into a cycle of loss of productivity and land degradation. At present, out of 6.5 million ha of land in the country, only about 33 percent or 2.2 million ha are considered arable. With 20 million of country's population to feed, per capita availability of arable land is about 0.13 ha. The total extent of steep uplands, where the average slope gradient generally exceeds more than 30 percent is about 1.45 million ha, which is about 22 percent of the total land area in the country. However, per capita availability of arable land in the steep hilly region is significantly reduced when areas unsuitable for agriculture is added into the calculation, either because they are reserved for forestry or wildlife or are too steep, rocky or eroded for agriculture.

As arable land becomes scarce, young farmers from the hill country are moving up the steep slopes into previously unsettled, marginally productive lands, often belonging to the government. The phenomenon is fairly recent, with more settlers having arrived within the last decades. Constrained by poverty and technology, the present users of these lands, in their pursuit of better income, food and fodder have converted large extent of marginal lands for annual cropping. The farmers grow lucrative annual cash crops such as potatoes, tomatoes and tobacco and rely on limited crop rotation or fallowing and heavy application of chemical fertilizers to maintain yields as topsoil erodes and fertility declines. These farming practices exacerbate soil erosion problems, reducing already marginal fertility in the highlands and increasing the silt load in dams for irrigation projects downstream. Therefore, it is imperative that a scientific approach to improved land use be continued and strengthened. More intensive use must be made of the land and higher yields must be obtained from agricultural areas, along with more careful husbandry of the land resources. Otherwise declining yields, impoverished soils, increasingly eroded areas with ever more common landslides, and many other characteristics of a land that is neglected will lead to a vicious circle of increasing poverty. Hence, there is an urgent need for a good land suitability assessment so that the appropriate crops can be grown on these marginal areas of steep highlands.

STATUS OF LAND CLASSIFICATION

The need for land suitability classification was strongly felt in 1940s with the implementation of major irrigation settlement scheme Galoya, when certain allotments distributed among farmers were found not suitable for cultivation. However, in 1960s, with the commissioning of Mahaweli river development project, the land classification work in the country got underway in a more systematic manner (Land Use Division). The scope of the land classification study was to determine at a scale of 1:10,000 the potentiality of the irrigable land that will be provided with water to be diverted from the wet zone. The limiting factors for the arability of the lands were recognized according to the general land classification specifications of the U.S. Bureau of Reclamation, with modifications to suit local conditions. The land classification maps compiled have been successfully used for delineation of suitable areas for upland crops, rice cultivation, settlements and siting of townships in the project area. Much of the work associated with the collection and analysis of land capability information has been carried out by the Land Use Division of the Irrigation Department. Most of these investigations were however, confined to areas coming under irrigation development projects in the Dry Zone.

In another study, the suitability of the lands for major land uses in Sri Lanka has been assessed using generalized Geographic Information System (GIS). Data on soils, climate and topography have been analyzed to arrive at overall land suitability for the entire country, regardless of present land use. These data can be used only to obtain overall notions of land suitability for national scale planning.

Land Use Division of the Department of Irrigation has recently carried out land suitability evaluation based on FAO classification system in five districts coming under Integrated Rural Development Project (IRDP), including two districts, Nuwaraeliya and Ratnapura where the landscape is predominantly hilly or mountainous. However, full use of this information has not been realized, as these regions are not understood by non-technical staff or even by local technical staff who are unfamiliar with the classification system.

Soil erosion hazard and land suitability survey carried out in the Nuwaraeliya district under IRDP (Zejestra, 1989) indicates that vegetatively propagated (VP) tea, mixed perennial crops or production and protective forestry are the highly or moderately suitable alternative land use systems for erosion-prone areas in the district.

Soil erosion hazard assessment carried out in the Nuwaraeliya and Kandy districts indicates that about 70 percent of the total land area of the two districts needs to be introduced with perennial tree-based cropping systems (Bandara and Somasiri, 1991).

The Natural Resources Management Centre of the Department of Agriculture has carried out soil erosion hazard mapping, using GIS technology in three districts in the mid and up country (Munasinghe, *et al*., 2001). This study provides some useful information on areas (land uses) affected under different degree of erosion, which could be used for identifying priority areas for land suitability classification.

LAND CLASSIFICATION IN SLOPING UPLAND AREAS

Subdued and relatively homogeneous topography, a limited number of land use options available for evaluation and, a little spatial variability in rainfall within a given agro-ecological region in the Dry Zone of Sri Lanka make it easier for the collection and analysis of information on land suitability. On the other hand, wide variations and combinations of soils, climate, topography, and susceptibility of lands to erosion, landslides or loss of fertility, make evaluation of land suitability in the steep hilly areas exceedingly complex. Hence, in order to determine land suitability for steep hilly regions, thorough understanding of the above factors of the physical environment and socio-economic conditions and, careful analysis of these data are very essential. Another major limitation with regard to land suitability evaluation in the hill country regions is the lack of adequate research information on the requirements of various land use options considered to be suitable for these areas.

Physical Environment

1. ***Climate***

According to agro-ecological map of Sri Lanka, country is divided into 24 agro-ecological regions (Figure 1). The total annual rainfall and its distribution, elevation above mean sea level, soil distribution and land use are the main criteria used in compilation of this map. The sloping uplands described in this report represent at least 12 such regions. The areas above 1,000 m, 1,000-300 m and less than 300 m above mean sea level (amsl) have been identified as up, mid and low country, respectively and denoted by letters U, M and L in the map. The numerical values 1 and 3 represent the highest and lowest rainfall regions while the value 2 represents intermediate level of rainfall within a given major agro-ecological region. At present agricultural planning in the country is primarily based on the information provided in the agro-ecological map. During land use planning and/or land classification studies, it is assumed that a given agro-ecological region has a uniform rainfall distribution and somewhat homogeneous physical environmental conditions. This assumption, in certain hilly areas, contradicts with the actual field conditions. The topographical variations in certain areas of steep high lands are so diverse and hence there is considerable spatial variability in rainfall even within the same agro-ecological region. Similarly, other physical environmental conditions

Zone	Agro-ecological Region and Symbol		75% Expectancy Value of Annual Rainfall (mm)
Wet Zone	Up Country	WU1	>3,175
		WU2	>1,900
		WU3	>1,400
	Mid Country	WM1	>3,150
		WM2	>1,400
		WM3	>1,250
	Low Country	WL1	>2,525
		WL2	>1,900
		WL3&4	>1,525
Intermediate Zone	Up Country	IU1	>2,150
		IU2	>1,400
		IU3	>1,150
	Mid Country	IM1	>1,400
		IM2	>1,150
		IM3	>900
	Low Country	IL1	>1,020
		IL2	>1,150
		IL3	>900
Dry Zone	Low Country	DL1	>775
		DL2	>900
		DL3&4	>575
		DL5	>500

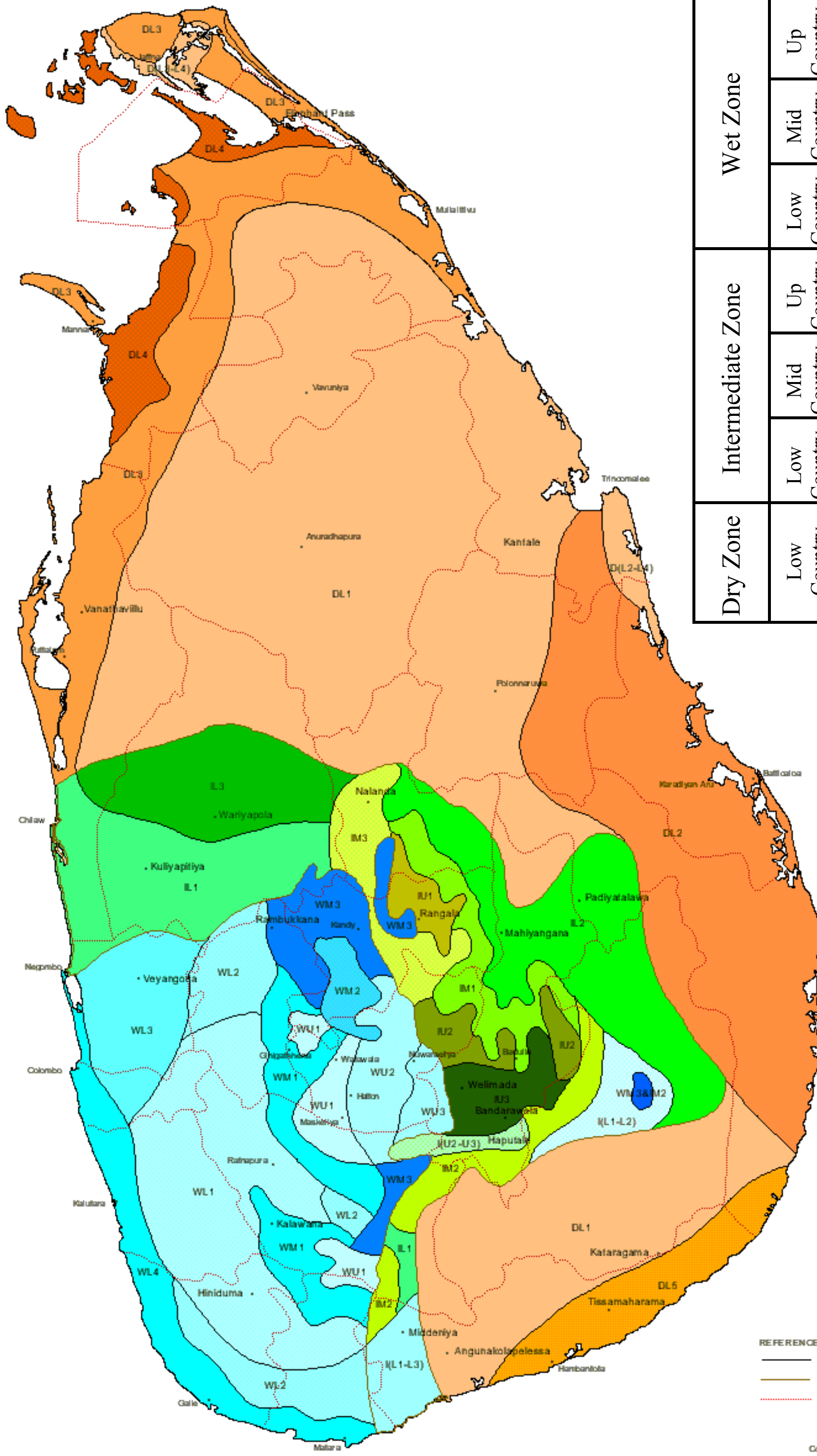

Figure 1. Agro-ecological Map of Sri Lanka

such as soil depth, relief, drainage, surface rockiness, as well as socio-economic status of people vary considerably. These micro variations have to be taken into consideration in order to develop land use scenarios for different situations that exist within a given agro-ecological region. Therefore, the existing agro-ecological map is presently being revised to enable better understanding of micro level agro-climatic variations in the country.

2. ***Land Use***

The land use distribution of six districts coming under steep hilly region of the country is given in Table 1. Other than tea, major land uses in steep hilly region are: rainfed vegetable or tobacco (sparsely used croplands), market gardens with continuos cultivation of vegetables or potato (other croplands), homesteads, scrublands, natural forest and forest plantation comprising pines and eucalyptus. Some of these land uses and land management practices associated with them do not fit very well with the physical environmental conditions of the area and hence, have a "bad press". The soil erosion reported under different cover types are shown in Table 2.

The above information indicates that market gardens, poorly managed seedling tea, *chena* and tobacco lands, pine plantation and degraded *patana* lands are the most vulnerable land use types in the mid and up country region. Another important aspect of environmental concern with regard to pine plantations is its effects on rapid depletion of soil moisture, which of course is yet to be assessed using quantifiable data. However, now it is generally accepted that dry weather flow generated from the areas occupied by this particular land use is quite low. If *patana* grasslands are protected against grazing, they provide a better protective soil cover than most forest plantations. But, most of the *patana* lands too are in a state of degradation primarily due to fire hazard and overgrazing. Hence, the lands occupied under above cover types are the areas where land use changes, and hence the land suitability classification studies should immediately be contemplated in the mid and up country of Sri Lanka.

3. ***Topography***

The topography of the sloping hilly areas can be characterized by rolling, hilly or mountainous landscape with average slope gradient ranging between 30 and 60 percent. It is reported that about 20 percent of the total land area in the hill country includes lands with more than 60 percent slopes. But this figure of 20 percent is seen by many to be slightly lower. Nevertheless, the landscape in the central hill country could be divided into four or five distinct slope categories in order to derive land suitability ratings for different land use options. Another important topographical feature, which apparently exerts significant influence on crop performance but has not been considered, hitherto in land suitability evaluation studies, is the slope aspect. This information could be derived from digital elevation models using GIS technology.

4. ***Soils***

The major soil types occurring in the central hill country are red-yellow podsolic (RYP) soils (*tropudults*), reddish brown latosolic (RBL) soils (*rhodudults*), immature brown loams (IBL) (*eutropepts*) and mountain regosols (MR) (*troporthents*). The RBL are best expressed within the 1,900 and 2,500 mm isohyets. When the rainfall is over 2,500 m isohyets, RYP is the dominant soil type. Except for the slightly higher base saturation in the subsoil of RBL, both soils are well structured and less erodible and hence impart better response to management. IBL soils are immature soils having weakly expressed profile characteristics. Because of the poor structural stability of soils steep hilly and rolling nature of the landscape on which they occur, these soils are highly vulnerable to soil erosion. MR occur on very steep slopes. They have undergone natural erosion and considerable mixing by colluviation and no longer have any recognizable genetic horizons except for a weakly developed surface horizon. Due to their shallow depth, they have limitations for supporting a good stand of vegetation and are therefore very fragile when exposed. However, none of these soil types can be treated potentially homogeneous in terms of land and crop management because of the variations in different phases of depth, drainage, slope and surface rockiness.

Table 1. Land Use in the Mid and Hill Country Regions (Kandy, Nuwaraeliya, Matale, Kegalle, Badulla and Ratnapura Districts)

Land Use	Kandy		Nuwaraeliya		Matale		Kegalle		Badulla		Ratnapura	
	Area (000 ha)	%	Area (000 ha)	%	Area (000 ha)	%	Area (000 ha)	%	Area (000 ha)	%	Area (000 ha)	%
Homesteads	37.16	19.6	11.40	6.7	20.65	10.3	44.27	27.0	35.23	12.5	52.48	16.0
Tea	29.34	15.5	62.58	36.7	5.52	2.8	5.66	3.4	36.02	12.8	21.30	6.5
Rubber	2.97	1.6	0.30	0.2	2.94	1.5	49.07	29.9	0.96	0.3	35.83	10.9
Coconut	3.87	2.0	0.31	0.2	4.97	2.5	10.78	6.6	-	-	3.73	1.1
Mixed perennial crops	9.06	4.8	0.49	0.3	4.70	2.4	8.22	5.0	0.52	0.2	4.22	1.3
Paddy	20.60	10.9	5.35	3.1	20.82	10.4	10.88	6.6	20.01	7.1	23.20	7.1
Sparsely used cropland	28.28	14.9	8.63	5.1	45.60	22.9	0.02	0.0	84.43	29.9	101.57	31.0
Other cropland	3.89	2.1	10.44	6.1	2.40	1.2	20.97	12.8	6.26	2.2	0.34	0.1
Dense forest	22.23	11.8	30.41	17.9	48.10	24.1	8.24	5.0	20.95	7.4	48.43	14.8
Open forest	8.12	4.3	10.57	6.2	9.51	4.8	2.45	1.5	34.50	12.2	14.07	4.3
Forest plantation	1.38	0.7	7.59	4.5	2.26	1.1	0.97	0.6	12.89	4.6	2.32	0.7
Scrub land	12.11	6.4	9.88	5.8	20.18	10.1	0.93	0.6	14.24	5.1	11.97	3.7
Grassland	6.01	3.2	7.56	4.4	5.58	2.8	0.20	0.1	10.23	3.6	3.15	1.0
Barren land	0.55	0.3	0.51	0.3	1.59	0.8	0.50	0.3	1.69	0.6	0.63	0.2
Other land use	3.56	1.9	4.32	2.5	4.68	2.3	0.95	0.6	4.27	1.5	4.30	1.3

Source: Proceedings of the Workshop on Economic Policy Reforms and the Environment – Land Degradation in Sri Lanka, 1997.

Table 2. Soil Erosion under Different Cover Types

Cover Type/Land Use	Soil Loss (mt/ha/year)	Location
Well-managed tea	20	Nuwaraeliya district
Poorly-managed tea	75	- do -
VP tea	15	- do -
Well-managed VP tea	0.24	Mid country
Rubber	10	Nuwaraeliya district
Chena and tobacco	75	- do -
Market gardens	20-100	Upper Mahaweli catchment
Mixed gardens	0.05-10	- do -
Patana	5	Nuwaraeliya
Degraded *patana*	30	Upper Mahaweli catchment
Dense forest	0.3	Nuwaraeliya
Degraded forest and scrubs	10	- do -
Pine (with ground cover)	0.5	Ginigathhena
Pine (no ground cover)	40	Madulkelle
Eucalyptus with cardamon	3	Kelebokke

Source: Munasinghe, *et al*., 2001.

Socio-economic Status

Watershed basis of land use planning/land classification is the widely accepted approach for sustainable agricultural development. Any area selected for land use planning or land classification in the mid and hill country of Sri Lanka on the above basis usually falls within more than one major agro-ecological region. The upper areas of watersheds, usually being confined to up country hilly region (where elevation usually exceeds 1,000 m amsl), encounter with temperature limitations for certain crops. The lower reaches of watersheds usually end up either in mid or low country where the elevations amsl are less than 1,000 m and 300 m, respectively. These elevation differences have direct impact on land use compositions, and consequently on socio-economic status of people in the watersheds.

The people who live in up country region are of two ethnic groups; Tamil estate workers of Indian origin and Sinhalese moved up steep slopes due to land limitations in their traditional villages in downstream areas. They have very small landholdings with which they are compelled to earn their living. Constrained by limited extent of partially degraded land and poverty but blessed with wealth of experience in soil conservation in nearby tea estates, farmers belonging to both communities are very keen to utilize every inch of their lands for agriculture, with precautionary measures to ensure long-term sustainability of their lands. Therefore, any incentives provided for the development of their lands are well received and fully made use of by these farmers.

On the other hand, the traditional villagers in downstream areas are blessed with more resources. The climatic and soil conditions in these areas are such that wide range of crops can be grown. Per capita land availability is considerably higher compared to that of upstream areas. However, these farmers are not very much concerned about conservation or sustainability of their uplands, because their main sources of income generates from rice and vegetable cultivation in valley bottoms and terraced rice lands in foothill slopes. Any land use or land management interventions recommended for improvement of uplands are considered unimportant and treated in a very lethargic manner.

The Use of GIS for Land Classification

The basic principles of land use planning and soil conservation teach us that each unit of land has its own particular characteristics, its own capabilities and its own limitations. Therefore, it is very important that we plan our systems of land use to fall within the capabilities of the particular unit of land being studied. If this is done properly, we produce plans, which can lead to optimum sustainable production. But, the diverse nature of the physiography, soils, climate, land use and socio-economic status in the mid and up country regions make land suitability evaluation extremely complex.

The aforesaid description of the physical environmental conditions of steep hilly regions clearly indicates the existence of large number of land units with various combinations of factors of the physical environment in the mid and hill country regions. Each of these land units need to be evaluated separately for number of land use options in order to determine the most suitable land use scenario for a particular land unit. Hence, manual interpretation, superimposition and analysis of large volume of data collected from number of disciplines would be a daunting task in the hilly region, where thematic information available are of different scales and intensities and, the spatial and temporal variability of the factors involved in land classification are so diverse. Hence the use of GIS technology would be very useful for land classification studies in these areas.

PRESENT GOVERNMENT POLICIES FOR SUSTAINABLE DEVELOPMENT OF SLOPING UPLAND AREAS

Article 28 of the Constitution of Government of Sri Lanka states that "it is the duty of every person in Sri Lanka to protect nature and conserve its riches". Sri Lanka has a long history of natural resource legislation. Among the more prominent pieces of legislation related to natural resources are: the Forest Ordinance of 1907, Land Development Ordinance of 1935, Fauna and Flora Protection Ordinance of 1937, Mines, Quarries and Minerals Ordinance of 1947, the National Heritage and Wilderness Act of 1987 and the National Environment Act of 1980 which was amended in 1988 to include Environmental Impact Assessment and issue of licenses for industries potentially producing air, water and land pollution.

However, the most important policy document, which is directly related to protection and development of sloping areas, is the Soil Conservation Act of 1951, in which number of regulations have been framed for the protection of sloping areas. The regulations on the use of lands steeper than 60 percent slopes as well as lands above 1,500 m amsl for agriculture and other development purposes, prevention of fire in *patana*, grasslands and scrub lands, protection and conservation of perennial spouts and natural springs, conservation of degraded lands with exposed rocks, stones, bare and shallow soils, conservation of lands cultivated to annual crops, the distances at which conservation measures to be adopted for specific slope categories and establishment of leader drains depending on catchment yields, etc. are included in the above Act.

The goal of the National Land Use Policy, which is being formulated, is the rational utilization of land as a resource, in the national interest while ensuring high quality of life, equity and ecological sustainability. The policy places much emphasis on agriculture and food security, land ownership and natural resource conservation. Most of the regulations on soil erosion control are included in this document too and hence there are certain overlaps between the National Land Use Policy and Soil Conservation Act. In addition, Land Use Policy document stresses the need to utilize state lands based on land capability and the needs of the both community and the national economy.

MAIN ISSUES AND PROBLEMS IN LAND CLASSIFICATION IN STEEP HIGHLANDS

Despite the grim warnings indicated by severe soil losses, earth slips, landslides, downstream flooding, and loss of life, land classification/land use planning as a strategy of development has been rather slow. Even today land use planning in the country is done on a very *ad hoc* basis. This situation is reflection of many constraints in the way of land use planning in Sri Lanka. The more important of these are:

1. ***Absence of Proper Land Use Policies***

Since significant proportion of the lands in Sri Lanka belongs to the state, much of the effort of successive government has been focused on the alienation of lands to the landless people. Consequently many of the statutes passed by the state pertaining to land contains provisions that relate more to the distribution of land rather than the actual use of the land. Provisions more directly related to land use planning are found only in statutes, such as Soil Conservation Act, the Agricultural Productivity Law, Agrarian Services Act, and the Natural Environmental Act. However, even in these Acts, no provisions have been made to address issues pertaining to haphazard allocation of lands for different uses without considering their suitability. The National Land Use Policy is now being formulated to ensure the rational use of land based on its suitability.

2. ***Land Ownership (State Lands)***

Other than lands belonging to private individual and private organizations, land ownership lies with number of boards and authorities. Hence state loses it control over them.

3. ***The Existence of Multiplicity of Institutions***

The existence of multiplicity of institutions dealing with matters related to land use planning. There is no coordination amongst them. The data collected by individual institutions are not easily accessible to others. As a result, there is a duplication of efforts by many institutions collecting the same information thus wasting public funds.

4. ***Absence of Adequate Data for Land Use Planning***

For effective land use planning, especially in hilly region of the country where physical environmental conditions are so diverse, the detailed information is necessary on the nature, suitability of the land, hazards involved in manipulating land for different purposes, and social, cultural and political constraints that may affect or limit options for recommended land uses. This type of information however, is not readily available. Furthermore, except for tea, the research information on the requirements of the land utilization types is not available for comparison with resource information and to determine their suitability.

5. ***Land Ownership and Land Tenure Constraints (Private Lands)***

The large extent of seasonal croplands, especially in areas where one season cropping is possible due to low rainfall distribution are leased out and their present users are not much concerned about soil erosion control or productivity enhancement. Most of these lands are not suitable for seasonal cropping and hence should be replaced with more stable land uses. But present users are reluctant to do away with the existing land uses since it will deprive of their regular source of income. Their only motive is to exploit these lands as much as possible during their period of tenure.

6. ***The Complexity of Technical Terminology Used in Land Classification***

The commonly used suitability classification system in Sri Lanka is the one adopted by FAO. This system of classification with certain modifications to suit local conditions could be a good replacement for land capability classification system of the U.S. Department of Agriculture, but it is not familiar to many technical staff. Some even believe that the land suitability evaluation study is purely a soil scientist's job. Hence, the land suitability information, given in the form of maps and reports are not understood by many technical and non-technical staff. Therefore, land suitability recommendations put forwarded, are left unused as irrelevant to agricultural development in the country.

CASE STUDY

The cross-fertilization between participatory methodologies, which have been rapidly developed since the 1980s, and more technical suitability surveys are starting to form the basis for participatory land use planning. In view of the above, small-scale participatory land use planning programs have been initiated in nine selected micro catchments in the central hill country areas of Sri Lanka under the World Bank funding.

The main objectives of this project were:

i. test and develop on watershed basis suitable technologies for minimizing the extent of land degradation and its on-farm and off-farm impacts and thereby increasing the agricultural productivity of selected micro catchments in the central hill country.
ii. examine feasibility of participatory management of micro watershed by beneficiaries.
iii. define technical and investment criteria useful in replicating watershed development activities in other hilly areas of the country.

Based on land suitability classification, suitable crops, crop and land management technologies have been identified for all the selected micro catchments. In certain areas, where there was full farmer participation, to a certain extent, the objectives envisaged by the project have been achieved in spite of certain limitations in administrative hierarchy. However, by taking into consideration overall progress of the project, this cannot be cited as an example of a successful participatory land use planning exercise.

Conflicts in administrative and technical hierarchy, officialdom of different government organizations, an eternal interference of NGOs and lack of farmer motivation and participation are the main detrimental factors which greatly contributed to slow progress of this project.

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14. THAILAND

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OVERVIEW

Thailand has a total area of about 513,115 km^2. The climate of the country is dominated by the monsoon and therefore, most of the country is a tropical savannah (Koppen 'Aw') with the exception of the southeast coast and southern peninsula where tropical monsoon (Am) predominates and the northern mountains which are humid subtropical (Cw). Country receives an average annual rainfall ranging from 900 to 4,000 mm. Annual temperature ranges from 24 to 26ºC in the northern highlands, 28 to 30ºC in the central plain and 26 to 28ºC in the rest of country. The six physiographic regions of the country (Moormann and Rojanasoonthon, 1968) are: North and West Continental Highland, Central Plain, Central Highland, Northeast Plateau, Southeast Coast and Peninsular Thailand.

Agriculture in Thailand

Agriculture in Thailand is guided by the dominating hot and humid climate. Over half (56.3 percent) of the landmass of the country is cropland (Table 1) where rainfed agriculture is widely practiced. Among the various crops grown in Thailand rice dominates the lowlands, while corn, sugarcane, cassava, rubber and fruit trees occupy important place in sloping upland areas (Table 2). Maize is mostly grown in the northern region from low to high elevation, while cassava and sugarcane are widely grown in the northeast on loamy and sandy soils. Rubber is predominant in the high rainfall areas of the south and the east. Fruit trees are distributed throughout the country but cover less area in the northeast.

Table 1. Land Use of Thailand

(Unit: km^2)

Land Use	North	Northeast	Central	East	South	Total	
Agriculture	66,447	117,322	38,712	22,162	44,308	288,951	(56.3)
Forestland	94,622	36,782	22,840	8,249	21,301	183,794	(35.8)
Water bodies	1,245	3,494	1,195	388	1,162	7,484	(1.5)
Miscellaneous lands	3,370	4,994	2,459	2,052	2,415	15,290	(3.0)
Urban area	3,961	6,262	4,314	1,530	1,529	17,596	(3.4)
Total	169,645	168,854	69,520	34,381	70,715	513,115	(100.0)
	(33.1)	(32.9)	(13.5)	(6.7)	(13.8)		

Source: Thongma, 1998.
Note: Figures in parentheses are percent of total.

Table 2. Distribution of Some Economic Upland Crops in Thailand

(Unit: km^2)

Types	North	Northeast	Central	East	South	Total	
Corn	10,370	4,753	3,239	1,758	-	20,120	(3.92)
Sugarcane	3,989	9,137	5,925	2,022	-	21,073	(4.11)
Cassava	2,873	14,805	1,794	3,356	-	22,828	(4.45)
Pineapple	115	20	1,636	235	4	2,010	(0.39)
Soybean	94	-	73	1	-	168	(0.03)
Rubber	5	136	109	2,750	28,473	31,473	(6.13)
Oil palm	-	-	3	2	156	161	(0.03)
Eucalyptus	167	562	546	319	6	1,600	(0.31)
Coffee	1	-	1	-	643	645	(0.13)
Orchard	2,422	732	2,668	2,236	3,565	11,623	(2.27)
Citrus	159	3	306	7	5	480	(0.09)
Coconut	-	17	1,225	211	1,272	2,725	(0.53)
Longan	684	4	-	-	-	688	(0.13)
Lychee	88	5	0.3	0.1	-	93.4	(0.02)

Source: Thongma, 1998.

Note: Figures in parentheses are percent of country.

In general, agricultural production in Thailand is low and unstable from year to year due to erratic rainfall and the naturally poor natural resource endowment. Land degradation is one of the key problems causing decline in productivity. Moreover, with increasing population farming is expanding to areas of low agricultural potential. In addition, cropping intensity is increasing without following adequate sustainable resource management practices. Consequently, farmers are registering declining crop yields across the country.

Shifting cultivation by the northern Thai tribes is common in the mountain areas. It is leading to declining natural vegetative cover that otherwise would protect the soil from erosion. At national level, shifting cultivation in Thailand is regarded as causing sedimentation of river courses and reservoirs, drought calamity, and flood disaster due to the high rates of surface runoff during rainfall events, and consequent soil erosion.

In addition, there are many problem soils that have low agricultural productivity due to physical and chemical constraints, such as shallow soils, sandy soils, calcareous soils, etc. In some areas such problem soils are quite extensive. Inappropriate land uses, i.e., cultivation of unsuitable lands or encroachment on forestlands are common in Thailand. The conversion of cropland for non-agricultural purposes is rising throughout the country.

Land Resources Inventory for Agriculture

The general approach to soil survey is based on the methods and techniques described in the U.S. Department of Agriculture (USDA) Soil Survey Manual and Soil Taxonomy with some modifications. The official soil classification system adopted is currently the USDA soil taxonomy system. Since 1963, systematic soil survey in Thailand has been carried out by the staff of the Soil Survey and Classification Division (former Soil Survey Division), Land Development Department (LDD), Ministry of Agriculture and Cooperatives (former Ministry of National Development).

At present, the Soil Survey and Classification Division of LDD is the only government organization carrying out the national, provincial and district soil survey programs in Thailand. Thai soil survey has completed the detailed reconnaissance soil survey of all provinces since 1979, and have published the general soil maps at a scale of 1:100,000 with the reports. Afterwards, semi-detailed and detailed surveys for districts, farms, and development projects have been conducted. Soil survey data and information have been interpreted for various purposes, but mostly for agriculture.

Sloping Uplands

The potential significance of slope to land use and management varies widely from soil to soil. Soils vary in their erodibility on different slopes and also behave differently under different crop or plant cover and cultivation techniques. However, there has not yet been clear definition of sloping upland in Thailand. During the detailed reconnaissance survey, Thai soil survey followed the USDA system and classified the slope into five classes: 0-2, 2-8, 8-16, 16-35 and >35 percent. Areas with slopes exceeding 35 percent are mapped as slope complex. To coincide with soil and water conservation techniques, the soil survey of Thailand modified the slope classes into 0-2, 2-5, 5-12, 12-20, 20-35, 35-50, 50-75 and >75 percent (Table 3).

Table 3. Sloping Land Classification in Thailand

Percent Slope	Complex Slope	Simple Slope
0- 2	Level to nearly level	Level to nearly level
2- 5	Gently undulating	Gently sloping
5-12	Undulating	Moderately sloping
12-20	Rolling	Strongly sloping
20-35	Hilly	Moderately steep
35-50	Steep	Steep
50-75	Very steep	Very steep
>75	Extremely steep	Extremely steep

Source: Potichan, 2002.

As indicated by the names of the slope classes, sloping uplands may be defined as lands with a slope of 2 percent or greater. As for drainage, sloping upland soils are commonly well-drained, moderately well-drained, or excessively drained, and as such are not suitable for paddy rice or hydrophilic plants. However, poorly drained soils may also occur on sloping uplands.

LAND CLASSIFICATION SYSTEMS

Thailand has adopted many systems for land classification, but most are based on soil survey interpretation systems: the modified USDA land capability classification, soil suitability classification, U.S. Bureau of Reclamation (USBR) economic irrigable land classification, and FAO guidelines for land evaluation. All are used by LDD. Watershed classification is used by the Royal Forest Department (RFD) to classify sloping upland areas.

Modified USDA Land Capability Classification

Thailand uses USDA land classification system with major modifications. The system is an interpretative grouping based on individual soil map units. Arable soils are grouped together according to their potential and limitations for sustained production. The classification is divided into different broad categories of land use: upland crops, paddy (wetland rice) and rubber. The broad capability class shows degree of limitation while subclass indicates the nature of any limitations.

Classification based on the land capability classification system for upland crops groups soils into eight broad classes, with the risk of soil damage or the limitations in use becoming greater from class U-I to class U-VIII. Soils in class U-I to U-IV are suitable for upland crops. Soils in class U-V through U-VII are not generally suited for the cultivation of upland crops. But they may be suited for other uses, such as grassland, woodland, tree crops and rice. Soils in class U-VIII do not produce economic returns in agriculture or forestry, but may require planting or treatment for watershed protection and downstream benefits.

A classification system based on suitability for paddy production was developed by the Land Classification Division of LDD. The soils are placed into broad groups: P-I to P-V. Soils in groups I through IV receive enough water and have characteristics that enable them to retain water on the soil surface for periods long enough to mature one crop of rice in most years. Soils in groups V are not suited for rice grown under submerged conditions, but may be well suited for other uses.

A special suitability grouping for rubber is classified into groups from R-I to R-IV. In group R-IV, soils are not considered suitable for rubber cultivation.

Soil Suitability Classification

Thai soil survey has determined that the modified land capability classification is not appropriate for land use in Thailand, due to the different kinds of crops and land use patterns. Therefore, it has developed guidelines for soil suitability classification for specific crops or groups of crops, such as paddy rice, upland crops, rubber, pasture, and woodland. In 2000, guidelines for soil suitability classification for 29 economic crops were revised.

The soils are classified into five classes according to their potential and degree of limitations: i) very well suited; ii) well suited; iii) moderately suited; iv) poorly suited; and v) unsuited.

Subclasses indicate the kind of limitations. Crop-wise suitability and unsuitability along with area under different land classes are given in Table 4.

Table 4. Land suitability in Thailand

S.No.	Land Suitability Class	Area		
		rai	km^2	Percent
1.	Suitable for cash crops	67,683,529	108,293	21.11
2.	Suitable for paddy field	84,469,300	135,151	26.34
3.	Suitable for trees in rainfed	16,359,806	26,176	5.10
4.	Unsuitable for economic crops but may may be some specific crops	49,828,820	79,726	15.54
5.	Unsuitable for agriculture	99,875,685	159,803	31.14
6.	Wetland	2,478,810	3,966	0.77
Total		320,695,950	513,117	100.00

Source: www.ldd.go.th/Efiles_htm/land%20resource/ed0200.htm.

Modified USBR System

This system was prepared for the conduct of feasibility grade land classification surveys for the Lam Nam Oon (Oon River) Project in 1967. It was essentially based on the standard USBR system but with the important modification of recognizing two special classes suitable for wetland rice. The classes are:

Class 1: Diversified crops-arable lands that are highly suited to irrigated agriculture.
Class 2: Diversified crops-arable lands that have moderate to fair suitability for irrigated agriculture.
Class 1 R: Wetland rice-arable lands that are highly suitable for paddy rice production under irrigation.
Class 2 R: Wetland rice-arable lands of moderate to fair suitability for paddy rice production under irrigation.
Class 5: Non-arable land not currently suited to irrigated agriculture, but warranting further study.
Class 6: Non-arable land not suited to irrigated agriculture.

Modified FAO Framework for Qualitative Land Evaluation

This system has been used by the Land Use Planning Division of LDD since 1985. It is a universal framework for the evaluation of land. It was developed by FAO after wide international consultation. This system provides practical guidelines on the planning and execution of the various steps in land evaluation from interpretation of basic data (mainly soil survey data) to the final recommendations, which form the basis for land use planning and project implementation.

There are two fundamental concepts in the system, land unit (LU) and land utilization type (LUT). LUs comprise the physical environment including climate, soils, relief, and hydrology, while LUTs are possible uses of land, including agricultural and non-agricultural. Principally, the system classifies all lands into order, class, and subclass according to the degree of suitability and types of limitations, as given in Table 5.

Table 5. Land Suitability Classes and Subclasses

Order	Class	Subclass
S: Suitable	S1: Highly suitable	
	S2: Moderately suitable	S2 m (moisture deficiency)
	S3: Marginally suitable	S3e (erosion hazard)
N: Not suitable	N: Not suitable	

WATERSHED CLASSIFICATION

In 1975, the Ministry of Agriculture and Cooperatives proposed the classification of the Mae Ping watershed in the North into three classes. These proposed criteria assigned about 60 percent of high altitude land (above 700 m above mean sea level [amsl]) as Class 1. Lands so classified were to be protected from any use of their natural resources. Classes 2 and 3, for land of lower elevation, could be utilized for mining, forestry, agriculture, etc. Since there were many squatters already resident in areas proposed as Class 1, considerable conflict and controversy developed among government agencies. For example, the Ministry of Industry, dealing mining operations, requested that the criteria be revised.

In 1979, a new concept for classifying sloping upper land areas, referred to here as watershed classification, was initiated with the support of various organizations both national and international, such as Kasetsart University (KU), the Office of National Environment Board (ONEB) of Thailand, and also Swedish Aid through the International Union for Conservation of Nature (IUCN). The objectives of watershed classification are an extension of land use planning for properly allocating land for various uses. The Watershed Classification Committee (WCC) was established to continue the identification of the inherent capacity of a landscape unit to be managed for the production of either plants or animals. It is intended to make man's use of land as compatible as possible with the features of the natural environment and to mitigate the on-site and off-site effects of such uses.

With the agreement among government agencies, the sloping upper land areas on the watershed were classified as:

1. ***WS Class 1: Protected or Conservation Forest and Stream Headwater Areas***

   This class is further divided into two subclasses:

   1A: These are protected forest areas and include the headwaters of rivers. These areas are usually at high elevations and have very steep slopes and should remain under permanent forest cover.

   1B: These are areas that have similar physical and environmental features to WS Class 1A, however, a portion of these areas has already been cleared for agricultural use. These areas may be fallow or cultivated; they therefore require special soil conservation protection measures. Where possible, they should be reforested or maintained under permanent agro-forestry.

2. ***WS Class 2: Commercial Forest***

These areas are designed for protection and/or commercial forests where mining and logging will be allowed within legal limits. They are usually at high elevation with steep to very steep slopes. Landforms usually result in less erosion than WS Class 1A and WS Class 1B. The areas may be used for grazing or crop production if accompanied by appropriate soil protection measures.

3. ***WS Class 3: Fruit Tree Plantation***

These areas cover uplands with steep slopes, but less erosive landforms. Such areas may be used for commercial forests, grazing, fruit trees, or certain agricultural crops with need for soil conservation measures.

4. ***WS Class 4: Upland Farming***

This class describes those areas of gentle sloping lands suitable for row crops, fruit trees, and grazing with a moderate need for soil conservation measures.

5. ***WS Class 5: Lowland Farming***

WS Class 5 includes gentle slopes or flat areas appropriate for paddy fields or other agricultural uses with few restrictions.

Methodology

In order to classify the land in this way, a method of establishing potential land uses based on physical and/or environmental features of landscape units is needed. Physical features, such as elevation, slope, landform, geology, soil, and long-term average climatic factors (temperature, rainfall, solar radiation, etc.), are quite stable. Environmental features are less stable and interact with short-term climate trends and human uses, which influence plant and animal populations.

The concept of "variable in a database" is used to represent features of landscape units without exact identification of the variables. It assumes an appropriate selection of variables for a database, and requires the manipulation of the database to produce a WS class map. Each variable must be assigned a numerical value and scale in relation to WS class and the method can be used to assess a functional relationship between variables and WS class number. Independent contribution of variables to variance in WS class must be identifiable so that the database created from measured and/or scaled features of the environment can be analyzed.

A functional relationship between features of landscape units and land use can be expressed as Land Use Capability (LUC).

$$LUC = F(C)\ (G)\ (S)\ (SLP)\ (LF)\ (B)\ (O)$$

where: LUC = land use capability – equivalent to the WS class number of a landscape unit.
F = an unknown mathematical relationship or interaction between variables or landscape features.
C = long-term average climate – includes seasonal or annual rainfall or temperatures, wind, solar radiation, evapotranspiration, etc.
G = geology – includes relationships of geological formations, geochemical weathering, etc.
S = soils – includes soil formation, physical properties related to erosion, chemical properties related to productivity.
SLP = slope – steepness of land surface.
LF = landform – defined based on geomorphology related to recent erosional processes.
B = biotic features – including interactions of climate, plants, soils and animals.
O = other features which should be considered in uses of the land, including forest cover, wildlife habitat, endangered species, or habitat for endangered species.

Watershed Classification in Thailand

The original watershed classification system proposed by RFD used only elevation as a variable and was found seriously wanting. The lesson learned was to consider all parameters relevant to the classification of the capability of watershed lands, including hydrology, soil, geology, geomorphology, geography, water quality, ecology, forestry and socio-economic variables.

Variable Selection

Requiring variables that are stable and currently available, five were selected from among the more than 20 variables initially proposed by committee members. The five selected for Thailand's watershed classification system were: **slope, elevation, landform, geology**, and **soil**. Slope, elevation and landform can be measured from contour maps. Soils and geology types also were generally available from maps prepared by LDD and the Mineral Resources Department, respectively. A **forest cover** variable was included after discussion during the second workshop in Chiang Mai in December 1984 for two reasons. First, an overall objective of the watershed classification system is to maintain a given minimum area under permanent forest cover. Second, many land areas mapped as WS Class 1 have been occupied by villagers and used for agriculture for several decades. Areas of WS Class 1 are subdivided into WS Class 1A and WS Class 1B based on the presence or absence of forest cover.

Derivation of Watershed Classification Prediction

Test areas for each region were selected for developing and testing a WS class prediction equation. Landscape units (1x1 km^2 grids) within the test areas were randomly selected and assigned a numerical WS class value based on the definitions of WS class and scale value for each variable. A multi-variable analysis developed the mathematical relationships of variables with known WS class. Thus, a prediction equation for each region based on values for each variable in the landscape unit was derived.

The prediction equations for each region are:

1. ***Northern (Ping-Wang-Yom-Nan watershed)***
   WS Class = (1.929-0.048 slope – 0.0036 elev + 0.1067 lform + 0.1159 geol + 0.1925 soil) + for
   $R^2 = 0.9682$
2. ***Northeastern (Mun-Chi watershed)***
   WS Class = (1.071-0.019 slope + 0.001 elev + 0.190 lform + 0.049 geol – 0.013 soil) + for
   $R^2 = 0.9925$ (if elev >50 or 500 m amsl, WS Class 1)
3. ***Southern***
   WS Class = (2.341-0.026 slope – 0.011 elev + 0.156 lform – 0.088 geol – 0.230 soil) + for + min
   $R^2 = 0.9682$
4. ***Eastern***
   WS Class = (1.882-0.0365 slope – 0.0019 elev + 0.1154 lform + 0.2716 geol + 0.070 soil) + for + min
   $R^2 = 0.9969$
5. ***Central/Western***
   WS Class = (1.838-0.0291 slope – 0.0066 elev + 0.1559 lform – 0.0452 geol + 0.0042 soil) + for + min
   $R^2 = .9830$

Field Test and Mapping Procedures

Testing procedures consisted of two steps. First, the equations were formulated through the use of the computer program, and maps were printed with grid areas of approximately 1x1 km^2. The computer maps were then checked in the field. In the second step, the selected area was mapped using the equations developed in the first step. The resulting maps were examined in the field and discussed in stakeholders' workshop. The final product was then applied to all areas in the region.

POLICY AND THE AGRICULTURAL DEVELOPMENT PLAN

Thailand is rapidly moving from an agriculture-based economy to an industrial economy. During the past four decades, much of Thailand's economic growth has been based on continued expansion of agricultural land, particularly in the steep highlands. This has had a major impact, contributing to the deterioration of the natural resource base, and degradation of the environment. Therefore, issues regarding agriculture, natural resources, and the environment have been included in the National Economic and Social Development Plans, since the Seventh Plan (1992-96). The emphasis in agricultural development is sustainability. The main objectives of the agricultural plan are:

i. to sustain the agriculture sector's growth at an appropriate level.
ii. to increase the income of farmers and eradicate poverty.
iii. to rehabilitate degraded natural resources.

Guidelines have been established in order to attain the aforementioned objectives:

i. Encourage greater efficiency in the use of natural resources to serve as a basis for agricultural production. Suitable agricultural land must be preserved. A land use plan for each area must be prepared.
ii. Encourage agricultural research and development. Emphasis will be placed on improving the transfer of production technology and the provision of necessary production inputs. The private sector will be encouraged to participate in conducting agricultural research.
iii. Restructure agricultural production in such a way that is in line with market demand.
iv. Conserve and protect the land suitable for agriculture (at least 35 percent of the country – 25 percent cropland, and 10 percent for livestock).

v. Promote and support the appropriate and efficient use of land compatible with its potential.
vi. Develop and support agro-industry. Support the production of value-added manufactured products, which use domestic raw materials.
vii. Improve the efficiency of agricultural development agencies. Prepare agricultural restructuring plans at the provincial, district, and sub-district levels.
viii. Protect against soil loss and soil degradation. Rehabilitate degraded soils.

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15. VIETNAM

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INTRODUCTION

Vietnam is located in the Southeast Asia region. The total land area of the country is about 33 million ha, three-fourth of which is mainly mountainous area with sloping uplands. Based on the ecological mapping, nine different zones have been identified in Vietnam, of which seven zones belong to sloping upland. Almost all of these areas have very poor living conditions and unstable agriculture production caused by various factors such as high and sloping topography, poor know-how of minority ethnic groups, slash-and-burn practices affecting soil fertility. During the past decade the Vietnam Government set up a specific strategy for the socio-economic development for the resource management of watershed regions. In the national land evaluation project focusing on the land-use planning of the sloping upland areas, Vietnam applied FAO guidelines based land classification methods for different levels (regional, provincial and district levels) so as to map suitable/sustainable land-use systems.

STATUS OF AGRICULTURE ON THE SLOPING UPLAND AREAS

One of the most important factors for assessment of the agro-forestry production systems in sloping upland areas of Vietnam is the agro-ecological zoning. These agro-ecological zones is given in Table 1.

Vietnam is entering into a new stage of its socio-economic development with rapid economic growth, albeit from a low base and a good track record of macroeconomic management. The economy has been transformed into market-oriented system since the introduction of "*Doimoi*" (reform) in 1989.

The first ever living standard measurement in Vietnam concluded that one-fifth of Vietnamese households lived below the internationally accepted poverty line, that is ranked on the basis of access to basic food and non-food needs. However, Government of Vietnam established its own norms for defining poverty and according to which 22 percent households live below the poverty line. Among these around 3-4 percent are affected by chronic hunger.

With nine out of every 10 poor living in the rural areas, poverty is essentially rural in nature. Geographically, uplands in the North, North Central Coast and Center Plateaus regions are home to poverty in Vietnam. Farmers as a class have highest incidence of poverty (60 percent) and within the farming community, the ethnic minorities inhabiting the sloping uplands have highest incidence (66-100 percent).

It is well recognized that strategies for agricultural development in the uplands should focus on adopting sustainable agriculture practices. As a consequence, almost all the national and international programs are based on the following:

C Hunger eradication and poverty reduction among ethnic minority.
C Increasing household incomes through promoting agro-forestry systems.
C Effective soil erosion control program on sloping lands.
C Growing diversity of crops on slopping lands based on suitable land classification and extension activities.
C Land and water resources management using Land Law 1993 as effective policy of land and forestry allocation to the households.

Table 1. Agro-ecological Zoning of Slope Lands in Vietnam

Zone	Area (million ha)	Topography	Soil	Rainfall (mm/year)	Vegetation
North-eastern	3.4	Sloping, steep mountains limestone highlands	Acrisols and ferralsols	1,300-2,700	Forest, fruit trees, annual crops, shifting cultivation
Vietbac-Hoanglienson (Northern)	4.2	Mountains and limestone highlands	Acrisols and ferralsols	1,500-3,000	Forest, fruit trees, tea, annual crops, shifting cultivation
North-western	3.6	Mountains and limestone highlands	Acrisols and ferralsols	1,100-2,400	Forest, fruit trees, tea, annual crops, shifting cultivation
Central Coast of Northern Vietnam	5.1	Mountainous uplands small plains	Acrisols, ferralsols and arenosols	1,300-2,400	Rice tea, coffee, fruit trees, annual crops, forest
Central Coast of Southern Vietnam	4.6	Mountainous uplands small plains	Acrisols, ferralsols and arenosols	1,500-2,000	Rice, fruit trees, black pepper, annual crops
Central High Plateau	5.5	Undulating to rolling, mountainous	Ferralsols and acrisols	1,500-2,000	Perennial industrial and annual crops, fruit trees, forest, shifting cultivation
East of Southern Vietnam	2.4	Undulating to rolling	Acrisols	1,800-2,500	Rubber, coffee, fruit trees, annual crops

Source: National Institute of Agricultural Planning and Projection, 1996.

SLOPING UPLAND CLASSIFICATION SYSTEM OF VIETNAM

Land classification is an important tool of land-use planning for sustainable production systems in the mountains of Vietnam. Since 1994, Vietnam follows the FAO framework on land classification and land evaluation. In 1996, Vietnam published the findings of the National Program on "Vietnam Land Use Evaluation for Productive Use and Ecological Stability". Under this program, different sustainable land-use types of Vietnam were classified jointly by the experts of Tran An Phong and other agencies. As a result of this program, the soil scientists of Vietnam completed the land suitability classification for land-use planning in different ecological zones of the whole country. Given below are key findings of this project.

Land Suitability Classification – Country Level

By matching land-use requirement with soil characteristics and qualities as well as other factors such as land management, environmental impact and socio-economical analysis for selected land-use types; a land classification map of Vietnam has been compiled at a scale of 1:1,000,000. Based on land suitability classification, three main land suitability classes – S1 (highly suitable), S2 (moderately suitable) and S3 (marginally suitable) have been identified. The main land-use types representing Vietnam's agricultural production systems were classified as follows (Table 2).

Table 2. Vietnam's Land Classification at National Level

S.No.	Major Land-use Types	Area (million ha)	Suitability Rating		
			S1	S2	S3
1.	Paddy rice	4.38	1.57	1.70	1.11
2.	Annual industrial and subsidiary crops	1.66	0.41	0.77	0.48
3.	Perennial industrial tree crops and fruit trees	1.84	0.54	0.73	0.57
4.	Grassland/pasture	0.53	0.15	0.22	0.16
5.	Agro-forestry systems	0.58	-	0.44	0.14
6.	Aquaculture	0.42	0.42	-	-

Source: Tran an Phong, 2001

Land Suitability Classification – Provincial Level

A case study for land classification at provincial level was carried out in Tuyen Quang, a mountain province in the Northern Vietnam. Based on land mapping units with sloping upland characteristics and based on land-use type characteristics like land-use conditions, socio-economic factors, environment and social impacts, the land classification map was completed at a scale of 1:50,000. Following land characteristics were used to set up land mapping units of land-use types (LUTs) of slopping upland:

1. ***Soil Type***

   G1-G7: where G1 denotes alluvial soils; G2 is grey alluvial soils; G3 degraded soils and terraced paddy soil; G4 black soils; G5 ferralic soil on limestone and shift stone; G6 ferralic soil on marimba acid stone, sandy stone and old alluvial; and G7 denotes ferric humic on the high mountain.
2. ***Slope Angle***

   SL_1-SL_4: where SL_1 >25º; SL_2, 15-25º; SL_3, 8-15º; and SL_4 <8º.
3. ***Soil Effective Depth***

   D_1-D_3: where D_1 >100 cm; D_2, 50-100cm; and D_3 <50 cm.
4. ***Total Temperature per Year***

   T_1-T_3: where T_1 <7,000ºC; T_2, 7,000-8,000ºC; and T_3 >8,000ºC.
5. ***Rainfall per Year***

   R_1-R_3: where R_1 <1,800 mm; R_2, 1,800-2,400 mm; and R_3 >2,400 mm.

From the present 37 LUTs of the province, through the suitable land classification, 10 suitable land-use types were selected:

i. Paddy rice on terraces
ii. Paddy rice – cash crops (maize, soybean, peanuts)
iii. Cash crops (maize, soybean, peanuts) and annual industry crops: lemon, crops, sugarcane, pineapples
iv. Long time industry trees (tea, coffee)
v. Fruit trees (orange, longan, jackfruit, banana, etc.)
vi. Upland crops (cassava, soybean, maize) by rainfall
vii. Agro-forestry systems
viii. Production forestry
ix. Pasture
x. Aquaculture.

Land Suitability Classification – District Level

This is a case study of land classification of mountainous Doan Hung district, Phu Tho province, northern agro-ecological zone (AEZ) (total land area of more than 30 thousand ha). At this level, detailed land-use types have been classified in the category of subclass and unit (cropping system) of land classification system. The land classification map is made at a scale of 1:25.000.

Land characteristics of land mapping unit are identified for land-use requirement of land-use types:

1. ***Soil Types***

Following soil classification of FAO-UNESCO, 13 soil types were chosen (district fluvisols, district leptosols, eutric leptosols, haplic arenosols, district gleysols, umbric gleysols, xanthic ferralsols, haplic ferralsols, plinthic acrisols, gleyic acrisols, ferric acrisols, arenic acrisols and haplic acrisols).

2. ***Slope Angle***

SL_1: 0-8º; SL_2: 8-15º; SL_3: 15-25º; SL_4: >25º.

3. ***Irrigation Condition***

1: Full irrigated; 2: partially irrigated; and 3: rainfed.

4. ***Effective Soil Depth***

D_1: >100 cm; D_2: 100-50 cm; and D_3: <50 cm.

5. ***Soil Texture***

ST_1: Light; ST_2: medium; and ST_3: heavy.

6. ***Rainfall***

R_1: >2,000 mm/year; R_2: 1,600-2,000 mm/year; and R_3: <1,600 mm/year.

Following land classification structure of FAO guideline, seven suitable LUTs have been identified for Doan Hung district (Table 3).

Table 3. Land Suitability Classification of Doan Hung District

S.No.	Major Land-use Types	Total Area (ha)	Suitability Rating		
			S1	S2	S3
1.	Two paddy rice crops	7,005.64	257.25	5,569.87	1,178.52
2.	Rice crop + subsidiary crop	219.63	186.35	33.28	-
3.	Subsidiary crop	1,163.69	915.74	224.59	23.36
4.	Non-irrigated tea	5,236.52	1,342.70	2,480.94	1,412.88
5.	Non-irrigated coffee	3,804.51	-	1,071.39	2,733.12
6.	Fruit trees	2,504.74	1,023.80	1,461.81	19.13
7.	Forest	10,976.52			

Source: Ho Quang Duc, 1999.

These results of land classification at different levels are an important database for land-use planning. They can be of great help when the government authorities make decisions on how to use land most effectively, especially of sloping upland areas.

GOVERNMENT POLICIES AND PROGRAMS FOR SUSTAINABLE DEVELOPMENT OF SLOPING UPLAND AREAS

Vietnamese Government recognizes that widespread poverty is one of the most pressing socio-economic problems in almost all upland areas of the country. The UN Poverty Report has found that households in the mountain areas, who have shifted to diversified economy, including diversification to agriculture, have attained higher living standards than those still depending on subsistent traditional rice-based farming systems, which also includes several other subsistence crops.

The government requested the Ministry of Agriculture and Rural Development (MARD) to prepare a National Program for Rural Development in Vietnam over the period 1996-2000 with long-term projections 2000-10 and sustainable mountain agricultural program 2000-05. After the National Program 327 for re-greening the barren hills, a new program has been launched on "Five Million Hectares of Agro-forestry" on sloping uplands of Vietnam. In order to implement this program, land-use planning at provincial to district level in the mountain regions needs to be accomplished. Therefore land classification, as a tool of land evaluation in this location is very important. From this land classification data, the decision-makers at local level can decide what suitable LUTs should be recommended to the upland farmers of the area.

Completing agricultural land and forest allocation to the farmers with the land-use rights is one of the key focuses of the Vietnam's Land Policy. All farmers, including farmers in the mountainous regions have the land-use rights for the land allocated to them. In order to improve the productivity of their land, the farmers need the support of the government and other organizations not only for investment through rural credit but also for extension services – consulting on more beneficial land use such as what kind of the annual crops or perennial trees can be grown. A number of agencies work on land evaluation issues with land suitability as the main goal.

ISSUES IN LAND CLASSIFICATION IN SLOPING UPLANDS

As a consequence of the land suitability classification survey, overall area of agriculture and forestry in mountain regions of Vietnam increased 6 and 2.8 percent, respectively. Land suitability classification procedure has been introduced by all the land administration and management agencies working in the mountain provinces. Geographical Information System (GIS) technology is used for land mapping unit and suitable land classification.

Problems

- Lack of GIS and Land Information System (LIS) database for all sloping upland areas.
- Low quality of photographic maps and cadastral maps for mountain areas.
- The local field staff in the land management agencies have low knowledge about land evaluation and land classification systems and limited skills to conduct this work.
- Lack of technique, equipment and facilities for land classification activities on sloping upland areas.

Suggested Strategies

- Setting up regional information system for each mountain region
- Improving facilities for mapping and data analysis
- Training courses on land classification procedures and techniques
- Completing pilot land classification projects as representative models for sloping uplands
- Enhance international cooperation in the field of upland classification through information exchanges, trainings/meetings, and collaborative projects.

CONCLUSION

- Vietnam applies FAO guidelines and framework for land use and land evaluation classification. The country is implementing a land suitability classification program at three levels; national, provincial and districts.
- Two pilot case studies have so far been carried out on land suitability classification and mapping; one in Tuyen Quang province and the other in Doan Hung district in the mountainous regions of Northern

Vietnam. These studies used agro-ecological zoning information, soil characteristics, suitable land-use requirements of different LUTs for different sloping areas, sustainable LUTs, etc.

C Land suitability classification is an effective tool for land-use planning in order to improve the agricultural production in the upland areas. It can contribute to effective implementation of programs on poverty alleviation in the mountainous areas largely inhabited by the minority people.

C However, there are some problems in implementing land suitability approach countrywide. Country lacks latest equipments, expertise and facilities of data collection and GIS technology. Thus, internationally supported collaborative project for setting up a regional information system in sloping upland areas in Vietnam will be highly desirable.

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2. PROGRAM OF ACTIVITIES

(10-17 July 2002)

Date/Time	Activity
Wed., 10 July	
Forenoon	Opening Ceremony
	Presentation and Discussion on Topic I: *Land Classification for Sustainable Production Systems in Sloping Upland Areas of the Asia and the Pacific: Issues and Strategies*
	by Dr. Tej Partap
Afternoon	Presentation and Discussion on Topic II: *Methodologies for Land Classification for Optimizing Agricultural Use of Sloping Uplands of the Asia-Pacific Region*
	by Dr. Suan Pheng Kam
	Presentation and Discussion on Topic III: *Land Classification for Promoting Sustainable Agricultural Use of Sloping Uplands – A Case Study of Terraced Paddy Fields in Japan*
	by Ms. Kazuko Endo
Thurs., 11 July	
Forenoon	Presentation and Discussion on Topic IV: *Spatial and Temporal Considerations Associated with Achieving Sustainable Steepland Agricultural Production*
	by Dr. Thomas L. Thurow
	Presentation of Country Reports by Participants
Afternoon	Presentation of Country Reports by Participants
Fri., 12 July	
Forenoon	Presentation and Discussion on Topic V: *Direct Payment Policy for Sustainable Farming in Hills and Mountains of Japan*
	by Dr. Masayuki Kashiwagi
	Presentation of Country Reports by Participants
Afternoon	Presentation of Country Reports by Participants
Sat., 13 July	
Forenoon	Workshop
Afternoon	Free Time
Sun., 14 July	Free Time
Mon., 15 July	
Forenoon	Leave Tokyo for Echigo-Yuzawa
Afternoon	Visit Yasutsuka Town Office (Niigata Prefecture)
Tues., 16 July	
Forenoon	Visit Farmers
Afternoon	Leave Echigo-Yuzawa for Tokyo
Wed., 17 July	
Forenoon	Summing-up Session
	Closing Session