From:

Impact of Land Utilization Systems on Agricultural Productivity

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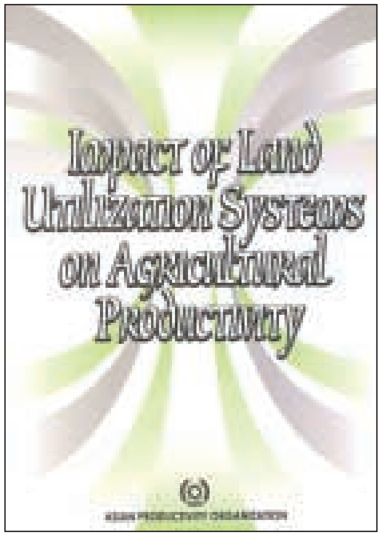

Report of the APO Seminar on Impact of Land Utilization Systems on Agricultural Productivity

Islamic Republic of Iran, 4–9 November 2000

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IMPACT OF LAND UTILIZATION SYSTEMS ON AGRICULTURAL PRODUCTIVITY

2003
Asian Productivity Organization
Tokyo

Report of the APO Seminar on Impact of Land Utilization Systems on Agricultural Productivity held in the Islamic Republic of Iran from 4 to 9 November 2000
(SEM-28-00)

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FOREWORD

Proper utilization of land is essential to sustainable agricultural production and economic development. In many APO member countries, however, land and other natural resources are under increasingly intense pressure for development. Industrialization and urbanization due to rapid population growth and efforts to reduce poverty threaten the land and water resources of many countries. Since most Asian countries cannot conveniently expand their cultivated areas, policy makers are seeking ways to intensify production and raise farmers' income on existing land. Heavy investments are being made to improve irrigation systems and to diversify and enhance the level of productivity. Land utilization systems are being developed to optimize land and water resource use. Land-use planning, however, must be based on reliable data and the application of scientific knowledge to conserve land resources and improve agricultural productivity.

To review the current status of land utilization systems in member countries and to identify issues and strategies for improving the contribution of land utilization systems to the enhancement of agricultural productivity, the APO organized a seminar on this subject which was hosted by the Islamic Republic of Iran in November 2000. This volume contains papers and proceedings of the seminar. We hope that it will prove useful to all those interested in land utilization systems and agricultural productivity relationships.

I wish to express my appreciation to the Government of the Islamic Republic of Iran for hosting the seminar and to the National Iranian Productivity Organization (NIPO) and Ministry of Agriculture for implementing the program. Special thanks are due to the resource speakers for sharing their time and expertise with the participants and to Professor Dr. Lyman S. Willardson for editing the publication.

TAKASHI TAJIMA
Secretary-General

Tokyo
February 2003

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SUMMARY OF FINDINGS

The Seminar on Impacts of Land Utilization Systems on Agricultural Productivity organized by the Asian Productivity Organization (APO) and hosted by the Government of Islamic Republic of Iran, was held in Tehran from 4 to 9 November 2000. The program was implemented by the National Iranian Productivity Organization (NIPO) in cooperation with the Agricultural Planning and Economic Research Institute (APERI), Ministry of Agriculture. Twelve participants from eleven member countries and eight resource speakers from the Netherlands, U.S.A. and Islamic Republic of Iran attended the seminar.

The objectives of the seminar were to: 1) review the current status of land utilization systems followed in member countries; and 2) identify constraints and suggest measures for improving the contribution of land utilization systems to enhance agricultural productivity.

The seminar consisted of the presentation and discussion of resource papers and country papers, a workshop, and field visits. The resource papers focused on the following topics: 1) Planning Support Systems to Enhance Sustainable Land Utilization; 2) An Analysis of the Issues and Problems in Improving Land Utilization Systems for Sustainable Agricultural Production; 3) An Overview of Current Land Utilization Systems and Their Contribution to Agricultural Productivity; 4) Islamic Republic of Iran's Policy on Land Consolidation and Reforms of Farming Systems; 5) Land Consolidation as a Movement Toward Agricultural Productivity Promotion: Experience of the Islamic Republic of Iran; 6) Land Consolidation: An Important Step in Increasing of Productivity (A Case Study and Implementation); and 7) New Approaches to Land-use Planning. The highlights of the seminar are presented below.

RESOURCE PAPERS

Planning Support Systems to Enhance Sustainable Land Utilization

(M. A. Sharifi)

Planning Support Systems (PSS) refer to the class of geo-information systems composed of data (geographic and thematic), information, models, and visualization tools which are primarily developed to support different phases of the planning process, mainly in the phases of problem analysis, formulation, evaluation and choice of plan and policies. PPSs are rationalizing planning and related decision-making processes that provide necessary support to systematically structure and formulate alternatives, policies, scenarios, and plans, assess and evaluate their impacts (considering objectives of the relevant stakeholders), and provide a rational basis selection of a proper policy, scenario, or plan.

Land-use planning for agricultural development has agronomic, social, economic and political dimensions and deals with the multipurpose use of land, trade-offs between different functions of land, and often conflicting interests among different categories of land users and conflicts between collective and individual aspirations and needs. Land-use planning is therefore a multiple objective endeavor, which includes a variety of complex agronomic, ecological, social and economic processes. Planning should provide a framework for operation and decision-making. A good land-use plan should reflect expectations about the environment, the capacity of the system, and the trade-offs between alternative options for allocation of resources and the direction of efforts.

A land-use plan can usefully be characterized by its main components: choosing objectives, stocktaking and diagnostic survey, demand and supply projections, setting targets and allocating resources, the choice of strategies and policies, programs and projects, institutional changes involved, monitoring, reporting, control and evaluation. Effective agricultural planning requires an appropriate system that includes all the appropriate planning components and can handle the complexity, diversity and dynamics of an agricultural environment. So far, planning for agricultural development has not been very successful. Many times plans have been made and ignored, or have been implemented in a very passive fashion. This lack of success is related to the nature and complexity of land-use planning for agricultural development (processes and data) on one side, and the unavailability of proper supporting tools on the other side.

Improvement of the effectiveness and efficiency of planning in such an environment requires proper tools/methods/procedures, which can support the decision-makers in their decision-making process. Such types of tools and techniques which can be integrated in a planning support system, must support the analysis of information, the finding and formulation of problems in the real system, the development of alternative solutions, the evaluation of pros and cons of each option, and decision-making which is in line with the sustainable development of the environment.

1. ***Main Components and Function of a PSS***

PSSs, as a specific type of decision support, includes the following main components:

A Resource Base: which is an information system designed to accommodate and organize the basic spatial and thematic data, provide facilities (interfaces) for the integration of various models, and enable visualization and communication results of analyses to the policy-makers in a manageable and understandable form.

A Model Base: which includes all quantitative and qualitative models that support resource analysis, assessment of production potentials of various types of land use at different levels of management, and their corresponding input requirements. Particularly the model base includes: a) an evaluation model, which allows appraisal and evaluation of each scenario and identifies the one which is most acceptable by all parties involved; and b) a planning model which integrates all magnitudes, potential, and capacity of the resources (biophysical suitability), socio-economic information, goals and objectives of the different stakeholders to allow generation of possible scenarios.

A Knowledge Base: which provides information on data and the existing processing capacity of resources and models which can be used to identify problem, to generate solutions, to evaluate and appraise them, and finally to communicate the results to the decision-makers.

A User-friendly Interface: which allows smooth and easy communication with the system and convenient visualization of the results.

Functionally, PSS as a special type of Decision Support System (DSS) should support the different phases of a decision-making process as follows:

Intelligence: In this phase, the environment is examined to identify problem or opportunity situations. In agricultural systems, opportunities and constraints may be related to agro-technological conditions (physical), or to agro-economic conditions (socio-economic). The physical aspects refer to the assessment of the biophysical productivity potential of each tract of land for each prospective land-use type, characterized by crop yield estimates. This can be derived from dynamic simulation modeling of the main growth controlling factors and processes, or from empirical or experimental models. The agro-economic aspects refer to existing socio-economic constraints and opportunities, through understanding the fundamental characteristics of resources and the processes through which they are allocated and utilized.

Design: In this phase, the possible courses of action are initiated, developed and analyzed. This involves application of decision models that generate solutions, test their feasibility, and analyze different alternatives. This is accomplished by applying planning models that generate alternative options, as well as the associated results and requirements of the plan. In this phase, depending on the steps in the planning cycle, different types of models are required to establish appropriate goals, and formulate alternative policies and plans.

Goal formulation is supported by explorative types of studies, which are focused on the questions such as “what would be possible?” Explorative types of studies aim at defining the envelope of development possibilities through combining the biophysical opportunities and limitations with societal objectives in order to explore ultimate options and consequences of priorities.

Policy formulation is supported by predictive studies, which are focused on the questions such as “what can be changed?” and “how can the desired changes be realized?” These studies, therefore, emphasize the current situation in terms of the existing (socio-)economic environment and land-use pattern, and consider these as the main constraints to modification. This approach allows improved interactions between policy analysis and agricultural research and development. The smallest unit of analysis here needs to include the socio-economic setting of an “Integrated Land-use System”. Plan formulation, depending upon the context and objectives makes use of different type of approaches. For example, if the issue is implementation of a policy decision then it relates to decisions about cost, provision of funds, organizational requirements, scheduling of the required activities, and other related issues. If it relates to the direct intervention of government then techniques which support project formulation, appraisal, and other methods such as Utility Based Analysis “UTA” for formulation of development options based on projects are more frequently applied.

Choice: In this phase, alternative development options are evaluated and one of the alternatives, i.e. a specific course of action is selected. During this phase, the planner ranks the alternative plans on the basis of their predicted results and level of decision impacts, and makes an acceptable choice. This is achieved through the application of multiple criteria decision-making methods, which call for priority of decision-makers or their readiness to trade-off between different objectives. An important consideration in evaluating alternatives, is the sensitivity of the solution to changes in the assumptions on which the decision is to be based or to the conditions which are expected to occur. PSSs are very important tools for improved resource management.

An Analysis of the Issues and Problems in Improving Land Utilization Systems for Sustainable Agricultural Production (Lyman S. Willardson)

Sustainable agriculture must have a stable supply of land and water resources. However, the land and water resources of the world are finite and some may be non-renewable. Soil is a non-renewable resource and it is also a finite resource. There is a finite area of land on the earth that is suitable for habitation and food production. Population pressures have brought some countries nearly to the limit of their agricultural land resources. Since obtaining additional world land area is not possible, the available land resource must be used as efficiently as possible and in a sustainable manner. Freshwater is a renewable resource, but the world supply freshwater is also finite. Many countries are beginning to realize that their supply of freshwater is limited. Some water-short countries are even watersheds for their neighbors. Their neighbors may have the same problem, so the available water must be shared. Cooperation between countries will be necessary to provide equitable and reasonable use of the world's freshwater resources.

Where there is a possibility of an excess demand for land and water resources, it will become necessary in the future to treat those resources as Common Pool Resources and manage them on a worldwide or regional basis. If common pool resources cannot be managed properly, what is known as "the Tragedy of the Commons" will occur. "Common" resources are used by many people who depend on the sustainable functioning of the resource. If more demands are made on a renewable resource than it can sustain, the resource will be destroyed by overuse and all of the users will be denied the benefit of the resource.

The problems associated with the successful management of finite, but sustainable, common pool resources will require sociological solutions that are supported by appropriate technology. Common pool resource problems cannot be solved by technology alone. Peaceful negotiation is critical. Some of the benefits from natural resources that, in the past have been considered inexhaustible and free to all people, are now being recognized as being finite and the use of those benefits will have to be controlled by mutual agreement to prevent irreversible damage to the resource.

To preserve the land, it must be protected from erosion, it must not be polluted, it must be continuously supplied with the necessary nutrients and it should be used for its highest purpose. The current food supply situation in the world has not yet made it necessary to replace houses with farmland, but it may become necessary in the future.

Consciousness of the environment has brought to the attention of the world that plants and animals are also legitimate users of the land and water resources of the world. We do not yet know our true ecological dependence on the vegetation and animals that inhabit the planet. They may also be finite resources whose destruction could bring unforeseen problems to the human population.

Data on total land area, proportion of the cultivable land area, percent of the cultivated land, and the proportion of the cultivated land that is irrigable are presented for Bangladesh, India, Indonesia, Pakistan, the Republic of Korea, Malaysia, Mongolia, Nepal, Sri Lanka, Thailand, and Vietnam. In Malaysia only 36 percent of the land that is potentially cultivable has been developed. In Bangladesh, 88 percent of the cultivable land is already in use. Four of the countries discussed have a water supply that is fully internal and two other countries depend on outside sources for less than 10 percent of their renewable water supply. More than 90 percent of the water supply of Bangladesh comes from outside the country. Groundwater is a renewable resource, but it must be used carefully if it is to be a sustainable resource. Overuse can create a "tragedy of the commons" situation if salt water intrusion or collapse of aquifers results from too much groundwater extraction. Fifty-three percent of the water supply of India currently comes from groundwater and the current use rate may not be sustainable.

Common pool resources have been managed successfully over long periods of time when they were managed within their limits of sustainable use. Only when they are mismanaged do they fail. Cooperation is better than war to solve the problems of sustainable use of any common shared resource. The world supplies of air, soil and water are shared common pool resources that are sustainable with proper management.

An Overview of Current Land Utilization Systems and Their Contribution to Agricultural Productivity (B. Najafi)

A serious problem the world is facing at present, is the deterioration of both the natural environment and natural resources. Human activities generate environmental pressure in different ways. Notable among them is overexploitation of renewable resources such as fisheries and forests, and degradation of basic resources such as land and water.

The paper discusses three phases of the Green Revolution (i.e., the Green Revolution of 1960s, the first post-Green Revolution of 1970s, the early 1980s, and the second post-Green Revolution of late 1980s and 1990s). Most advanced post-Green Revolution areas of Asia have reached a point of diminishing returns to further intensification and have entered a phase characterized by the use of better knowledge and management skills to substitute for higher levels of input use. A study conducted during 1988-92 by the author to evaluate the "Wheat Improvement Program in Iran" indicated that in spite of increasing farmer's technical efficiency, there are differences in productivity among farmers due to differences in their managerial skill level. An identified production setback was due to input intensification and the ignoring of crop rotation.

In the second section of the paper, physical limits to crop productivity are discussed. Population pressure and land tenure insecurity has led to land degradation in most Asian countries. In order to increase investment for better land utilization, appropriate incentives for land management must be provided through institutional reforms.

Considering the dominant land utilization systems in Asian countries which limit agricultural productivity and sustainability, some policy and institutional reforms need to be introduced to overcome present problems.

In the final section of the paper, the future challenges are pointed out and some recommendations are made toward developing more efficient land utilization systems and toward increasing agricultural productivity.

Policy recommendations include: 1) strengthening extension services; 2) more investment in plant breeding research/biotechnologies; 3) sustaining agricultural system through efficient use of best management practices; 4) introduction of appropriate price policy reforms; and 5) institutional reforms (e.g., better land tenure systems, including participation of farmers in the form of water users' associations).

Islamic Republic of Iran's Policy on Land Consolidation and Reforms of Farming Systems (Reza Arjmandi)

Agriculture provides 85 percent of the domestic food needs of Iran. However, Iran suffers from low productivity. Despise the endeavor of the whole household working on the farm, farms do not yield adequate income. A major constraint to increasing productivity is the small size of landholdings and scatteredness of landholdings. Other constrains are low investment, absence of suitable farming practices, paucity in applying modern appropriate techniques, especially congruous mechanization, high costs of production, inadequate management protocol, poor transport, an improper marketing system, high cost of production, and inadequate pest control.

It is a well established fact that to determine the optimum size of farmland parcels certain technical and economic criteria must be taken into account so that utilization of modern farm machinery may be possible. In developed countries the growth of agriculture albeit in various forms, has certainly heeded this axiom in combining and consolidating the farmland.

Concern over feeding the increasing population on the one hand and exploiting the resource on other hand, has led the Iranian Ministry of Agriculture (MOA) to take drastic measures in making reforms in the country's farming systems, especially where scattered small plots prevail. The experiences of the 1970s and 1980s show that land consolidation, mobilization, and renovation must be applied within the framework of an appropriate movement toward the rural production cooperatives (RPCs).

An RPC is defined as an NGO economic integration with a relating high management skill, which are based and dependent upon the available human resources of its members and their joint decisions while preserving and protecting ownership. It is established out of the drive drawn from individual and family incentives. RPCs give priority to land consolidation and proper allottment taking into account the potential for beneficial crop rotation. Because of their capability to tackle the problematic issues of optimum landholding size and application of sophisticated technology paying due attention to sustainability, the environment, and cultural and social values, the RPCs symbolize a very workable "Rural Development Pattern".

An MOA approach has encouraged proliferation of land consolidation with due regard for individual ownership in the process. During the First and the Second Economic Development Plans (1989-93 and 1994-98, respectively) 752 RPCs with 156 thousand family members in 2,970 villages encompassing 2.1 million ha land area (out of 18 million ha cultivated land) burgeoned. The figure is projected to increase to 1,700 RPCs encompassing 4.5 million ha (25 percent of the total cultivated land) by the end of the Third Economic Development Plan. The government is providing both financial and technical assistance to RPCs.

This paper, in a prologue, discusses the necessity of reforms concerning the prevailing farming system from the viewpoint of sustainable agriculture development, food security, and land consolidation in an attempt to achieve the maximum productivity. It also expounds the policies of the Islamic Republic of Iran and discusses the current achievements of these policies.

Land Consolidation as a Movement Toward Agricultural Productivity Promotion: Experience of the Islamic Republic of Iran (Ahmad Najafi)

Agricultural growth depends on productivity promotion through proper resource management, development of adequate infrastructure, application of appropriate technology, new farming methods, and farm management improvement. In recent years countries with traditional agricultural practices have developed fragmented, non-geometric small plots of different household's farmland and created some difficulties for agricultural development, especially the limitation for agricultural mechanization. This, in turn, leads to low productivity.

The promotion of modern agriculture is associated with the development of large-scale plots in the farm units of households. Therefore, achievement of appropriate scale and shape of field plots is an effective factor for promoting productivity. Consolidation of small plots of farmland is used to generate larger farmland units which are technically and economically viable.

In Iran, after the land reforms of the 1960s, the smallness and fragmentation of household plots became more serious. Various production improvement projects were undertaken, but because of various reasons, these projects were less successful. After the victory of the Islamic Revolution (1979), land consolidation became a necessary movement among farmers and the officials. They believed that consolidation is needed for productivity promotion, infrastructure development and new technology extension.

This paper reviews traditional structural difficulties within the small and fragmented plots of farmlands and farming systems. It also gives a brief review of the history, concepts, methods, and the process of land consolidation as a means for solving the problematic case of fragmentation in Iran. The central point of the process of land consolidation is to organize all activities with participation from farmers. The paper also discusses several case studies in Iran.

Land Consolidation: An Important Step in Increasing of Productivity (A Case Study and Implementation) (Gh. A. Najafi)

The Haraz River Basin Agricultural Development Project (HRBADP) was started in 1984 to provide comprehensive agricultural development in the Haraz River Basin area, with the cooperation of Japan International Cooperation Agency (JICA). The project ended in 1988. The result was a master plan study with a general view of agricultural development in the Caspian Sea coastal area.

In continuation of the master plan study, a feasibility study was conducted from 1989 to 1999 by Sanyo (a Japanese consulting engineering company) with cooperation of Iranian experts. The result of this feasibility study was presented as “the feasibility study on the irrigation and drainage development project in the Haraz River Basin”. Three villages – one in the highland, middle land, and low land regions – were selected as a pilot area and land consolidation work was implemented in the selected pilot villages. The results of master plan and feasibility studies and the data and information of before and after implementation of land consolidation in pilot villages indicated that the land consolidation had increased the productivity of paddy rice through reduction in land fragmentation, establishing farm roads and access roads, increasing farm mechanization, changing the traditional system to a mechanized system, improvement of the drainage systems and water management, reduction in difficulty of rice cultivation, more possibility of second crop cultivation, cost deduction, and enhancement of farmers revenues.

The paper discusses in detail the HRBDAP and its impact on the agricultural productivity and socio-economic status of the project area.

New Approaches to Land-use Planning (A. Moghaddam and Farahara Nowrouzi)

Agriculture is a system consisting of a group of interrelated components that interact for a common purpose and react as a whole to external or internal stimuli. The human systems (social system), natural resources systems (ecological system) and economic systems (market system) are sub-systems of the agricultural system. Adoption of a systematic approach is, therefore, inevitable to land-use planning for such a complicated system.

Modern approaches to land-use planning are characterized by a multiplicity of objectives, attributes, criteria, disciplines, functions and agents. Modeling is the only way to fulfill the tasks of land-use planning since the human mind is not capable of capturing the interrelations and interactions between the numerous components of this huge system. Nonetheless, a single model cannot be found that will simulate the entire system. Instead, a set of specialized models is required for different disciplines that must then be synthesized by a multiple criteria decision-making model.

Appropriate adoption of river catchments and sub-catchments has been cited as the proper geographic framework of land-use planning. Furthermore, dynamism is an important characteristic of agriculture system. The systemic nature of agriculture as well as continuous interactions and interrelations among its elements make adoption of a dynamic system approach inevitable.

Data and information play a key role in effective performance of land-use planning. Many sets of data have to be collected, generated, screened, and organized for the purpose of model building. Performance of these tasks necessitates application of appropriate advanced technologies such as Geographic Information Systems (GIS) and Remote Sensing (RS). Clearly, accessibility to the modern hardware and software as well as modern computerized mathematical programming package is an important prerequisite to carry out an effective land-use planning endeavor.

Great efforts, using operational research in exploration of modern techniques for land-use planning, have been made in the last two decades. Land-use planning approaches have been evolved through introduction of new methodologies and combination of different techniques. Several approaches have been identified by different acronyms based on the viewpoints and method of the concerning agents: SYSNET is a recent methodology developed to support regional land-use planning in humid and sub-humid tropics and subtropics, land-use planning and analysis system (LUPAS) is a generic methodology (a policy-oriented analytical framework), "the Multi Functional Character of Agriculture and Land" (MFCAL); is a general system framework for organizing the large amounts of information that are relevant to decision-making in land-use planning; and different models have been used as the components of the NERC-ESRC Land-use Program (NELUP) that are synthesized within a Decision Support System (DSS). GIS and Data Base Management Systems (DBMS) as well as mathematical programming models including Multiple Criteria Decision-Making (MCDM) and Interactive Multiple Goal Linear Programming (IMGLP) approaches have been widely used within these systems.

The Iranian experience regarding land-use planning began with a National Cropping Plan (NCP) conducted by the MOA in the mid 1970s. The Ministry, in collaboration of different international agencies, has conducted several case studies and regional land-use planning projects since 1990. National Comprehensive Planning Studies is the current prevailing project in hand. So far, the reconnaissance phase and provincial synthesis of this multidisciplinary project has been completed. Preparations are being made to commence the national synthesis for which application of modern technologies has been proposed.

COUNTRY PAPERS

Strategic agricultural planning to identify and address the most relevant issues for a given region is a universally recognized need. This may be a trade-off between achieving a food production target at some point in time and its environmental costs, or a choice between farmer income and production targets. A key to resolving the existing conflict between the required increase in productivity, farmer's income, and the environmental issues, such as soil, water, biodiversity, and other natural resources, is to identify land utilization systems and technologies that make optimum use of inputs, natural resources and that avoid degradation of natural resources, and the policy measures supporting their adoption.

In many APO member countries, land and other natural resources are under increasingly intense pressure brought about by rapid population growth, widespread poverty and growing industrialization and urbanization. Since most Asian countries cannot conveniently expand their cultivated areas, focus has been on adoption of measures to intensify production and farm incomes from the limited land stocks, through heavy investments on irrigation and drainage systems, crop diversification, and land consolidation.

South Asian countries (Bangladesh, India, Iran, Sri Lanka) are constrained by low or stagnant crop yields, land tenure insecurity, small size and fragmentation of landholdings, land degradation and lack of farmers' participation in decision-making processes. These countries are looking for positive measures/policies for improving their land utilization systems to enhance productivity and conserve their land resources. The major problems pointed out by the South-East Asian and the Pacific Countries (Indonesia, Malaysia, Rep. of China, Thailand, Vietnam, Fiji, Mongolia) were inappropriate land conservation measures, land degradation, land re-zoning, inadequate land tenure system, and lack of appropriate land law.

Despite the diverse land utilization systems followed by different member countries and different problems faced by them, all the member countries are striving hard to maximize productivity to ensure their national food security. Though at different stages of adoption of measures/policies to ensure land use for sustainable agricultural productivity, all countries in the region are aware of the constraints and show a willingness to adopt better land utilization systems for sustainable agricultural productivity.

In Bangladesh, a draft land-use policy is being examined by a cabinet committee wherein problems pertaining to sustainable land use have been addressed. In India, the USDA Land Capability Classification is being widely adopted by different organizations. In Indonesia, emphasis is given to integrated farming systems including soil conservation and land rehabilitation; and re-evaluation of land classification to achieve proper land use. The Islamic Republic of Iran has indicated its full commitment to improvement of agricultural productivity on a sustainable basis through establishment of Rural Production Cooperatives (RPCs), land consolidation and crop diversification. Thailand is striving hard to pass a law on land utilization and to ensure training/participation of all the stakeholders. Malaysia is setting up and gazetting permanent food production zones, integrated farming systems in paddy field and plantation crops as well as group farming and mini-estate farming systems for small landholders. Sri Lanka has embarked upon, though in an infancy stage, a community-based participatory program, and strengthening the linkage between farmers, extension workers, and researchers. The Republic of Korea established the "Farmland Act" in 1996 to contribute to stabilizing farmers' agricultural management, and to strengthening the competitive power of agricultural industry through enhanced productivity by efficient utilization and management of farmland. The Act stipulates necessary matters concerning the ownership, utilization, and preservation of farmland. As regards Vietnam, significant progress has been made in developing and adopting measures to increase agricultural productivity and improve soil fertility. It was stated that land-use systems with intercropping and crop rotation, as well as intensive and irrigated cultivation, gave high yields and could improve soil fertility. In Fiji, a draft National Land-use Plan has been prepared – hopefully to be adopted in the near future. Training and awareness on land-use systems is emphasized. Mongolia is working for improvement of its land tenure system, land reform, expansion of technical knowledge, conservation of land, and improvement of farmers' and herders' communities.

The future of agricultural land-use sustainability in the region may, however, depend on formulation of sound land laws and policies and their enforcement in order to enhance agricultural productivity and conserve the agricultural land and water resource simultaneously, through appropriate land utilization systems.

FIELD VISIT

On 8 November 2000, the participants visited the "Haraz River Basin Agricultural Development Implementation Center". The project area is located about 220 km north of Tehran in the Amol Township at the center of the Caspian Sea coastal region in the delta plain of the Haraz River. The project area observed is situated in a paddy production zone.

Dr. Gh. A. Najafi and his colleagues explained the following six components of the Master Plan of the Haraz Project: 1) Area Drainage Project; 2) Terminal Facilities Improvement Project; 3) Farming Practices and Farm Management Project; 4) Livestock Farming Promotion Project; 5) Post-harvest Improvement Project; 6) Village Modernization Project; and 7) Land Holding Consolidation.

Different socio-economic aspects and targets of the project, especially land consolidation, were explained. The participants were told that 800 ha of land has been redeveloped through consolidation. This project on land consolidation and other aspects of agricultural development was started in 1984 with cooperation of Japan. In this regard, the cooperation between the MOA of Iran and the JICA continued from 1984 to 1995.

During this period, a master plan study, feasibility study, establishment of a center (Caspian Sea Coastal Area Agricultural Development Project Pilot Implementation Center [CAPIC]) for farming and implementation works, and implementation work in three pilot areas (three villages) were accomplished. The center is also launching the project of the Haraz Agricultural Human Resources Development Center with the cooperation of a JICA short-term expert program beginning in 2001. The participants were taken to Agronomy/ Postharvest Lab, paddy germination rooms, and the machinery workshop of the Center. The workshop of the Center is equipped with the Japanese machinery including paddy dryers.

The participants also visited the fields of the Haraz Agricultural Development Implementation Center. The participants were told that land consolidation had helped a lot in enhancing crop productivity, crop diversification and water saving. For instance, one previously paddy crop was followed by radish or lettuce but after land consolidation, paddy crop is being followed by cabbage, lettuce, spinach, and radish. The participants took a keen interest in the field visits in the project area.

WORKSHOP FINDINGS

Group I

Issue/Problem	Strategic Action
1. Low or stagnant crop yields	– More investment on research and extension – Strengthening linkages between research and extension – Demonstration fields, and diagnostic visits
2. Land tenure insecurity	– Establishment of long-term land tenure policies that are immune to the changes in the government – Farmers' participation in formulation of land-use policies – Enhance law enforcement – Promotion of long-term right of land use to enhance investment
3. Lack of farmers' participation	– Enhance participation of farmers and other stakeholders in decision-making for land use
4. Small size and fragmentation of farms	– Promotion of land consolidation – Promoting cooperative farming while protecting individual property rights – Establish required services through farmers' organization, e.g. cooperatives to support management of consolidated lands – Enhancement of farmers' know-how through training, etc.
5. Land degradation	– Set up infrastructure to improve land conservation measures – Promote watershed management – Enhance initiative to reduce degradation of the agricultural lands
6. Government intervention	– Formulate and execute positive price policy by guarantee price system – Refine crop insurance to be more meaningful – Attract educated youth to farming profession – Formation of coordination bodies to integrate activities of different organizations to implement land-use policy
7. Lack of monitoring environmental indicators	– Develop appropriate system of monitoring environmental indicators to minimize land and water resource degradation

Group II

Issue/Problem	Strategic Action
1. Agricultural sustainability	Since agriculture is closely linked to the environment, it is a multidisciplinary in nature. It is only possible through applied training, and dissemination of information with an aim to maintain production of food, wood and fisheries products to satisfy both domestic and export requirements of the country in ways most friendly to the environment for the ultimate purpose of improving the quality of life of the people.

... To be continued

Continuation

Issue/Problem	Strategic Action
2. Inappropriate land-use planning and policy-making	– Flexible land-use planning and policy-making. – Formulation of appropriate top-down and bottom-up macro and micro policies focused on sustainable, economic, ecological, social and environmental aspects of land use. – Enhanced policy implementation.
3. Inadequate land conservation measures	– Adoption of proper and adequate land conservation practices to protect all environmental resources.
4. Land degradation	– Adoption of proper and adequate land conservation practices.
5. Inadequate land tenure system	– Develop a long-term land tenure system with special consideration for the farmers and other stakeholders. – Equal application of land-use regulations for tenants, landowners, and government.
6. Lack of technical knowledge and information exchange	– Promote use of information technology (IT). – Introduce and promote effective extension services. – Organize training courses, study missions, seminars, etc.
7. Inadequate/improper land classification	– Generate a multidisciplinary land classification system for multipurpose uses (land-use map) to ensure optimum land use, optimum water supply, etc., while meeting the environmental requirements.
8. Inadequate land law	– Revision of land law to define minimum economical size of landholding/farm household to prevent excess fragmentation.
9. Absence of/inappropriate land zoning	– Promote/introduce land zoning to permit flexible changes according to land-use regulations.
10. Lack of/inadequate agricultural credit	– Creation and/or improvement of agricultural credit for land/ water use sustainability activities.

WORKSHOP RECOMMENDATIONS

In a plenary session, the participants identified the following issues important to increase sustainability of land utilization systems.

- Increasing yield;
- Making agriculture business competitive to other sectors (cost-effective);
- Improve farmers' participation;
- Reduce land degradation; and
- Define government responsibilities.

In order to deal with the above-mentioned issues, the participants formulated and identified the following recommendations aimed at improving sustainability of land-use systems as well as increasing agricultural productivity.

Increasing Yield

- Encourage more investment in research and extension to develop high yielding varieties and improve farming efficiency.
- Strengthen linkages between research and extension through proper methods such as demonstration fields, and diagnostic field visits.

Making Agriculture Business Competitive to other Sectors (Cost-effective)

- Establish long-term land tenure policies that are immune to the changes in government policies.
- Enhance land-use law enforcement.
- Assure long-term right-of-use of public and leased lands to enhance investment.
- Emphasize uniform application of acceptable land-use regulations for all landowners including government.
- Formulate/revise land law to define a minimum size of the inherited land holdings to prevent excessive fragmentation of small farms.
- Create and/or improve the agricultural credit supply for implementing sustainable land management practices.
- Refine crop insurance to be more meaningful against natural disasters.
- Educate youth to promote interest in agriculture-related professions.

Improve Farmers' Participation

- Establish required services through farmers' organization, e.g., cooperatives to support secure management of consolidated lands.
- Encourage land consolidation and cooperative farming laws that protect individual property rights.
- Include farmers' participation in all agriculture related land-use policies.

Reduce Land Degradation

- Enhance environmental and proper land-use knowledge of farmers through training and other appropriate measures.
- Set up institutional framework and financing systems to improve agriculture-related conservation measures.
- Promote watershed management to preserve soil and water resources.
- Provide farmer education/awareness programs to reduce degradation of agricultural lands.

Define Government Responsibilities

- Establish proper agricultural development plan including realistic goals, policies, and the required actions to promote sustainable natural resource management.
- Revise the present land classification systems and land classification categories to generate a multidisciplinary land classification system for multipurpose uses (land zoning/land-use maps).
- Create a land zoning system to provide flexible variance of land-use regulations.
- Establish a positive price policy to guarantee agricultural commodity prices.
- Ensure availability of the supporting services to farmers in implementing sustainable agriculture practice (credit, land consolidation, extension).
- Reduce government intervention in production and improve participation of farmers in various decision-making processes.

– Form coordination bodies to integrate the activities of different organizations to implement land-use policies.

1. PLANNING SUPPORT SYSTEMS TO ENHANCE SUSTAINABLE LAND UTILIZATION

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INTRODUCTION

Agricultural systems are dynamic in the sense that they are in a continual state of change and evolution; whereby, events, which occur at the present time, affect its performance both financially and biologically in the future. The finances of the system are always dynamic with future possibilities being affected by many different events. Which, in turn, influence the biological and economic efficiency of the system. Agriculture is practiced in the form of production systems, enterprises, or farming systems. Their economic viability generally is an important evaluation criterion, although it is not the only one. Agricultural systems are ideally analyzed from economic, social, and environmental points of view, but common analyses mostly concentrate only on the economic views. FAO (1999) has suggested four functions for agricultural activities and land use: food security, environmental, economical, and social, all of which are defended by different stakeholders.

Strategic agricultural planning needs to identify the most relevant issues for a given region. This may be a trade-off between achieving a food production target at some point in time and its environmental costs (nitrate leaching), or the trade-off between farmer's income and a production target. A key to resolving the existing conflicts between a required increase in productivity, farmer's income, and the environmental issues – such as soil, water, biodiversity, and other natural resources – is to identify land utilization systems and technologies that make optimum use of external inputs and natural resources and avoids degradation of natural resources and to identify the policy measures supporting their adoption. The field of matching quality of natural resources with the various societal demands is the basis of land-use system (LUS) analysis and should aim at developing effective tools for land-use planning (LUP) (van Keulen, *et al*., 2000).

In the realm of agricultural planning, formal techniques of LUP with agro-technical and socio-economical orientations have been developed and critically reviewed by many authors. For example, Fresco, *et al*. (1990), Van Diepen, *et al*. (1991), Sharifi (1992 and 1994), and Mohamed (2000). From these reviews the following main problem areas can be identified:

– Identification of the biophysical potential of the land.
– Integration of biophysical, social, and economic data.

- Operational and implementational aspects of the methods used.
- Integration of the existing information and knowledge into management decisions.

Because of the diversity and complexity of the processes involved in agricultural systems (ecological, agronomic, social, and economic), a comprehensive technique requires a considerable amount of data from various related disciplines. In actual practice, implementation of these methods requires many data collected in a systematic or task-wise fashion. Sharifi and van Keulen (1994), Mohamed (2000), and van Keulen, *et al*. (2000) discussed some of the operational and methodological constraints that prevent full integration of existing and collected data into the management decisions. From those discussions and personal experience, the following constraints can be identified:

- Complexity of the system and decision environment, which calls for more research, careful analysis, and modeling of the related processes.
- Large data sets in different formats and quality: different departments and disciplines using different techniques to collect data, which results in different formats and quality.
- Requirements for high-quality experts in different disciplines (usually in teams).
- Lack of tools for analysis and integration. This has resulted in more concentration on the data collection phase (uneconomic growth of data and information).
- Lack of consistency between the available data and the data required.
- Uncertain future and difficulty of foreseeing future events.
- Operational constraints in an agricultural environment. Data collection costs much time and money, manual organization and processing are difficult and inefficient, if not nearly impossible.

The above mentioned constraints constitute severe limitations on the use and integration of existing data and knowledge into the management decisions, to the extent that planning activities are frequently neglected, not carried out, ignored, or implemented passively. The use of management support systems can remove some of these constraints and enhance the quality of the planning function, which is a significant activity of management (Sharifi and van Keulen, 1994). Development of such a LUP system requires understanding of the system, its constituent processes, and their impact on system behavior. Understanding of the agricultural system requires synthesis of the important ecological, environmental, social, managerial, and economic processes of the system. With the increasing availability of computer power, extensive disciplinary knowledge organized in various types of models can allow development of comprehensive techniques that support resource analysis. Development and analysis of various planning scenarios, all integrated into a Geographic Information System (GIS) to form a powerful planning support system, is becoming more and more feasible.

In this context, this paper tries to elaborate on the nature and elements of sustainable planning for agricultural development and the way that it can be formulated and supported. It also briefly describes the planning process, its required steps, and the type of land-use studies that are required at each step. Finally, the content of a planning support system that can support policy and plan formulation for sustainable agricultural development is introduced.

PLANNING FOR AGRICULTURAL DEVELOPMENT: WHAT IS IT?

There are innumerable definitions of planning, one of which is the definition given by Conyers and Hill (1989). They define planning as *a continuous process that involves decisions, or choices, about alternative ways of using available resources, with the aim of achieving particular goals at some time in the future*. This definition attempts to incorporate the main points included in most other definitions, and thus to convey the most important elements of the concept of planning. In order to explore the nature of planning in more detail, the basic elements of planning as described by Conyers and Hill (1989) are briefly presented.

1. ***To Plan Means to Choose***

There are two main types of choices involved in planning. Choosing between many desirable activities/options, because not everything can be done at once, is one type of choice. Choosing alternative ways of achieving the same objective is the second type of choice. Let us take one of the simplest examples of planning – that of planning a journey. In most cases there will be a number of alternative ways in which the prospective traveller can reach his destination, including different routes and different modes of transport. Planning the journey involves deciding which of these ways to take. In other words, making choices about what to do and how to do it.

2. ***Planning as a Means of Allocating Resources***

Another important element of planning is concerned with the allocation of resources (land, water, human, and capital resources). Planning involves making decisions about how to make the best use of the available resources. Consequently, the quantity and quality of these resources has a very important effect on the process of choosing between different courses of action. The fact that there are almost always limits to the quantity and quality of available resources constitutes the main reason why planning involves deciding which of a number of desirable courses of action should be given priority. On the other hand, where choices have to be made between alternative courses of action, the availability of resources plays an important part in determining both the ranges of alternatives available and the one that is likely to be most acceptable. Because planning is concerned with the allocation of resources, an important component of the planning process is the collection and analysis of information about the availability of existing resources. This raises both conceptual and methodological questions about how thorough the process of information collection should be, in terms of the quantity and quality of the information. It also raises methodological questions about ways of collecting and analysing information.

3. ***Planning as a Means of Achieving Goals***

It is not enough to say that planning involves making decisions about the use of resources because the 'best' use of any particular set of resources will depend very much on what one is trying to achieve. In other words, planning involves making decisions about alternative ways of achieving particular goals. This was already implied, when the example of planning a journey was used. In that case, the goal of the planning exercise was to reach a particular destination and the traveller had to decide the best way of getting there. This example illustrates the importance of having some sort of goal, since there would be little point in planning a journey unless one knows where he wants to go.

Agricultural planning involves making decisions about the type of agricultural activities to be developed, the location of these activities, the methods of production to be used, the type of infrastructure, and the extension services required. It is very difficult to make these kinds of decisions unless one knows what one is trying to achieve. For example, is the main aim to increase domestic food production or to increase the production of export crops? Is it more important to maximize output per ha or to ensure an equitable distribution of the benefits from agricultural production? To decide on effective policies or plans for intervention – analysis, understanding, and modeling of the planning process is required.

The concept of planning as a means of achieving goals raises issues about the nature of the goals and the process of goal formulation. One of the problems that planners often have to face is that their goals are not adequately defined. Very often goals are too vague. For example, the goal of 'increasing agricultural production' would not provide much guidance for the agricultural planners. In other cases, goals are unrealistic given the resources available to achieve them. In many cases, planners are also faced with the task of trying to achieve more than one goal, and on some occasions, one of these goals is inconsistent with another. Thus it would be difficult for planners to maximize output per ha and reduce inequalities between farmers because these two goals are in conflict with each other. Less common, but more serious when it occurs, is the situation where there are no meaningful goals at all, or where the goals are obviously contrary to the interests of the majority of the country's population.

4. ***Planning for the Future***

There is one other important element of planning which is incorporated in most definitions – that is the element of time. The goals which planning is designed to achieve obviously lie in the future; thus, planning is inevitably concerned with the future. This concern with the future manifests itself in two main ways. One manifestation is that an important part of planning involves forecasting, or making predictions about what is likely to happen in the future. More specifically, predicting the outcome of alternative courses of action in order to determine which one to adopt. It is, of course, impossible to know exactly what is going to happen in the future, and therefore, planning involves a degree of uncertainty and risk. However, there are various techniques that planners can use to improve the accuracy of their predictions and to deal with the problems of risk and uncertainty.

The other manifestation of concern with the future is its role in scheduling future activities. Planning involves not only deciding what should be done to achieve a particular goal but also deciding the sequence in which the various activities should be performed in order to proceed in a logical and orderly manner, step by step, towards the achievement of the goal. How far into the future does planning extend? This depends entirely on the nature of the particular planning activity. At one extreme there are some activities that individuals or organizations may have to plan on a daily, or even an hourly-basis. At the other extreme some planning exercises involve making predictions about the state of the world several decades into the future. However, the types of planning we are dealing with in this paper generally have a time horizon somewhere between these two extremes, usually within the range of 1-20 years.

Discussion of alternative time horizons for the preparation of plans runs the risk of giving the impression that planning is a finite activity. It suggests that a plan is prepared for a fixed period of time – for example, the next five years – and that planning comes to a halt until the end of the five years, then it is time to start planning for the next five-year period. In the 1950s and 1960s many planners adopted this view of planning, but more recently it has become generally accepted that planning should be regarded as a continuous activity. This means that although it may be necessary to plan for a specific time period, the plans should be constantly monitored and reviewed during this period and, if appropriate, extended into another planning period.

Finally, it should be noted that although planning is inevitably concerned with the future, this does not prevent planners from devoting a great deal of their attention to studies of past and present situations. In fact, studies of the present are essential in order to provide information about existing conditions and the needs and the resources currently available for development. Studies of the past can provide a useful basis for predicting possible future trends.

Planning, Policy-making, and Implementation

Planning in its broadest terms refers to a wide range of activities that may be performed at various spatial and operational levels. However, the actual process of planning is an identifiable activity that can be distinguished from other related activities. At this point it is necessary to consider whether or not this is actually the case, and in particular, to examine the relationship between 'policy-making', 'planning' and 'implementation'. It is possible, and useful, to attempt to distinguish between these three related activities. In very simple terms it may be said that policy-making involves making decisions about the general directions in which change or development should occur; particularly for decisions which have direct or indirect implications of a controversial, sensitive, value-laden, or 'political' nature. While planning is the process of deciding what courses of action can best bring about the desired changes or developments, how they should be undertaken and implemented is the actual execution of the chosen course of action.

In order to illustrate this distinction, an example related to the process of formulating plans for increasing agricultural production in an imaginary country is given. In this case, the process of policy-making might result in, among other things, a decision to increase agricultural production through the provision of the required land-and-service schemes, where the government provides sites supplied with basic infrastructure/services on which farmers can then practice agriculture. Planning would then involve making decisions about how many such schemes should be established, where they should be located, what types of infrastructure/services should be provided, how land should be allocated to individual farmers, and what restrictions (if any) should be imposed on these farmers in terms of the way in which they develop the land. It would also include decisions about how much the schemes will cost, how funds will be obtained, and who will be responsible for their organization and implementation. Finally, the implementation stage would consist of the actual establishment of the schemes, including preparation of land, provision of infrastructure/services, and selection of farmers.

It is seldom possible to draw clear boundaries between policy-making, planning, and implementation or between the roles of the politician, the planner, and the administrator. An example is the role of policy-making in the formulation of the goals of planning. The formulation of goals generally involves making policy decisions about the nature of the development one is aspiring to achieve, although it is, at least in theory, possible to conceive goals that do not have any significant policy component. This relationship is reflected in the fact that much of policy-making is concerned with the definition, elaboration, or refinement of goals, and that although planning and policy-making cannot be clearly separated policy decisions tend to precede planning decisions in the same way that goals have to be formulated before their implementation can be planned. The close relationship between planning and policy-making is also reflected in the fact that plan documents frequently include a mixture of 'policies' and 'plans' and often the two cannot easily be separated. Furthermore, most plan documents and other forms of plans – including the obvious but very important example of annual budgets – have to receive political approval and are, therefore, in a sense, policy documents.

LAND-USE PLANNING: ENVIRONMENT AND PROCEDURE

Tinbergen (1956), and Thorbecke and Hall (1982) consider LUP as part of agriculture sector and/or regional planning, where the effects of economic policies on patterns of and changes in land use are studied. In this approach, changes in land use are considered as the result of the interaction between policy variables (like infrastructure, investments, prices, credit facilities) and exogenous parameters (resource endowments) that lead to realization of a number of defined goals (welfare, equity) and possible (undesired) side effects (environmental pollution).

For better understanding of the planning process, a planning environment is depicted in a systems perspective (Figure 1). This perspective consists of four major systems: the ecological system (the natural resources and environmental quality), the economic system (the production and consumption of services, investment and technological development), the socio-cultural system (norms and values), and the government. These systems are interrelated, and agricultural production is one of the economic activities taking place as a result of interactions between them. In this system, land-use decisions involve choices on at least two levels, e.g., regional and farm levels. At the regional level, a policy-maker, through a planning system, is trying to decide how best to allocate resources or lead the agricultural development process to the desired direction, in the face of uncertainty about the impact of the allocation process on the other systems. This uncertainty is related to the way that farmers in the economic system will respond to the new policy. At the farm level, farmers have their own decision problem – how best to respond to the new policy, given their own resources and objectives that are influenced by socio-cultural values and impacts of the other systems. In order to reduce the uncertainty about farmer's reaction and support an effective decision on a proper policy measure at the macro level, their impact at the farm level has to be evaluated. Such a procedure can be supported by a good LUP procedure.

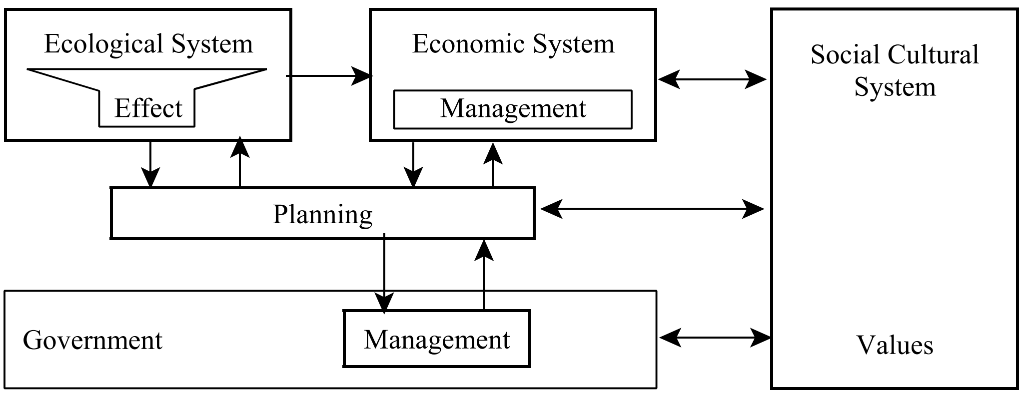

Figure 1. Planning in a System Perspective

Land-use Planning Procedure

At a highly schematized level, LUP is represented by van Keulen, *et al.* (2000) as a planning cycle with various distinct steps/phases (Figure 2): (i) resource analysis which describes and analyzes the current situation as a basis for current problem analysis; (ii) identification of objectives for future developments; (iii) identification of technically feasible land-use options (explorative land-use studies: 'what is possible?'); (iv) within the set identified in (iii), identify socially acceptable and economically viable options; (v) discussion of the possible options (stakeholders, policy-makers, disciplinary specialists) to identify the desired future situation ('compromise solution': 'what can be changed?'), and the policy measures necessary to initiate the required developments: 'how can the desired changes be realized?' (policy formulation); and (vi) policy implementation and monitoring. In theory, these steps should be executed iteratively, where at almost each step, the results can call for repetition of the preceding step(s), while in practice, the different steps are often implemented (at least partly) in parallel. Each of the above phases requires different types of information, which can only be derived from its specific type of land-use studies and modeling approaches. Based on the level of uncertainty and causality, Ittersum (1998) has distinguished four different categories of future-oriented land-use studies:

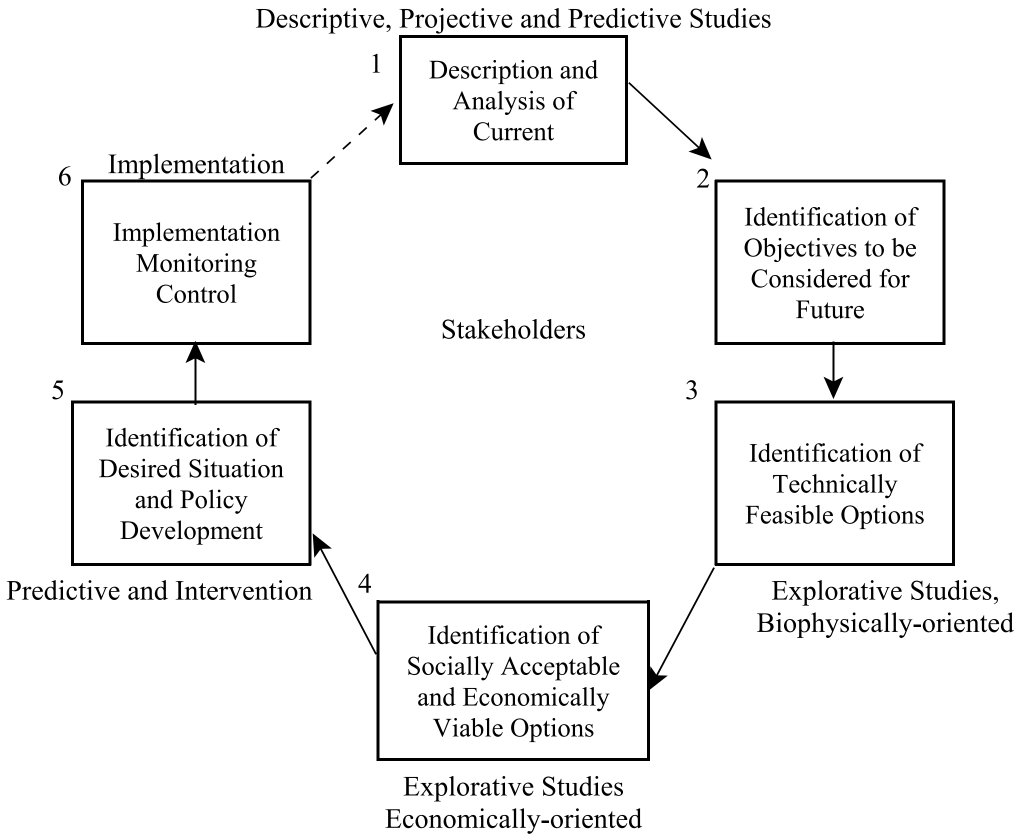

Figure 2. Land-use Planning Cycle

Source: van Keulen, *et al.*, 2000.

1. ***Projection***

Based on a low level of causality and valuable for those conditions where the level of uncertainty is relatively low, due to a short time horizon for which the projections should be valid and relatively stable or has negligible exogenous conditions.

2. ***Prediction***

If more information on causality and relations behind a projection is available, a projection may evolve into a prediction.

3. ***Speculation***

If the level of uncertainty increases, usually associated with a longer time horizon, a projection based on a low level of causality might evolve into a speculation.

4. ***Exploration***

If more information is available about causal relationships within the system, it becomes possible to explore future options, even though future developments on exogenous factors are highly uncertain. If causal information is only available for subsystems, explorations may show options for future developments given explicit assumptions about uncertain developments, for other parts of the entire system.

The ultimate result of planning, when implemented, is agricultural production and environmental impacts, which are the aggregate results of production on each individual tract of land by farmers. Results are mainly two kinds: the positive result, which is production of agricultural production, and the negative results, which are possible environmental degradations. Since the actual production or degradation is taking place at the farm level, any LUP effort should be based on the understanding of the performance of land-use at this level. If production systems are properly selected, the economic efficiency will be high, the environmental degradation will not exist or will be low, and the whole process will be socially desirable. Therefore, definition, characterization, and quantification of sustainable LUSs play an important role in the planning process.

LAND-USE SYSTEM AND SUSTAINABILITY CONCEPT

In the process of agricultural production, extensive use of resources or pollution of the ecosystem have led to negative impacts on the environment. To avoid this, information about the adverse effect of agricultural production systems on the health of people and environment should be incorporated in the decision-making process related to the selection of LUSs. Unfortunately, the problem of adverse use effects is often not incorporated in the decision process and leads to imbalances between economic and environmental systems.

Protection of the environment and public health interests, as well as to stimulate sound environmental behavior, balancing the economic, environmental, and socio-cultural systems in particular, is important when considering development possibilities for future generations and strongly relates to the concept of “sustainable development” (Brundtland, 1987). To tackle the imbalances, government can intervene in the economic system (e.g., through regulations or levies), the ecological system (e.g., through rehabilitation of ground water), or address the economic system in more direct ways via the socio-cultural system (by stimulating more environmental consciousness in the economic decision-making process). These interventions may take place at different spatial scales (e.g., local, regional, national, and international).

The United Nation Conference on Environment and Development (UNCED, 1992) and the resulting Agenda 21 have bestowed worldwide respectability on the concept of sustainable development. There are over 70 different definitions of sustainable development, offering a number of possible modifications of the development process and a number of different reasons for doing so (Steer and Wade-Gery, 1993). Sustainability means that the evolution and development of the future should be based on continuing and recommendable processes and not on the exploitation and the exhaustion of the principal or the capital of the living resource base. Population growth is a key factor to be considered in the implementation of sustainable development, which can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem.

Differences may be found in the definitions of sustainable development. Some definitions of sustainable development are mainly focused on sustaining economic development. However, some authors think that ecological consideration should always be involved in the total developments, not just economic development. Barbier (1987) argues that sustainable development depends upon interaction among three systems, the biological system, the economic system, and the social system. The goals of sustainable development for the three systems are:

– *For the biological system*: Maintenance of genetic diversity, resilience, and biological productivity.
– *For the economic system*: The satisfaction of the basic needs (reduction of poverty), equity enhancement, increasing useful goods and services.
– *For the social system*: Ensuring cultural diversity, institutional sustainability, social justice, and participation.

While sustainability has become a widely acknowledged concept in the recent developmental thinking, there are considerable arguments on how the concept should be implemented. Pearce and Turner (1990) propose a working definition that involves maximization of the net benefits of economic development subject to maintenance of the services and quality of natural resources over time. In this definition, the maintenance of services and quality of the stock of resources over time implies, as far as practicable, the adherence to the following two rules:

– Utilize renewable resources at a rate less than or equal to the natural rate in which they regenerate. Keep waste flows to the environment at or below the assimilating capacity of environment.
– Optimize the efficiency with which non-renewable resources are used, subject to sustainability between resources and technical progress.

However, in general, as claimed by Gar-on Yeh and Li (1996), there is a general lack of a general framework for guiding economic development while achieving sustainable development.

Definition and Description of Land-use Systems

Sound LUP is crucial to the realization of sustainable development. The starting point in this process is definition, description, and quantification of land-use capability or land utilization systems, as that is where the actual agricultural practice is taking place. There is no agreement on how LUSs should be defined (Beek, 1978), and the methods for describing and quantifying LUSs are subjects of continuing discussion (FAO, 1983; Stomph, *et al.*, 1994; Jansen and Schipper, 1995). However, for effective LUP and policy analysis, it is recommended to consider LUSs as integral systems that include both biophysical and socio-economic elements (Stomph, *et al*., 1994).

The term, LUS, can be used for any description of land use at any land unit level. The FAO (1998) defined LUS as: a specified land utilization type practiced during a known period of time on a land unit that is considered homogenous in land resources, and associated with inputs, outputs, and possible land improvements. A land unit is defined as an area of land possessing specified land qualities and land characteristics that can be demarcated on a map. Land-use type (LUT) is defined as a crop, crop combination, or cropping system with specified irrigation and management methods in a defined technical and socio-economic setting (Fresco, *et al*., 1990).

In theory, the compounded requirements of a LUT, in combination with compounded qualities of the land unit (LU) and prevailing socio-economic conditions, determine the suitability of the LU-LUT combination LUS in terms of productivity, sustainability, economic viability, and social acceptability (Figure 3). Jansen and Schipper (1995) use the term LUST (LUS + Technology) to describe a LUS with defined technology.

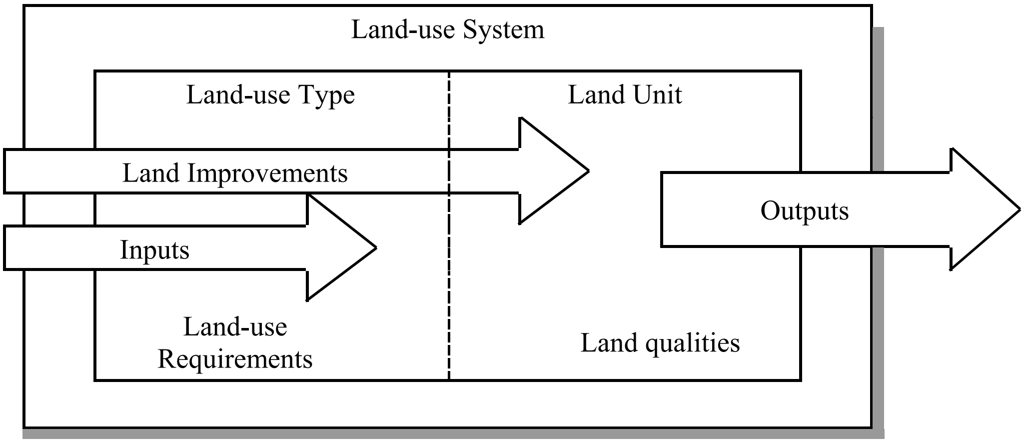

Figure 3. Land-use Systems (LUS = LU + LUT)

Source: De Bie, 2000.

Common in the definitions of LUSs is that LUs are defined only with specific biophysical characteristics. This LU may therefore be called a biophysical land unit. Although, theoretically, many definitions recognize that LUTs are parts of farm systems, and therefore not independent. In practice, they only assess the suitability of LUs for specific types of land use, without taking into account the farm as a decision-making unit. In a way, they look at land use on a (sub-)regional level, omitting the farm level. Many LUS assessments, although still relevant, are therefore less applicable for LUP and policy analysis, and certainly for use as a basis for implementing a proposed land-use change (Polman, *et al*., 1982; Fresco, *et al*., 1990; and Erenstein and Schipper, 1993). Although the concept of LUST can be considered a step forward in linking LUTs and farm systems, the interaction between socio-economics and biophysics is loosely represented as the only link to an assumed level of technology. Socio-economic characteristics receive little or no attention. Moreover, as socio-economic conditions are defined at a farm type level and the biophysical conditions at a LU level, the use of farm types (which are socio-economically but not necessarily biophysically homogenous units) as units for land-use modeling, may not correspond to a farmer's behavior and therefore result in serious aggregation errors. These definitions may be suitable for prospective studies, however, for predictive studies socio-economic specifications should be included in the description of LUTs, in an operational way. Because to simulate the behavior of the farmer, LUTs demand socio-economic requirements that are not supplied from the respective LUs.

To incorporate socio-economic specifications in the definition of a LUS, the concept of integral LUS (ILUS) (Mohamed, 2000) is introduced (Figure 4). The concept of ILUS is based on the logical argument that LUSs, no matter at what level they are defined, are integral systems and their description should include both biophysical and socio-economic characteristics. Only then one can compare what land can supply with what land-use demands. Lands can supply not only biophysical characteristics but also socio-economic conditions. Land-use demands both biophysical and socio-economic requirements for proper planning.

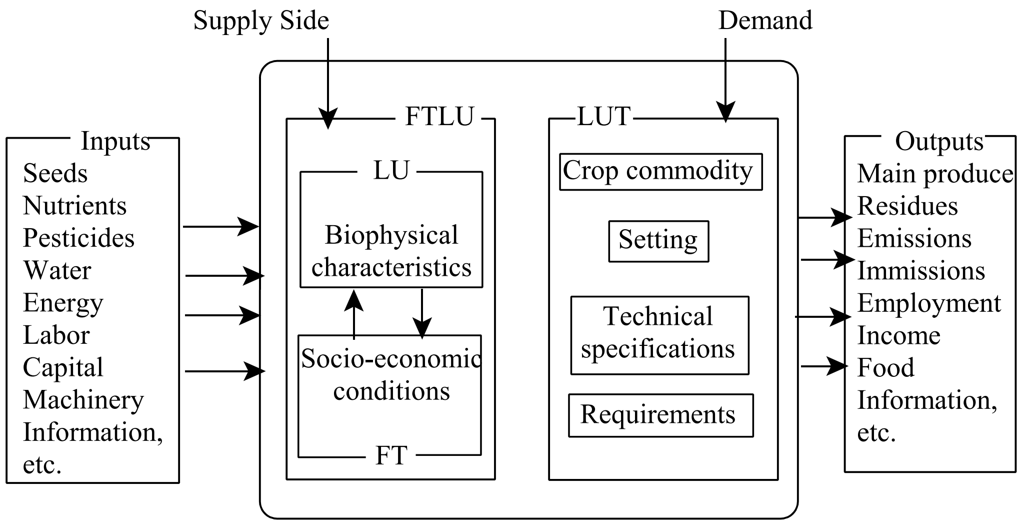

Figure 4. Simplified Diagram of an Integral Land-use System

In accordance with the definition of systems, inputs and outputs can be defined. The transformation processes from inputs to outputs in the system are identified and quantitatively described. The simplified diagram presented in Figure 4 illustrates some of the important components considered. ILUS itself is not a closed system but a sub-system of a larger system at a higher level of aggregation.

To deal with a socio-economic sub-system within the integrated framework, the approach starts at the farm – the decision-making unit with respect to land use – and from there describes the ILUS. In this concept, land in a socio-economic sense is linked to the farm. Therefore, the biophysical LU needs to be adapted to include the farm system. This has been conceptualized by introducing the concept of a farm type land unit (FTLU) (for more see Mohamed and Sharifi, 1998) that links farm type and LU into an integrated unit (Figure 4).

In general, LUTs are part of farm systems and are not mutually independent. In this concept LUTs are described in relation to FTLUs. Any LUT can be practiced in various socio-economic and biophysical settings, depending on the FTLU. Various (agronomic and socio-economic) technical specifications can be defined for a given LUT dictated by different biophysical and socio-economic settings. Combining information on the settings and specifications with information on type of land use (e.g., crop commodity) allows description of LUTs with both biophysical requirements and socio-economic requirements. This description then forms the basis for quantification of input and output coefficients of the ILUS.

In predictive land-use studies, ILUS descriptions then serve as a basis for the calculation of the required input-output coefficients. This has the advantage that LUSs do not have, to be described again for each change in the calculation of the coefficients. Each unique operation sequence within an ILUS can be interpreted as a specific land-use activity. Each activity is defined and described quantitatively in terms of input and output coefficients, which quantify the relation between inputs of production and outputs of production, desired as well as undesired.

PLANNING SUPPORT SYSTEMS TO ENHANCE SUSTAINABLE LAND UTILIZATION

Planning is a specific type of decision-making. As such, it should comply with the definition and phases of decision-making and problem-solving processes, and includes the following main phases (Sharifi, 1999):

– *Intelligence*: In this phase the environment is examined to identify problem situations or opportunity situations.
– *Design*: In this phase the possible courses of action are initiated, developed, and analyzed. This involves application of decision models that generate solutions, test their feasibility, and analyze different alternatives.
– *Choice*: In this phase alternative options are evaluated and one of the alternatives, i.e. a specific course of action, is selected.
– Implementation.
– Monitoring and control.

Planning Support Systems (PSSs) is a term that refers to the class of geoinformation systems composed of data/information, models, and visualization tools that are primarily developed to support different phases of the planning process – mainly in the phases of problem analysis, formulation, evaluation, and choice of plan and policies. PSSs are rationalizing planning and related decision-making processes by providing necessary support to systematically structure and formulate the alternative, policies, scenarios, and plans, to assess and evaluate their impacts (considering objectives of the relevant stakeholders), and to guide the selection of a proper policy, scenario, or plan. Underlying the work on PSS is the assumption that planning is a dynamic process and therefore needs the relevant support for continuous updating of data, and by generating and evaluating plans and policies based on the new assumptions. Naturally, a greater degree of access to relevant information will lead to the consideration of a greater and more effective number of alternative scenarios, which will result in a better informed planning and public debate.

Main Components of the System

PSSs, as a specific type of decision support systems, includes the following main components (Figure 5):

- *Resource base*: An information system designed to accommodate and organize the basic spatial and thematic data, provide facilities (interfaces) for the integration of various models, and provide visualization and communication of the results of analysis to the policy-makers in a manageable and understandable form.
- *Model base*: Includes all quantitative and qualitative models that support resource analysis, assessment of production potentials of various types of land use at different levels of management, and their corresponding input requirements. Model base includes:
  - Planning model: Integrates all potential and capacity of the resources (biophysical suitability), socio-economic information, and the goals and objectives of the different stakeholders to allow generation of possible scenarios.
  - Evaluation model: Allows appraisal and evaluation of each scenario and helps identify the one that is most acceptable by all parties involved.
- *Knowledge base*: Provides information on data and existing processing capacity and models which can be used to identify problems, to generate solutions, to evaluate and appraise them, and finally to communicate the results to the decision-makers.
- *User-friendly interface*: Allows for smooth and easy communication with the system and visualization of the results.

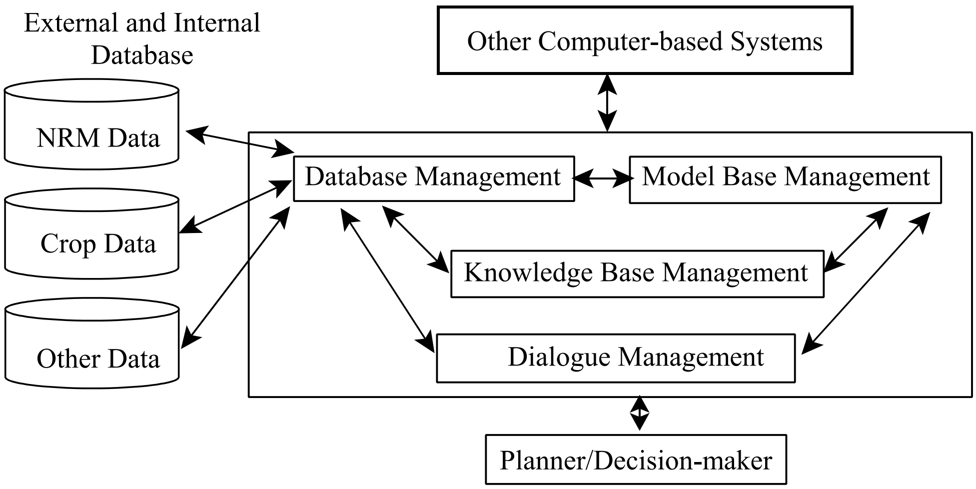

Figure 5. Overall Architect of a Planning Support System

Planning Support System for Sustainable Land-use Systems

Careful comparisons of steps in the LUP procedure and problem-solving process reveals a perfect match: intelligence corresponding to problem formulation, design procedures for development of proper policy and plans, choices for selection and recommendation of proper policies or plans, implementation, monitoring, and evaluations are a one to one match.

In the LUP process, which is composed of the first three phases of problem-solving, the model-based planning support procedures, as presented in Figure 6, are highly recommended. As was discussed earlier, the information requirements of each phase can only be derived from special types of studies. In the following sections, the proper type of studies for each phase in the process of LUP is introduced.

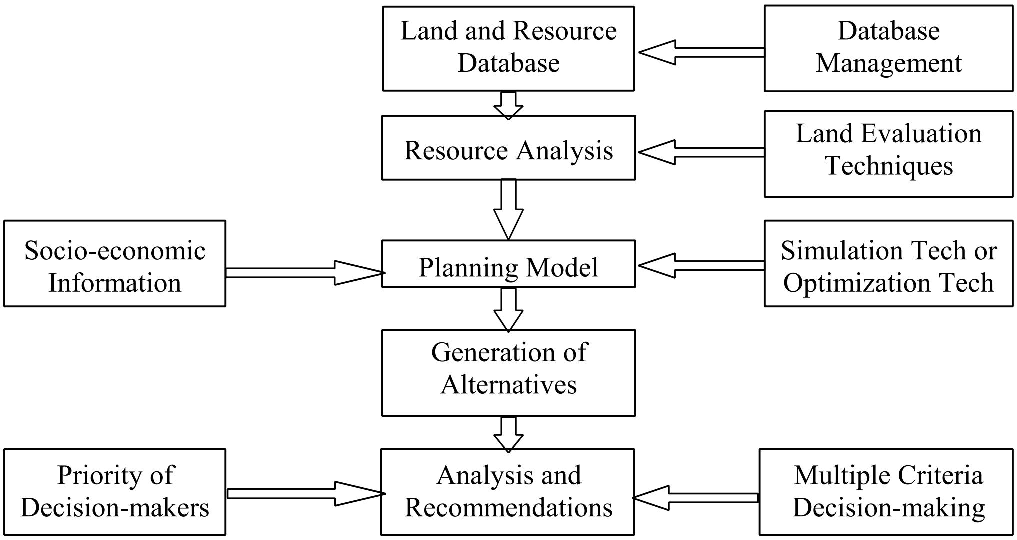

Figure 6. Basic Principles of Model-based PSS

1. ***Intelligence***

In agricultural systems, opportunities and constraints may be related to agro-technical conditions (physical), or to agro-economic conditions (socio-economic). The physical aspects refer to the assessment of the biophysical productivity capability of each tract of land for each prospective LUT, and are characterized by crop yield estimates. This can be derived from dynamic simulation modeling of the main growth controlling factors and processes, or from empirical or experimental productivity models. The agro-economic aspects refer to existing socio-economic constraints and opportunities, through understanding the fundamental characteristics of resources and the processes through which they are allocated and utilized (Sharifi and van Keulen, 1994).

In this phase, projective and predictive land-use studies can each play a role. These studies are based on extrapolated trends and facts from the past and present and may shed light on plausible developments. Results can be used to project future land-use changes and to analyze possible impacts of changes in land-use drivers. In general, studies that are used in this phase support resource analysis in which identification and comparison of the current uses, with the biophysical, technical capacity of resources, or expectations about the system, are carried out. If the differences are meaningful, a decision problem is triggered.

2. ***Design***

This is the most important part of the decision-making process. It identifies facilities needed to analyze the problems, generate solutions, and to test the feasibility of the solutions. As was discussed in the LUP cycle, design and development of policy requires proper land-use studies to establish the goal, and to formulate policies and plans. This is accomplished by applying planning models (Figure 6) that generate alternative options, including the associated results and requirements of the plan. Depending on the steps in the planning cycle, a special type of study should be used.

3. ***Goal Formulation***

This step makes use of explorative type of studies that are focused on the question, "what would be possible?" Explorative types of studies aim at defining the envelope of development possibilities through combining the biophysical opportunities and limitations with societal objectives, to explore ultimate options and consequences of priorities. They emphasize the biophysical possibilities in the belief that, at least in the long run, most human-related factors and attitudes can be adapted (or can be forced in a desired direction), whereas the biophysical conditions can hardly be modified. Exploratory studies are very effective in showing technical and biophysical possibilities and limitations of the agricultural system, and in creating consensus on objectives, and will lend to a targeted identification of policy instruments and plans. The smallest unit of analysis here can be LUS as defined by FAO.

4. ***Policy Formulation***

This requires more predictive studies that are focused on the questions 'what can be changed?' and 'how can desired changes be realized?' These studies emphasize the current situation in terms of the (socio-)economic environment and land-use pattern, and consider these as the main constraints to modification. These types of study are based on simulation models that are trying to simulate the behavior of the target group (farmers) given different policy goals and measures. Mohamed (2000) gives examples of this type of study. Predictive land-use analysis instruments, such as farm household modeling, in which the current situation, in both an agro-technical and socio-economic sense, can be taken into account as determinant for agricultural development and the associated changes in land use.

This type of analysis has a strongly predictive character. The major aim is to test the effectiveness of possible policy measures in inducing farmers to change their choices with respect to land use in the desired (in the first instance identified by policy-makers) direction. The relevance of the results for actual policy formulation strongly hinges on the accuracy with which technological options can be quantified. Therefore, this approach also allows improved interactions between policy analysis and agricultural research and development. The smallest unit of analysis here can be ILUS as defined earlier.

5. ***Plan Formulation***

Depending on the context and objectives, plan formulation makes use of different types of approaches. For example, if the issue is implementation of a policy decision then it relates to decisions about cost, provision of funds, organizational requirements, scheduling of the required activities, and other related issues. If it relates to the direct intervention of government, techniques that supports project formulation, appraisal, and other methods such as Utility Based Analysis (UTA) for formulation of development options based on projects, are more applicable.

6. ***Choice***

During the choice phase, the planner ranks the alternative plans on the basis of their results and level of decision impacts. The planner then makes an acceptable choice. This is achieved through the application of a multiple criteria decision-making method. This method calls for the priorities of the decision-makers and their readiness to trade-off between different objectives. An important consideration in evaluating alternatives is the sensitivity of the solution to changes in the assumptions on which the decision is to be based or to the conditions that are expected to occur.

CONCLUDING REMARKS

LUP for agricultural development has agronomic, social, economic, and political dimensions. LUP deals with multipurpose use of land, trade-offs between different functions of land, and often conflicting interests among different categories of land users and between collective and individual aspirations and needs. LUP is therefore a multiple objective problem, which includes a variety of complex processes such as agronomic, ecological, social, and economic factors. Planning should provide a framework for operation and decision-making. The plan should reflect expectations about the environment, the capacity of the system, and the trade-offs between alternative options for allocation of resources and direction of efforts. A principal problem, that an agricultural development plan will have to address, is how to achieve sound, optimal (considering the objectives and constraints), and sustainable development of resources in the country. Food production has been identified as the principal development thrust in the rural areas, and will remain so. However, it needs to be harmoniously balanced with sound environmental protection policies. The plan has to promote sustainable land utilization systems, taking into account prevailing, and expected physical, human, and financial constraints.

A sustainable development plan can be usefully characterized by its main components: choosing objectives, stocktaking and diagnostic survey, demand and supply projections, setting targets and allocating resources, the choice of strategies and policies, programs and projects, the institutional changes involved, monitoring, reporting, control and evaluation. Each of these components requires a special type of land-use study, based on different principles and assumptions. The time horizon for planning is particularly very important and planning must fully take that into account. Planning is a dynamic process that requires a dynamic approach that enables continuous flexible development of planning data, models, and results. Effective agricultural planning requires an appropriate system that includes all the planning components and that can handle the complexity, diversity, and dynamics of the agricultural environment. So far, planning for agricultural development has not been very successful. Many times plans have been made and ignored, or implemented in a very passive fashion. This is related to the nature and complexity of LUP for agricultural development from one side, and unavailability of proper supporting tools and data from the other side.

Improvement of the effectiveness and efficiency of planning in such an environment requires proper tools, methods, and procedures that can support the decision-makers in their decision-making processes. Such types of tools and techniques which can be integrated in a PSS, can support the analysis of information, can find and formulate problems in the real system, develop alternative solutions, evaluate pros, cons, and consequences of each option, and make a decision that is in line with the sustainable development of the environment. Such a system should support all elements of planning through providing facilities to update the required data, accomplish a comprehensive resource analysis, continue identification of constraints, and enable integration of the biophysical and socio-economic information to develop the proper planning model and appraise the costs and benefits of various policies and land utilization systems.

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2. AN ANALYSIS OF THE ISSUES AND PROBLEMS IN IMPROVING LAND UTILIZATION SYSTEMS FOR SUSTAINABLE AGRICULTURAL PRODUCTION

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INTRODUCTION

Sustainable agriculture is a term that is on the minds of many managers, engineers, and scientists who are concerned with the future food supply of the world. Population projections have, on a number of occasions, predicted that the number of people needing food would outrun the food supply, in what was considered to be the foreseeable future at the time of the prediction. The most famous of these predictions was made by Thomas Robert Malthus (1798). What Malthus could not predict was the improvements in crop genetics, cultivation methods, fertilizer application, insect and plant disease control, and irrigation of arid lands. These advances have resulted in a food supply that has, fortunately, stayed ahead of the world food demand. This does not mean that there has been no suffering and starvation, but these problems are localized and are usually a result of drought, natural and man-caused disasters, and wealth distribution. A number of years ago, Dr. D. F. Peterson, Dean of the College of Engineering of Utah State University said, "There is no economic food shortage in the world". What he meant was that there was enough food for anyone who had enough money to buy it. The basic problem was that the people who were starving did not have the financial resources to pay for the food they needed. The very insightful statement by Dr. Peterson is still true. Money can still move the food of the world to wherever it is needed. The basic problem of having adequate incomes for people, who need food, can only be solved by stable governments, universal education, and serious peaceful cooperation between nations and nationalities and ethnic groups. With that kind of peace, governments can work in an environment that will result in an improved level of individual productivity and international commerce. That kind of peace and cooperation will make it possible for all people to obtain the food they need on a continuous basis. However, education and income alone will not solve the more fundamental problem of finite natural resource allrentron.

It is time to make a new prediction about the inevitable collision between food production and food consumption. World population is seemingly growing at a rate that modern predictions again say will outrun the food supply. Agricultural productivity can be improved by genetic engineering, but there is opposition to that approach. Birth control advocates say that forcefully lowering birthrates will solve the problem, but that is also a solution that does not enjoy universal acceptance. People who have adequate incomes will not be the ones who starve. The race is therefore to increase the productivity of people so that they can live with some feeling of long-term security and at the same time do something about population growth. Puerto Rico, a small island in the Caribbean, in the 1950s had a growing population problem and tried to export people to the United States (to which they could emigrate freely). The newspapers carried a daily log of the number of people entering and leaving the island, including new births. The government also began to encourage labor-intensive industrialization to give employment to people with little education. In pursuit of those daily population statistics, the Puerto Rican Government observed that when family income reached a certain level, the number of children born to a family decreased. Families with that critical level of income realized that fewer children meant better education, better healthcare, better living conditions and better future incomes for all family members and voluntarily reduced the number of children per family. Any new prediction of future food needs must consider sociological factors as well as technical factors and, in addition, must consider the fact that we live on a finite globe with finite resources. Sending people to the United States, or to live on Mars, or to live on the Moon, is not the answer to the ultimate food supply-population problem. The fundamental question is how to coordinate the food needs of a growing population with the finite productive capacity of the planet earth. This question directly affects the Asia and the Pacific region, which is a significant part of the world picture.

FINITE RESOURCES

The finite resources of primary concern in relation to food production are air, land, and water. There should be plenty of people available to grow the food that will be needed in the future, but there may not be enough suitable soil and water. The atmosphere is a concern because we are learning that global warming may change local climates. The long-term climate data that we depend upon to plan for future use of our limited supply of freshwater may be invalidated by the climate changes. Other atmospheric problems are arising simultaneously such as the diminishing ozone layer and the lowering of the quality of the air that we breathe. Much good agricultural land is being covered by roads and cities. There is a finite amount of soil that is suitable for growing crops and it needs preservation. Water is another finite resource and all life on earth depends on the existence of water in a timely and usable form. There are a few bacteria that have adapted to very toxic water, and the oceans teem with life forms that have adapted to saline water, but the remainder of plant and animal life on the earth needs relatively pure water. Naturally occurring freshwater is another finite resource.

Every use of water diminishes its quality, so there is a quality, as well as a quantity concern that affects how many times a given water supply can be reused. Agricultural plants and animals cannot use water that is fully acceptable as seawater. People require high quality water, relatively free of all kinds of contaminants and toxic elements.

Land, suitable for food production, is another finite resource. Most of the surface of the earth is covered by salt water. The remaining area consists of all types of landforms including steep rocky mountains where no plants can grow, land in arctic areas with extremely short growing seasons, and deserts that are essentially devoid of plant and animal life. Human populations are therefore restricted to that part of the world’s land area that has a climate suitable for crop production and animal life, and that has adequate soil and water resources to permit a sustainable existence. There is a limited area of the earth’s surface that meets all those requirements and it is not renewable.

When populations were small, growth was absorbed by people moving onto new land. The world is now approaching a population level where expansion into new lands is no longer a reasonable option. That means that we have to learn to exist within the limits of the available natural resources. In addition, recognition of the importance of a balanced world ecology has created an awareness of the importance of a varied environment and the interaction of environmental elements for sustainable plant and animal life. Some obvious solutions to specific problems may not be viable. For example, the use of DDT solved an insect problem, but created an unacceptable environmental problem related to birds. We must now be concerned, not only for our own environment, but the environment of all other forms of life on the earth. There is no longer a status quo with respect to the past procedures for managing the available supply of soil and water and air. When one thing is changed, something else must change. This phenomenon is sometimes referred to as a "zero sum situation". If land is used for a city, there is less land on which to grow food. The proportioning of critical resources may be manipulated, but the total resource is finite and cannot be increased. Careful evaluation and planning are critically important for management of the finite air, soil, and water resources of the planet.

THE TRAGEDY OF THE COMMONS

In 1968, an article entitled "The Tragedy of the Commons" by Garrett Hardin (1968) appeared in science magazine. "Commons" were community pastures used in rural England and the eastern United States in the 1700s. Citizens of the community, which owned and managed the Commons, were entitled to pasture whatever animals belonged to their household. The tragedy arose when people began to add more and more numbers of animals to the Commons until the animal population destroyed the pasture resource and none of the animals had food. Hardin discussed the inevitability of destruction of a finite resource by a management system that allowed full and unrestricted personal benefit to an individual and distributed the negative dis-benefits of the action of an individual to all the other users. As long as there were fewer animals than the Commons could support, the system was sustainable. The capacity of the Commons was finite, so use had to somehow be restricted to prevent destruction of the resource. How to manage that restriction while respecting the rights of the participants is a difficult sociological problem with no technical solution.

Ostrom and Field (1999) have recently examined the ideas presented by Hardin (1968) and have discussed new insights and alternatives for management of what they have termed "Common Pool Resources". Since the world has a finite number of food production resources available, the land and the freshwater and the atmosphere of the world must now be treated as Common Pool Resources.

According to Ostrom and Field (1999), Hardin's suggested solutions to the "Commons" problem were either socialism or the privatization of free enterprise. It was therefore argued that solutions must be imposed on users by external authorities. Ostrom and Field pointed out that for thousands of years, local people have self-organized to manage common-pool resources and have successfully devised long-term, sustainable institutions for governing use of those resources. Other management alternatives may not be successful. They gave an example of some adjacent modern grassland management systems, in Russia, in China and in Mongolia. Mongolia has allowed traditional pastoralists to continue their group property management institutions that involve migration of animals between seasonal pasture areas. Across the borders, both Russia and China have imposed state-owned agricultural collectives with permanent settlements. China has taken the privatization solution by dividing the pasture land into individual allocations for each herding household. Russia socialized the management. An analysis of satellite data shows that 75 percent of the

Russian sector and 30 percent of the Chinese sector is degraded, but only 10 percent of the Mongolian sector is classified as degraded. Ostrom and Field noted that, "Here, socialism and privatization are both associated with more degradation than resulted from a traditional group-property regime".

In their paper, Ostrom and Field (1999) also describe, in some detail, the nature of common-pool resources. They discuss alternative institutions for governing and managing these resources and describe the evolution of necessary norms and rules for effective management and for assuring sustainability of resources. They suggest that, "Users need some autonomy to make and enforce their own rules, and they must highly value the future sustainability of the resource". They gave an example of an irrigation project in Nepal where strong locally crafted rules, as well as evolved norms, have made the system water management efficient and effective. They continued to say, "Because the rules and norms that make an irrigation system operate well are not visible to external observers, efforts by well-meaning donors to replace primitive, farmer-constructed systems with newly constructed, government-owned systems have reduced rather than improved performance. However, the cropping intensity achieved by farmer-managed systems is significantly higher than on government systems. Both government ownership and the presence of modern headworks have had a negative impact on water delivered to the tail end of the system, hence a negative impact on overall system productivity".

In an effort to avoid "tragedy" in the management of one type of common-pool resource, there is a movement toward returning the management of irrigation systems to the users by organizing Water Users Associations. The objectives are to make the use of the water resource more efficient and to make the land more productive, while at the same time promoting sustainability. Such actions may solve a local problem, but may also create other problems on a broader scale. More efficient irrigation management may result in more of the freshwater supply being consumed. More crop production means that more water has been turned into plant material. There is almost a straight-line relationship between water consumed and vegetative production. If more water is consumed in an upstream location, there will be less water available for downstream users and the resulting return flows may have a lower quality. Social problems are difficult to solve. Therefore, any solutions to common-pool resource problems must also be based on and be supported by reliable physical data.

In their closing statement, Ostrom and Field (1999) wrote, "We have only one globe with which to experiment. Historically, people could migrate to other resources if they made a major error in managing a local common-pool resource. Today, we have less leeway for mistakes at the local level, while at the global level there is no place to move".

IRRIGATION IN ASIA

With the development of modern mechanized irrigation systems such as sprinklers, surface and subsurface drip irrigation, center pivot systems, and linear move systems, many countries have opted for mechanization to expand their irrigated areas. In spite of this trend, the majority of the irrigated land area of the world, and of Asia in particular, is currently irrigated by surface methods. There have been some recent improvements in surface irrigation techniques, such as surge flow irrigation, but most irrigation water control is by people using hand implements. The majority of the irrigation is done with furrows or small basins that are filled individually. The labor requirements for these types of irrigation are high, but in many areas there are no alternatives. Landholdings are small and will not individually support the financial investment that mechanized irrigation requires.

Surface methods of irrigation have been criticized as being universally inefficient, but when surface irrigation systems are properly managed, they can attain efficiencies equal to the most sophisticated modern equipment. Where climate permits, rice can be grown in constantly flooded plots that require little irrigation labor once the paddy has been established and stabilized. Paddy irrigation is efficient for both water use and labor. The plants use only the water they need and the excess water is directed to the next paddy. Mechanization is effective in the preparation of the individual paddy fields, but not in the application of irrigation water. Furrow or basin irrigation is a periodic operation that requires constant attention from the irrigator during water application to assure good distribution and to minimize runoff. The root zone of the soil can only hold a specific amount of water so that any excess amount applied beyond the water holding capacity of the soil goes to deep percolation, which recharges the groundwater. If the infiltrated water greatly exceeds the water holding capacity of the soil, the water table may rise and cause salinity problems. The water use by the surface-irrigated plants is limited to the amount they can extract from the soil between irrigations. If the frequency and amount of water applied is correct, the efficiency of the surface irrigation will be high and the crop will do well. Over- or under-irrigation will have a negative effect on crop yields. Too little water will result in less plant growth and lower production rates. Too much water will leach nutrients from the soil and may cause erosion and high water tables. Since the majority of the land is surface-irrigated, the critical factors are the application frequency and the correct amount of water to apply. Water user associations can help solve the sociological problems, but good physical data and knowledgeable management are also needed.

There are methods of estimating when and how much water to apply to a given soil and crop. The challenge is to deliver the correct amount of water to the farmer in a timely manner. It is assumed that the farmer knows how to spread the water uniformly over the land surface. This challenge to irrigate well can only be met by having adequate technical information in the hands of people who have the capacity to deliver the proper amount of water at the proper time. Both technical and sociological expertise is needed. Irrigation in Asia will improve only as fast as the infrastructure and the management of that infrastructure improves together.

Approximately 50 percent of the irrigated land in the world is found in the 21 countries that comprise Asia and the Pacific Zone. Most of the countries in this area have a high population density, few undeveloped resources, and a continuing need to develop food security. The land and waters resources of these countries are reaching the status of "Common-Pool Resources" and will require sociological as well as technical management if they are to avoid a "tragedy of the commons" experience. There is not an unlimited supply of new land and new freshwater, so peaceful cooperation is extremely important. The true extent of the resources must be measured and then the people affected by any management changes must be included in the decision-making process.

In 1999, the FAO published Water Reports Number 18, entitled *Irrigation in Asia in Figures*. Data were collected by the AQUASTAT program of FAO's Land and Water Division and were summarized in figures and tables. The report illustrates the current status of the irrigation and land resources in the area. The following is a quotation from the foreword of that document.

The countries of Asia now face new challenges for agricultural production. In many areas the extent of land available for cultivation has reached its limits and intensification is necessary to satisfy the needs of the population. In the most arid areas of the region, mainly in parts of China and India, water is increasingly becoming a limiting factor to agricultural extension. At the same time, problems of land degradation are affecting the agriculture potential of the region.
A good understanding of the major trends and challenges facing irrigated agriculture in Asia is only possible with a complete, up-to-date information base covering all issues related to irrigation in the region.

Most of the data presented in this paper were taken from the text, tables, and figures of the FAO report (FAO, 1999). The original data for the publication were condensed from numerous sources and were carefully examined by FAO experts to make the analysis as accurate as possible. Only a portion of the information is presented here for illustration.

Table 1 is a list of the countries mentioned in the report. Some of the data were combined for five different sub-regions of the area. The authors of the report thought that the data would be more meaningful if the sub-regions were made somewhat homogeneous. Table 2 shows that the total population of the separate sub-regions of Asia, as defined in the FAO Report, comprises nearly 53 percent of the world population. The Table also shows that this population is living on approximately 15 percent of the land area of the world. This kind of population density places a serious strain on the land and water resources of the region. Both living space and space to produce food are required. Agricultural land must be preserved and improved if food security is going to be achieved and maintained.

Table 1. Countries Included in Various Sub-regions

Indian sub-continent:	Bangladesh, Bhutan, India, Maldives, Nepal, Sri Lanka
Eastern Asia:	China, DPR Korea, Mongolia
Far East:	Japan, Rep. of Korea
Southeast:	Cambodia, Lao PDR, Myanmar, Thailand, Vietnam
Islands:	Brunei, Indonesia, Malaysia, Papua New Guinea, the Philippines

Table 2. Regional Distribution of Population

Sub-region	Km^2	Percent	Region Inhabitants
Indian sub-continent	3,691,680	18.1	1,106,849,000
Eastern Asia	11,285,070	55.3	1,263,255,000
Far East	477,060	2.4	170,665,920
Southeast	1,939,230	9.5	195,114,000
Islands	3,002,930	14.7	295,017,000
Asia	20,395,970	100.0	3,030,900,920
World	133,870,200	-	5,767,775,000
Asia as percent of world	-	15.24	52.55

A sociological factor that must be considered for the future is the distribution of population within the various countries and the density of population. Rural populations tend to have lower incomes than those found in urban areas and the only way to raise their standard of living is to make them more productive. In the beginning of the last century in the United States, one farmer was able to feed himself and three others. Now, one farmer can feed himself and more than 90 others. Most of the 90 others have left the farms and have gone to school and to factories and into service industries. They now have good incomes that allow them to buy food and lodging and enjoy a relatively high standard of living. Table 3 shows the percentage of the population that currently lives in rural areas in each of the sub-regions. In Asia, 67 percent of the population lives in rural areas, compared to 54 percent of the world population. Sixty-two percent of that population is directly involved in agriculture. When people change from rural agricultural occupations to other jobs, there will be less people to care for the land resource and more people in the cities in need of food and water in the cities. Table 3 also shows the population density in Inhabitants per square kilometer. The Far East sub-region has the highest population density and the lowest percentage of agricultural workers. Japan and Korea are the two countries in the Far East sub-region. Both of these countries are industrialized and have a relatively small rural population. The food and water from the agriculture sector now goes to the cities. If the social systems are to be sustainable, careful planning will be required to maintain a rational distribution of the food-producing land and the water needed to produce the food.

Table 3. Population in Agriculture

Sub-region	Rural (percent)	Inhabitants (/km^2)	Percent in Agriculture
Indian sub-continent	74	300	62
Eastern Asia	68	112	70
Far East	21	358	7
Southeast	78	101	67
Islands	58	98	49
Asia	67	149	62
World	54	43	47

Water Report 18 (FAO, 1999) contains detailed country profiles for the individual countries for each of the sub-regions. Table 4 lists the countries that are profiled in the report. The country profiles describe: Geography and Population, Climate and Water Resources, Irrigation and Drainage Development, Institutional Environment, and Trends in Water Resources Management, and have a list of the sources of information for each country. The country profiles also have individual tables that give more detailed information than is shown in the summary tables.

Table 4. Country Profiles in FAO Water Reports 18

Bangladesh, Bhutan, Brunei, Cambodia, China,
India, Indonesia, Japan, DPR Korea, Rep. of Korea,
Lao PDR, Malaysia, Maldives, Mongolia, Myanmar,
Nepal, Papua New Guinea, Philippines, Sri Lanka,
Thailand, Viet Nam

There is also a detailed narrative about each of the subjects included in the country profile, with subheadings on related subjects.

In order to align the information in this paper with the interests of those attending the Seminar, the remainder of the tables and information presented will be for those countries in attendance. If sustainability is a significant goal, then information about the remaining extent of the land and water resources is important. Table 5, extracted from tables in FAO Water Reports 18, shows something of the extent of the land resources remaining to be developed. In Bangladesh, for example, 88 percent of the land area is considered to be cultivatable and 86 percent of the cultivatable land is considered to be irrigable. Since Bangladesh has a long growing season and most of the land can be cultivated and irrigated, it would appear that the country has the potential for very intensive food production. There are some other factors that will affect such a conclusion. Bangladesh has the highest population density (874/km^2) of any country in the report, and has 16 persons per ha of cultivated area. There are also problems of excess water (flooding) in some periods of the year and water scarcity in other periods. The full picture of land and water development in each country needs to be examined before conclusions can be drawn about how to balance the needs of people for living space, water, and land on which to grow food.

Table 5. Cultivation and Irrigation Potential

Country	Area (000 ha)	Cultivable (ha)	Cultivated (percent)	Irrigable (percent)
Bangladesh	14,400	8,744,000	88	86
India	328,759	183,956,000	77	62
Indonesia	190,457	-	-	30
Pakistan	79,610	29,900,000	55	-
Rep. of Korea	9,926	-	-	-
Malaysia	32,975	14,174,688	36	3
Mongolia	156,650	1,800,000	37	29
Nepal	14,718	3,955,100	67	55
Sri Lanka	6,561	-	-	30
Thailand	51,312	26,790,000	76	46
Vietnam	33,169	7,086,000	95	85

The water supply problem of Bangladesh is very apparent in Table 6. FAO Reports 18 gives information on the renewable water resources available to each country. Some countries have water supplies that are independent of any other country. Other countries receive a large proportion of their water from rivers and aquifers that originate outside their borders. Malaysia does not depend on any external renewable water resources. If Malaysia's rainfall pattern and amount is adequate, they should be able to develop their land and water resources without international treaties. Bangladesh is on the other end of the scale. More than 90 percent of their renewable irrigation water resource comes from outside the country. Their water supplies originate in India and China and some sort of international treaty or agreement will be necessary to assure a dependable and secure renewable water supply for irrigation in Bangladesh. Some countries, with adequate rainfall for groundwater recharge, can depend on their own groundwater system to supply the freshwater needed for cities and irrigated farms. India gets more than half of its irrigation water supply from groundwater.

Table 6. Renewable Water Resources

Country	External (million m^3) (A)	Total (million m^3) (B)	A/B (percent)
Bangladesh	1,105,644	1,210,644	91.3
India	647,220	1,907,760	33.9
Indonesia	0	2,838,000	0
Pakistan	-	-	-
Rep. of Korea	4,850	69,700	7.0
Malaysia	0	580,000	0
Mongolia	0	34,800	0
Nepal	12,000	210,200	5.7
Sri Lanka	0	50,000	0
Thailand	199,944	409,944	48.8
Vietnam	524,710	891,210	58.9

Table 7 shows that a little less than half of the water used for irrigation in India comes from surface sources, which originate in China, Nepal and Bhutan. Some small rivers, which originate in India, flow into Myanmar and Bangladesh. The Indus River originates in China and flows into Pakistan. India will be sharing water supplies with an outside provider and will be a provider of water to other countries. The sociological problems of shared water supplies may be greater than the physical problems and costs associated with management of water that is a Common-Pool Resource.

Table 7. Irrigation Water Source

Country	Irrigation (ha)	Surface (percent)	Groundwater
Bangladesh	3,751,045	30.8	69.2
India	50,101,000	40.5	53.0
Indonesia	4,427,922	99.0	1.0
Pakistan	16,960,000	63.0	37.0
Rep. of Korea	888,795	94.9	5.1
Malaysia	362,600	92.0	8.0
Mongolia	84,300	-	-
Nepal	1,134,334	73.9	12.4
Sri Lanka	1,550,000	90.2	9.8
Thailand	5,003,724	99.8	0.2
Vietnam	3,000,000	-	-

Table 7 also shows that India obtains a large proportion of its renewable irrigation water supply from groundwater. Groundwater is recharged by rainfall and by seepage from rivers. Over-pumping of groundwater under a river system may effectively be a direct diversion from a river that will diminish the downstream flows. Malaysia gets only 8 percent of its renewable water from groundwater, but may be limited in the amount of pumping it can do due to problems of salt water intrusion into coastal aquifers.

Resource development in Asia and the Pacific area will be highly dependent on realistic understanding of the management requirements of limited, but renewable resources and the wise care of the non-renewable resources such as forests and soils. The countries in the Islands sub-region in Table 1 are possible sources of examples of workable practices and data for managing common pool resources. They each have very apparent finite limits to all of their resources.

CONCLUSIONS

Sustainable agricultural production is an internationally acceptable goal. What is not universally acceptable is the wide range of compromises that are necessary to attain it. The political boundaries that have been drawn on the map of the world do not correspond to fully defined land and water resources and that creates some inequities. An ideal situation might be to have each parcel of land with an independent supply of air and land and water and the right to discharge any wastes freely across its boundaries. These specifications are not attainable because the boundary of one parcel of land is also the boundary of an adjacent parcel which might, itself, like more water and which objects to accepting wastes. For agriculture to be truly sustainable, it must be designed and managed according to the laws of physics and chemistry and according to the needs and preferences of the inhabitants. It is easy to make agricultural production sustainable on a given area, if the surrounding areas can be called upon to service the needs of the given area. Since the adjacent areas have similar needs, compromises and cooperation are necessary.

If a group of people were to take a voyage on a spaceship that would last for three generations, they would have to organize every detail for the spaceship to be able to support sustainable life for a long period of time. The earth has been called a spaceship because nothing enters or leaves it except radiant energy. The earth has been stocked with provisions to support all kinds of plant and animal life, and for many years has been functioning on a sustainable basis. “Commons” have also been successful for long periods of time when they were managed within the limits of their animal carrying capacity. Only when Commons were mismanaged did they fail. The soil of a Commons and the associated rainfall were capable of producing adequate food for a finite number of animals. Fewer animals could survive without difficulty, but more animals would destroy the Commons and all the animals and the people who depend on them would perish.

The earth is now approaching some recognizable limits with respect to sustainability. More pollution is being put into the atmosphere than the atmosphere can assimilate and process. There is more demand for land for housing and industry than is available in some areas and agriculture is being crowded out for economic reasons. The best and smoothest lands that are suitable for growing food are also very desirable for building sites. Covering agricultural lands with buildings has not created serious problems recently because food can be brought from other places to feed the people that occupy the buildings. Waste disposal is a problem because sanitary waste disposal uses water as a transport mechanism, causing the water to become too polluted for human use. Unpolluted water is needed to grow food, so the competition is building between cities and industries and farmers for the finite freshwater supply. The oceans contain great quantities of water, but salt removal to make the water useable for humans, animals, and plants is an uneconomical process under present conditions. Plants also require soil in which to grow and there is a limited supply of soil with suitable properties to support agricultural production. Just as water must be protected to preserve its usefulness, soil and air must also be protected. If the air is treated as a Commons and every industry discharges its wastes into the atmosphere in an uncontrolled manner to maximize their own benefit, the air may be destroyed and the people will die. All uses of air, soil, and water must be considered in the light of the long-term sustainability of our life support system.

Sustainable agricultural projections can be attained if the soil is maintained. That means that erosion must be controlled and the soil must be managed to maintain its fertility and water supply. Over-application of fertilizer and pesticides may damage the water supply. Over-application of water can cause salinity problems and destruction of nutrients and can even cause plant diseases. To make agriculture sustainable, all the involved systems must also be made sustainable. It must be recognized that a sustainable level of production might be lower than our wishes, but we may have to reduce our demands in order to preserve the resource. Some fishing resources have nearly been destroyed because they were treated as uncontrolled Commons and bigger and bigger boats caught more and more fish until the resource was in peril of being destroyed. These kinds of mistakes can now be avoided by reasonable cooperation between the local and international users of Common-Pool Resources.

A sustainable agriculture must have land and water, erosion control and fertility, and voluntary cooperation between all the users of the many resources required for a sustainable system. Adjacent countries share watersheds and drainage basins and the air supply. Cooperation is better than war to solve the problems of sustainability of any common-pool resource. It would be well to remember that oil is a finite resource that is presently being mined. When the oil supply has been used up, agriculture may be called upon to produce fuel as well as food, and it will require an additional part of our limited supply of soil and water suitable for agriculture.

It must be recognized that the planet earth is a "commons" that has a finite capacity to produce food. The capacity of the earth to produce food on a sustainable basis may be limited by one or more of the resources required, such as soil, or water, or air. Plants and animals and insects must be included in the negotiations. Cooperation between people and nations will absolutely be required to make reasonable and sustainable divisions of the available life-supporting finite resources of the earth.

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3. AN OVERVIEW OF CURRENT LAND UTILIZATION SYSTEMS AND THEIR CONTRIBUTION TO AGRICULTURAL PRODUCTIVITY

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INTRODUCTION

One of the most serious problems endangering the world today is the deterioration of the natural environment and resources. It occurs at any scale, ranging from individual, to regional, to the entire world. In a dynamic sense, these environmental pressures imply the risk that future generations will have fewer natural resources to sustain themselves. As far as current land utilization systems are concerned, human activities generate pressure by the following impacts on environment:

– Over-exploiting renewable resources such as fisheries and forests.
– Influencing the rate of regeneration of renewable resources through pollution.
– Intrusion into ecosystems.
– Degrading basic resources, such as water, which causes damage to human health and well-being.

Economic activity, as related to production and consumption, is primarily undertaken to serve human needs; however, the ultimate effect may be destructive in terms of sustainability of mankind's welfare, now and, even more so, in the future. Currently, about 40 percent of the biological productive potential of the land is used by mankind, and it is expected that this percent will increase to 80 by the year 2030. The loss of topsoil and global warming indicates severe environmental degradation. The implications in terms of costs – that is, agricultural losses – due to global desertification, have been estimated to be in the range of US$26 billion per annum. Forested areas are demolished at unprecedented rates and per capita arable land is diminishing.

The nature and intensity of environmental problems and the need to address environmental problems at the national level have been clear ever since the first report to the Club of Rome, "Limits to Growth" in 1971.

Critical objectives for environmental and economic policies compatible with sustainability are:

– Reviving economic growth.
– Changing the quality of growth.
– Meeting essential basic needs.
– Ensuring a sustainable level of population.

– Conserving and enhancing the resource base.
– Reorienting technology and managing risk.
– Merging environment and economics in decision-making.

The latter strategic imperative is meant to induce a change in attitudes, objectives, and institutional arrangements at all levels – ranging from the individual household and farm to regional and national levels.

In this paper, the current state of land-use systems in Asia are examined, the limits to growth, and the future challenges ahead are reviewed.

THE STATE OF LAND-USE SYSTEMS IN ASIA

The past three decades have been a period of relatively rapid change in Asian agriculture. The "Green Revolution" in rice and wheat, initiated in the 1960s, is often cited as one of the great success stories of agricultural research. Highly focused investments in research, irrigation, and extension infrastructure led to food self-sufficiency among previously food deficit countries of South and Southeast Asia. Rapid adoption of modern high yielding varieties of rice and wheat led to a substantial drop in the cost per unit of food output and a decrease in the real price of food to consumers. Economic rates of return to investments in rice and wheat research have been very high, mostly greater than 50 percent.

In Asia, the first technological breakthrough came in the late 1960s with the development and widespread distribution of high yielding varieties of rice and wheat combined with expanded use of irrigation and fertilizer. The widespread adoption of new varieties followed by a "post-Green Revolution" phase of land saving input intensification and, in many areas, the adoption of labor-saving technologies resulted from growing scarcity of labor. Intensification was manifested in both increasing use of inputs, especially fertilizer and water, and increased multiple cropping.

The movement from a single crop cultivation system to a double and a triple crop system also increased the demand for labor, especially at peak seasons. This lead to an increase in real wages, even in densely populated countries such as India and Indonesia. Adoption of labor-saving mechanical and chemical technologies has alleviated these constraints and has contributed substantially to overall productivity growth. The research and development of labor-saving technologies has largely been done in the private sector – most of them through technology transfer from higher wage economies.

By the late 1980s the most advantaged "post-Green Revolution" areas of Asia had reached a point of sharply diminishing returns to further intensification and had entered a second "post-Green Revolution" phase characterized by the use of better knowledge and management skills to substitute for higher levels of input use.

In Iran, during the first economic development plan (1988-92) after the Islamic Revolution of 1979, a wheat improvement program was launched to integrate extension with providing subsidized inputs to farmers. The program succeeded to increase the average yield per ha of wheat from 2.5 mt to 3.7 mt in irrigated lands, but after reaching that point, there was a setback in this upward trend mainly due to intensive use of new inputs and neglecting crop rotation. The study conducted by the author to evaluate the program reached the conclusion that, as Table 1 shows, there are differences in productivity among farmers equal to 20 percent. This is mainly due to variations in their managerial level.

The review of farm level studies in other Asian countries suggested that the average level of technical inefficiency is about 30 percent. Another group of studies also reveals substantial allocated inefficiencies, especially for modern production inputs such as fertilizer and other chemicals.

Table 1. Frequency of Distribution of Technical Efficiency Rating

Efficiency Rating (percent)	1988-89	1989-97	1990-91	1991-92
1 - 40	0	0	0	0
40 - 45	2	0	0	0
50 - 55	4	0	0	0
55 - 60	6	3	0	0
60 - 65	9	7	4	1
65 - 70	2	9	7	4
70 - 75	3	3	3	9
75 - 80	2	3	5	5
80 - 85	1	2	3	5
85 - 90	6	4	3	2
90 - 95	1	3	4	6
95 - 100	0	0	1	1
Mean	0.6862	0.7268	0.7637	0.7967
Maximum	0.9336	0.9442	0.9532	0.9607
Minimum	0.4106	0.5204	0.5532	0.5944

To increase a farmer's efficiency and productivity of natural resources, a large body of literature emphasizes investment on human capital – especially formal schooling and extension. These studies strongly suggest that formal education improves a farmer's ability to use new technologies more efficiently as well as to adopt new technologies more rapidly. These results call for higher investment in formal schooling in rural areas, as well as extension services, to accelerate agricultural productivity.

PHYSICAL LIMITS TO CROP PRODUCTIVITY

Food production can be increased extensively through expansion of areas under cultivation, and intensively by increasing cropping intensity or through increasing agricultural productivity. Crop area harvested and land productivity is expected to grow slowly mainly due to land degradation. The main types of land degradation are classified as soil erosion from wind and water, chemical degradation (e.g., loss of nutrients, soil salinization, urban/ industrial pollution and acidification), and physical degradation (e.g., compaction, water-logging, and subsidence of organic soils). Out of the total land resource base, Oldeman, *et al*. estimated that 1,964 million ha suffered from some degree of soil degradation. Water erosion accounted for 56 percent of land degradation, wind erosion for 28 percent, chemical degradation for 12 percent, and physical degradation for 4 percent. However, for the estimated 562 million ha of degraded agricultural land, chemical degradation was much more important – accounting for 40 percent of degraded land.

Degradation leads to reduction in crop yields and may reduce total factor productivity by requiring the use of higher input levels to maintain yields. It may also lead to the conversion of land to lower value uses and may cause temporary or permanent abandonment of plots. The national-level estimates of the impact of land degradation imply that it can be devastating in some countries, especially in fragile environments within sub-regions of countries.

Degradation of natural resources including forests, rangelands, and irrigation water that has been taking place in most Asian countries, in the opinion of some experts, is partly due to population pressure and the land tenure system. The growing population has increased the demand for land, trees, and water, which, coupled with tenure insecurity or the absence of clear property rights, has resulted in the over-exploitation of these natural resources. This in turn has threatened the sustainable development of agriculture, forestry, and livestock sectors. The critical question is whether the current trend will continue and result in further degradation of natural resources and, ultimately, significant deterioration of human welfare.

Based on the recently completed project on land tenure and the management of land and trees in Asia and Africa (Otsuka, 2000), population pressure has lead to the individualization of land rights and it has had consequences on the management of land and trees. In the article, a particular focus has been placed on the development of agro-forestry systems growing commercial trees such as cocoa, coffee, cinnamon, and rubber, which are becoming important farming systems in agriculturally marginal areas, where people are particularly poor and natural forests have been degraded rapidly.

In Asian countries, as population increases, land becomes scarce relative to labor. The growing population requires increasing area for agricultural production and, hence, large areas of forestland are opened up. As the rate of area expansion falls short of the growth rate of population, land becomes scarce relative to labor, which is reflected in the relative factor price ratio. As a result fallow periods tend to be shorter and soil fertility declines and farming becomes unsustainable.

An alternative to unsustainable farming under shifting cultivation and continued deforestation is to improve land quality by investing in land and trees, and to maintain soil fertility under continuous cultivation by using compost made from grasses and leaf litter collected from the forest and woodland, as well as animal manure. Relative to pure cropping systems, the productivity of tree farming systems can be sustainable for longer periods of time with lower application of organic and inorganic fertilizer primarily due to their deeper and denser rooting systems and perennial ground cover which makes them less vulnerable to soil loss and nutrient leaching. Because of increasing use of labor and continuous cropping, new farming systems are labor-intensive and land-saving. Under the new farming system, in which production is assumed to be more feasible, physical investment, such as terracing and tree planting, is required to adopt the new farming system.

Under such circumstances, land tenure institutions must change in order to encourage long-term investments. Since land-use rights are not totally secure and transfer rights are restricted under traditional land tenure institutions, the expected returns to investment may be depressed; i.e., those who plant trees may not be able to sell the land freely if the need arises. Therefore, land rights institutions are induced to change towards greater individualization in order to provide appropriate incentives to invest in land and trees.

Best Management Practices and Policies: Future Challenges

Considering the dominant land utilization systems in Asian countries that limit agricultural productivity and sustainability, some policy and institutional reforms are proposed to overcome the current problems. The major recommendations are the following:

1. ***Strengthening Extension Services***

As indicated in the article by Otsuka (2000), there is still an efficiency gap among farmers due to differences in managerial levels. A large number of farmers still do not stand on the production frontier and therefore produce less than their potentials due to lack of knowledge and information.

Besides that, some farmers misuse new inputs such as fertilizer and pesticides that create an unsafe agricultural environment. Therefore, there is a need to adjust extension services to the needs of different groups of farmers, even in the same region.

2. ***Plant-breeding Research***

Considering the diminishing returns to input intensification, the focus of research in the 'post-Green Revolution' areas must shift from input intensification to cost control and environmental concerns. In spite of this, investment in varietal development and bio-technologies will play an important role in the future in expanding the yield frontier.

Two innovations promise to increase the cost-effectiveness of conventional plant-breeding research in the future. The first is the exploitation of heterosis to increase yield potential. Hybrid seed is now widely used in maize, sorghum, millet, cotton and some oilseed crops in the region. However, the largest opportunity lies in extending the technology for hybrid seed production in rice, the dominant food crop in Asia.

The second area of opportunity is in biotechnology, which offers the potential to reduce the cost of varietal development through the use of molecular makers to more precisely select plants that carry genes for desirable characteristics, and to transfer genes from unrelated species, which would not be possible through conventional breeding. The most advanced work, which can be used widely in Asia, is the research conducted in the rice biotechnology network, which has been successful in inserting several new resistance genes for various rice pests.

3. ***Sustaining Agricultural Systems***

The most critical challenge to policy-makers and researchers is to arrest the tendency towards a long-term decline in productivity of intensive irrigated systems. The problem of sustaining productivity growth is due to inadequate attention to understanding and responding to the physical, biological, and ecological consequences of agricultural intensification. The emphasis of research must shift from a fixation on yield improvements to an approach to the long-term management of agricultural resource base that considers the true costs of production (including environmental costs).

4. ***Price Policy Reforms***

There is need to revise government policies in both the input and the product market to achieve sustainability objectives. Government policies on subsidizing fertilizer and pesticides in some Asian countries has led to over-utilization of nitrogen and phosphorous fertilizer and sub-optimal use of micro-elements and also overusing pesticides which has caused land and water pollution. Removal of input subsidies and price distortions will prevent socially sub-optimal use of these inputs. In addition, negative price policies of the government on staple foods, such as rice and wheat, in some Asian countries have weakened farmers' incentives to increase production through adoption of modern technologies.

5. ***Institutional Challenges***

Since investment is required to establish intensive farming (e.g. investment in the construction of irrigation facilities, terracing, and tree planting), sufficient attention must be paid to incentive systems to ensure that the appropriate investments are made. In those countries where land tenure systems are insecure or communal ownership of land prevails, investment are likely to be weak, and therefore, land tenure or property right institutions must be reformed in a way that provides incentive to increase investment.

The fact that small family farms are dominant in most Asian countries, in order to make best use of the scarce managerial skills existing to achieve “best management practices” goals, the government policies should be aimed at persuading farmers to form agricultural cooperatives around the needs felt such as land consolidation, joint sale of products, and buying inputs, operation and management of water downstream of dams, and adoption of more sustainable good production technologies.

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4. ISLAMIC REPUBLIC OF IRAN'S POLICY ON LAND CONSOLIDATION AND REFORMS OF FARMING SYSTEMS

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INTRODUCTION

The agriculture sector in Iran has been growing remarkably in the recent years to meet 85 percent of the food requirement. It has had a 25-percent share of the GNP, 27 percent of the country's employment, and 33 percent of the non-oil exports.

Despite of imposed sanctions, the agriculture sector has achieved a growth rate of 5 percent (A. Najafi, 1998). Nevertheless, the full utilization of all the agriculture potential has faced certain stumbling blocks, the main one being the number and diversities of the utilization systems, in which traditional peasantry farms prevail. Scattered villages and small-size and fragmentation of landholdings are serious impediments to the optimum utilization of water, soil, and other resources.

Growth of agriculture is principally dependent upon the way primary resources, most importantly the land, are exploited. So, any changes in the exploitation pattern of the land or the "Utilization Systems", will certainly affect the rate of agricultural growth.

CHANGES IN THE LAND UTILIZATION SYSTEM IN IRAN AND THE WORLD

Developed countries have witnessed a long period of satisfactory growth and reforms of traditional farming patterns of the previously existing feudal system. Modern land utilization systems comprising private farms and private and public companies have burgeoned. These companies have enjoyed efficient management, technical know-how, and skilled labor. Land and production factors were either owned or hired, the average farm size ranging from 20 ha to 200 ha. Market conditions and the need to make the land size economic has necessitated the maintenance and preservation of consolidated lands. In some countries, the heir-apparent could inherit his share, and either buy up the rest of the land from other heirs or run his late father's farm in a form of family or private holding (Abdollahi, 1998a).

Agriculture has been the principal activity in Iran since time immemorial. The issues of land utilization systems (i.e., ownership and management of resources and production factors – especially land, water, and pasture) have always been a main concern.

Land utilization before the Land Reform (1962) was in the form of a sharecropping system, tenant holding, and contract holding within the overwhelming feudal system. Peasant proprietors had a puny 5 percent share in regards to the number of farms and the area of land.

In the feudal system, the peasant worked on the land of the landlord and was attached to it. His share of the crop was based on the five elements of production – land, water, seed, ox, and human labor – but was limited to 1/5-1/3 of the crop produced. Primitive work tools, using traditional farming methods, were applied, which resulted in low yield (Abdollahi, 1998a). The types of ownership were as follows:

- State-owned lands.
- Crown lands.
- Large lands.
- Small lands, of the owner who owned less than a whole village.
- Family holdings.
- Endowed lands.

Furthermore, there existed other particular types of traditional group producers named "Boneh", "Haraseh", "Sahra", etc., that practiced certain types of cooperative systems. The idea was to utilize the water and land together. The landlord, who would deal with a few group-heads (instead of myriads of peasants), encouraged the system (Azkia, 1994).

Following Land Reform, the feudal system was abolished and state-owned and crown land, and to a large extent large land ownership, was eliminated. Instead, a new form of ownership, public ownership, based on the outcome of the nationalization of forests and pasture lands, was created. On the whole, the Land Reform program resulted in the following changes shown in Table 1 (Melkanian, 1987).

- The number of farm holdings increased from 1,877,000 in 1960 to 2,479,000 in 1974.
- In most of the farm holdings below 10 ha in size, the average land area decreased.
- The traditional "Boneh" cooperatives vanished.
- Following the abolishment of the feudal system the production management system weakened.
- The peasantry utilization system replaced the feudal system.
- The proliferation of small and fragmented land plots was aggravated.

To cope with the problem of the small scattered farmlands and to improve the management, the regime created farm corporations, and Rural Production Cooperatives (RPC). Their aim was to consolidate lands, promote mechanization, render infrastructural services, improve farming methods, develop animal husbandry, increase productivity, develop rural agricultural processing industry, and raise the incomes of the member farmers. However, ignoring the desires of the members, separation of ownership, holdings from management, lack of farmers' participation from the inception, and their destruction of local organizations resulted in the dissolution of many of the said units at the start of the Islamic Revolution in 1979 (Table 2).

Another action of the Land Reform program was the formation of agro-industrial integration of agro-industries in the areas irrigated by the dams. The objective was to blend farming, harmonize the industrial and service operations on production, store, preserve, process, and market to align them with market features and requirements. Most of these units again could not achieve their goals because of difficulty in land preparation and high costs, inflexibility in management (as a result of government interference), financial difficulties, and shortage of skilled manpower. Many organizations, except the state-owned agro-industries, dissolved (Johnson et. al, 1995).

Table 1. Trend in Changes of Area of Landholdings in Iran

	Area	<10 ha	10 ha and More	Total
1960	No. of units (000)	1,573	304	1,877
	Percent of total units	83.8	16.2	100
	Percent of total area	40	60	100
	Average area/unit	2.9	21.7	6.05
1974	No. of units (000)	2,026	453	2,479
	Percent of total units	81.7	18.3	100
	Percent of total area	33.4	66.6	100
	Average area/unit	2.7	24.3	6.6
1982	No. of units (000)	2,301	355	2,656
	Percent of total units	86.6	13.4	100
	Percent of total area	43.3	56.7	100
	Average area/unit	2.5	20.9	4.9
1988	No. of units (000)	2,344	475	2,819
	Percent of total units	83.2	16.8	100
	Percent of total area	36	64	100
	Average area/unit	2.6	23.2	6.08
1993	No. of units (000)	2,382	425	2,807
	Percent of total units	84.9	15.1	100
	Percent of total area	37.2	62.8	100
	Average area/unit	2.4	22.8	5.5

Source: *Agriculture Yearbook and Census*, 1989, 1994.
Note: All holdings have been classified into two options: under 10 ha and over, so, joint units, corporations, and state-owned units under 10 ha are placed in the second option.

Table 2. Creation and Dissolution of Farm Corporations and RPCs at the Start of the Islamic Revolution (1979)

	No. of Co.	No. of Villages	No. of Members	Cultivated Land (ha)	Dissolved	
					Number	Percent
Farm Corp. (1969-79)	93	851	35,097	326,300	88	95
RPCs (1973-79)	39	214	11,200	40,000	20	52

The second Land Reform took place after the Islamic Revolution in 1979. In some rural areas the government either confiscated and took possession of the large and average-size ("semi-large") farmlands or parceled them out to small farmers and farm workers. A vast majority of the wastelands (which were arable) were also parceled out. This meant there were practically no changes in the form of land ownership as compared with that in the pre-Revolution era; the only change being a further reduction in the size of the farm holdings. A new system of ownership, common ownership, developed the members made up of small farmers, farm workers, jobless college graduates, etc. Each group consisted of 7-15 members, each member being allocated 5-15 ha of land. The lands were to be cultivated jointly, but in practice, a type of internal arrangement was made and each member cultivated his own share of land (Melkanian, 1987). So far over 1,314,000 ha of land has been thus parceled out to 22,548 such groups.

The process of land disaggregation was further aggravated during this period (Table 1). In 1993 the numbers of farmholdings rose to 2,808,000 and the average area of each decreased to 5.5 ha. Therefore compared with the year 1974, that is, in 20 years' time, the number of farm holdings showed an increase of 16.5 percent and a decrease of 17 percent in the land area of each holding. This process has also resulted in further disaggregation and dispersion of lands. The problem, apart from the adverse effects of the first and the second Land Reform program, have been further aggravated by the inheritance law.

STUDIES DONE ON UTILIZATION SYSTEMS

As pointed out, scattered villages and fragmented small farmlands are an impediment to agriculture development. This dilemma, which is the result of the traditional peasantry utilization system, constricts the introducing of modern agricultural techniques and interferes with the promotion of mechanization, which in turn leads to reduction in productivity and lowers farmer income. The condition imposes pressure on resources and increases their rate of wastage and hence threatens their sustainability. The authorities and the experts who are aware of the necessity to provide food for the increasing population and who are mindful of preserving and sustaining the country's resources, are striving to solve the problem. Thus, numerous studies on utilization systems have been undertaken to find solutions to overcome the dilemma. The researchers unanimously agree that the only cure is the consolidation of lands and attainment of technically and economically optimum farm sizes within the framework of an appropriate and sustainable utilization system. One of the studies made, *The Comparative Studies and Evaluation of the Past Records of Different Types of Utilization Systems in Iran*, was conducted by a number of university professors in 1998 under the aegis of the Office of the Deputy Minister for Utilization Systems. The study recommends RPCs, commercial farms comprising individual farm holding companies, farm corporations, and agro-industries. Individual farm holding companies are mostly the peasant farm units that have bought new plots, consolidated them, and have converted them into suitable farm sizes. They enjoy a higher level of education, know-how, and modern techniques compared with those of traditional peasantry and cooperative farms. As for the farm corporations, only the remaining five corporations out of the 93 (established before the Revolution), have been studied. These corporations, which have survived and which have been independent from the government since the Revolution, are doing quite well.

The RPCs, in which the farmers and especially small landowners (below 10 ha) take interest, have been established since 1971. By the year 1979, 39 such units have been set up. They differ from the farm corporations in that the lands have clear boundaries, whereas, in the case of farm corporations, land and water is shared and the corporation can exploit it (the land and water) after it has bestowed the respective share/shares to the farmers. The main reason for the survival of the RPCs is this preservation of ownership. That is why farmers show more interest in them compared with the farm corporation. The authorities also prefer them.

RPC is defined as an NGO economic integration with a relatively high management skill, which is based and dependent upon the human resources (its members) and joint decisions, while preserving and protecting ownerships, and is established out of the interest drawn from the individual and family entities. With due regard for sustainable agriculture, it strives through mutual cooperation to increase productivity and create employment and, as a result, to improve the standard of living of the members and reach the pinnacle of success.

RPCs give priority to land consolidation and proper lot sizes taking into account the crop rotation. Their other functions consist of equipping and renovating farmlands, supplying water, setting up irrigation networks and drainage, promoting mechanization, applying modern farming techniques, providing inputs, establishing food processing, preserving units, and marketing.

To start an RPC, the government provides part of the budget for establishment and assists the technical and financial staff and finance management, research and development, training and extension, through the banking system. The government further finances the preliminary master studies, does the land consolidation design, and performs land consolidation, leveling, road construction, leaching and sets-up the irrigation network. Villages that are under the protection of the RPCs enjoy priority in respect to projects aimed at development such as hygienic, educational, and welfare institutions.

POLICIES AND ACCOMPLISHMENTS OF THE FIVE-YEAR DEVELOPMENT PLANS

First Development Plan (1989-93)

In legislation and documents of the First Development Plan (FDP), the following concepts have been observed:

1. Changing the traditional farming structure to the modern economic one.
2. Consolidating lands.
3. Defining and fixing land ownership and providing security for the capital investments.
4. Organizing rural societies through farmer and landholder unions.
5. Planning and accomplishing suitable utilization systems.
6. Developing and expanding RPCs and Rural Cooperative Unions taking into account the principle of land consolidation and satisfying the initiatives and motives of the members, respecting their freedom and their rights to make decisions, and continuing this support until they are able to compete in the market. The FDP was continued in 1994.

Accomplishments

It had been planned to consolidate one million ha of farmlands and to establish 50 RPCs and farm corporations. The former has not been achieved; that is, the consolidation has not reached the projected one million ha. But, the latter objective exceeded the projected figure of 144 RPCs, which together with the 19 RPCs (that had been set up before the Revolution) make up a total area of 499,422 ha belonging to 34,458 members in 917 villages (Table 2).

Studies have been made on mobilizing and expanding existing agro-industries, and setting up new ones through eight projects. The most notable of these is the sugarcane industry and the by-product project, which is being implemented in an area of 84,000 ha in the south of Iran. The project, upon completion, is to achieve the following:

- Production of 7.63 million mt sugarcane (700,000 mt sugar).
- Establishment of 24 by-product processing and production units such as sugar refineries, paper and pulp mills, feed mills, MDF and cell protein.

So far most of the projected figures have been achieved.

Second Development Plan (1995-99)

Based on the evaluation of the accomplishments during the FDP, the Second Development Plan (SDP) played an overwhelming role in land consolidation, which was to emphasize the creation of RPCs (in which land consolidation and revolution of farming structures were taken into account). And in fact 310 new RPCs have been established. The SDP outlined the following policies (8/93-96):

1. Emphasizing creation of concrete economic units through farm associations.
2. Encouraging and supporting the land consolidation process.
3. Supporting creation of cooperative units for farming, animal husbandry, pasture and forestry, and farm mechanization services.
4. Stabilizing and securing individual land ownership.
5. Emphasizing infrastructural development concerning farm associations.

So, during the SDP the following progress has been accomplished:

- Comparative studies have been conducted and assessment done on the accomplishments of land utilization systems.
- Preliminary master plans have been prepared for expansion of 66 RPCs on 100,000 ha land (in a number of which the fundamental operations have already started).
- Creation of Farmer Cooperatives Unions. They serve to fulfill the needs of RPC members and to implement big projects such as provision of sophisticated machinery, establishment of food processing units, and marketing.

Table 3. Accomplishments of RPCs by the End of FDP and SDP

	No. of Members	No. of Villages	Cultivated Land (ha)	No. of RPCs
FDP	34,458	917	499,422	163
SDP	110,793	1,750	1,464,558	535
Total	145,251	2,667	1,963,980	698

Third Development Plan (2000-04)

This plan outlines the following policies:

1. Supporting the creation of RPCs and farmers' associations for water, land, and natural resources.

2. Government's paying of part of the interest on bank loans, borrowed by private investors, cooperatives, RPCs, service rendering cooperatives, tribal cooperatives, cooperatives for exploiting natural resources, and job creating projects.
3. Proposing a change of law to stop fragmentation of farmlands as a result of certain laws and practices such as the Law of Inheritance.
4. Amendment of the laws so RPC members engaged in common cultivation operations can harvest their shares individually.
5. Support the creation of private agro-industries.
6. Creation of one thousand new RPCs on 2.5 million ha in addition to the existing 698 RPCs (on two million ha land) established in the SDP.

Note: 4.5 million ha, that is, 25 percent of the total 18 million cultivated land area will then have been covered by the RPCs. The total number has already reached 752.

CONCLUSIONS

Studies done on the accomplishment of land utilization systems show that 66 percent of changes of related variables (accomplishment of the utilization system) is determined by the three following variables:

– Type and features of the utilization system.
– Features of the social surroundings.
– Features of the natural surroundings.

The first variable has been shown to play the most important role. This suggests that the growth and improvement in economic, social, cultural and environmental dimensions of agriculture, which imply sustainability, creates quality orientated modifications in the agricultural structure through institutionalizing the appropriate utilization systems (Abdollahi, 1998a).

Therefore, the need for a suitable utilization system, formed by farmers themselves, that can challenge and help check that the division of farmlands, cannot be de-emphasized.

Cultural and social backgrounds among the farmers as regards *esprit-de-corps* types of cooperation, which has burgeoned within the framework of traditional cooperatives, since the time immemorial, enables the RPCs (whose objective is to make use of and strengthen these cultural and social pillars, that is, cooperation) to modernize the agricultural structure. Because of their capability to tackle the problematic issues of the optimum land sizes and the application of sophisticated technology in them, with due regard for sustainability and processing, the environment and concern for the enrichment of cultural and social values, the RPCs symbolize the "Rural Development Pattern".

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5. LAND CONSOLIDATION AS A MOVEMENT TOWARD AGRICULTURAL PRODUCTIVITY PROMOTION: EXPERIENCE OF THE ISLAMIC REPUBLIC OF IRAN

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INTRODUCTION

Islamic Republic Iran's agriculture sector is the most important non-oil commodity-producing sector of its economy. It has quick returning investments, limited need to forex, the capability to produce direct and indirect employment and low costs to provide a unit of employment. These comparative advantages for some of the field or orchard crops are among the real benefits of agriculture relative to other sectors (Ministry of Agriculture [MOA], 2000).

In recent years, the agriculture sector has shown a significant development potential. It can provide 85 percent of Iran's food needs and 90 percent of the raw material needs of its food processing industries. The sector contributes about 25 percent of the GDP and 27 percent of the employment, as well as 33 percent of non-oil exports. Therefore, the agriculture sector has a most important place in the macroeconomics at Iran (Najafi, 1998). Before land reform in the 1960s, the agriculture sector, in addition to meeting the domestic food requirement, contributed to exports. Agricultural growth depends heavily on productivity promotion. Production resources can be increased through infrastructural developments, appropriate technology, new farming methods, and farm management improvement. Countries with traditional agricultural structures face small and fragmented plots, cultivation is carried on to non-geometric small-scale plots which limit application of farm machinery, mechanization development, and putting to practice new cultivation methods. Therefore, application of modern technology, aimed at increasing yield and reducing production costs, has a direct relationship with land consolidation and optimum size of cultivation plots. Many studies prove this assertion. For example, in irrigated wheat, 1 percent of increase in farm size causes a 0.4-percent decrease in cost, and a 1-percent decrease in fragmentation causes a 0.44-percent decrease of costs (Arsalanbod, 2000). Another study shows that land consolidation causes a 20-percent yield increase (Haidari, 1996). It is true that in traditional systems, fragmentation had some advantages (Taleb, 1987), but under an agricultural renovation condition, fragmentation is a serious limiting factor. It causes high increase in costs, and makes the productivity improvement activities uneconomical. Therefore, consolidation of fragmented plots of lands for achievement optimum size and shape of farmland, directly effects productivity. The experiences of different countries confirm this concept.

CONCEPTS OF LAND CONSOLIDATION

Fragmentation is measured by the number of land plots of a single farm-holding. Increases in fragmentation result in further smallness of plots. Distances between the separate plots of a farm unit are also used as indicators in this issue. The fragmentation phenomenon exists in traditional agriculture systems in different countries and it is not a peculiar feature of one country. For example, in the past, in Germany, a single 20 ha farm-holding was formed from 283 distinct and fragmented plots (Soltani, *et al*., 1993).

The terminology used in consolidation efforts has widely divergent definitions according to different types of consolidation procedures that convey often contradictory meanings even within the same country. For an understanding of the terminology used in different countries, it should be noted at the outset that consolidation measures may be designed to remedy two distinct conditions: the division of rural property into undersized units unfit for rational exploitation, and the excessive dispersion of the parcels forming parts of one farm (Lopez, 1962).

In Islamic Republic of Iran, there are three conceptual approaches to land consolidation (Khadem Adam, 1995):

- Entire plot consolidation;
- Entire cultivated crop consolidation; and
- Land consolidation.

1. ***Entire Plot Consolidation***

The grouping of scattered plots of a single farm-holding by interchanging and transfer of land plots of other farm-holdings: This process would ultimately lead to one large piece of land in every farm-holding.

2. ***Entire Cultivated Crop Consolidation***

To cultivate one crop on the adjacent plots of different farm-holdings: In this process, there is no interchange or exchange of plots.

3. ***Land Consolidation***

The grouping and reallocation of all farm-holdings of small land plots into new larger farm land units that are technically and economically appropriate.

In the first two concepts, there is little difference in the methods of implementation. Land consolidation is carried out with very different methods and dimensions. It may be carried out in several neighboring small farm-holdings, all of the farm-holdings in a village or of more than one village.

METHODS OF LAND CONSOLIDATION

The main concept of land consolidation is to remove the borders between farm-holding land plots, grouping scattered plots, and redistributing the land to increase the size of farm units, while respecting the farmer's ownership rights.

In this process, the procedure may be simple or complex. The difference is that if the land consolidation steps are merely limited to grouping and redistributing of land plots, it called the simple method. If consolidation is combined with rural engineering work, such as land leveling, an irrigation and drainage net, a road net, etc., it is called the complex method, the integrated improvement, or land consolidation in the full sense of the phrase. In this latter method, a grouping and redistribution of land plots is designed in which new zoned farms are formed, proportionate to an optimum regional crop rotation pattern, and each zone is plotted based on an appropriate technical and economical scale. Each zone is seasonally allotted to a certain crop indicated in rotation patterns (entire cultivative consolidation).

Determination of the new farm-holding ownership borders may be simultaneous with redistribution of land in each zone. In this case, some activities, like tilling the land, are accomplished jointly and other activities, like irrigation, individually. The land utilization system, in this case, is based on a production cooperative. If land consolidation is accomplished without determination of any ownership border (land amalgamation), this kind of utilization system is based on a farm corporation. In some cases, consolidation of water resources are taken into consideration in land consolidation plans, providing it is technically, economically, and socially feasible.

These diverse land consolidation cases are a collection of methods that have been used in Islamic Republic of Iran. Land consolidation, especially in the simple method, may be organized and executed by the farmers themselves. This is called "indigenous", and it is done without external assistance. When land consolidation is carried out with assistance of external resources, such as agriculture and extension experts of the government, it is called "exogenous".

LAND FRAGMENTATION AND PROCESS OF ITS CHANGES

Table 1 indicates the fragmentation of plots and their average plot area in different farm-holding ownership classes in different statistical periods. According to 1960 and 1971 data, the fragmentation phenomenon was increased after the Land Reform (1960s). The average number of plots in a farm-holding increased from 6.1 plots to 8.5, and the average area of each plot decreased from 0.99 ha to 0.82 ha. This trend was intensified in some classes. The comparison of 1971 and 1991 data shows that during those years, the fragmentation intensification decreased from the viewpoint of average number of plots (a decrease from 8.5 to 5.3) and the average plot area increased from 0.82 to 1.33. This improvement was due to the second Land Reform (1980s) that was carried out in the post Islamic Revolution era (1979) and an increase of cultivated land in those years. However, the fragmentation of farmland plots still occurs. Several case studies show that fragmentation phenomenon has serious intensification in some provinces.

Table 2 shows the average number of plots in farm-holdings in some provinces (Niazi, 1993). In some cases the number of plots in a farm-holding reported was 54, 88, and even 120 plots. Some plots were found with only 250 m^2, 400 m^2, or 800 m^2 of area in different farm-holdings. One study shows that the average number of plots in wheat cultivation per farm-holding is 2.5 plots and the maximum number is 4.5. In rice cultivation the average is 1.6 plots and the maximum is 2.4. In potato cultivation the average is 1.7 plots and the maximum is 2.5. In cotton cultivation the average is 1.6 plots and the maximum is 1.7 (Niazi, 1992). This study also showed that the increase of seed and fertilizer consumption has a direct relationship to the increased number of plots.

Table 1. The Average of Plots Number and Their Areas within Stratified Farm-holdings

Stratification	1960 Average		1971 Average		1991 Average	
	No. of Plots	Plot Area (ha)	No. of Plots	Plot Area (ha)	No. of Plots	Plot Area (ha)
< 1 ha	2.0	0.14	3.4	0.14	2.4	0.18
1 < 2 ha	4.2	0.35	5.7	0.27	2.8	0.45
2 < 5 ha	5.4	0.61	8.7	0.44	4.2	0.73
5 < 10 ha	7.8	0.90	12.5	0.67	6.3	1.06
10 < 50 ha	11.4	1.50	17.5	1.20	9.6	1.80
50 < 100 ha	16.0	4.20	18.3	4.20	12.6	5.02
> 100 ha	24.4	9.90	14.6	16.60	12.4	15.57
Total average	6.1	0.99	8.5	0.82	5.3	1.33

Source: Statistical Center of Iran, *Agriculture Census*, 1960, 1971, and 1991.

Table 2. Farm-holdings Land Plots Fragmentation in Some Provinces of Iran

Provinces		Average Number of Plots in Each Farm-holding		
		Dry Farming	Irrigated	Total
Lorestan		5.9	6.0	11.9
	Khorramabad	4.7	3.0	7.7
	Broojerd	13.0	12.8	25.8
	Aligoodarz	4.8	3.0	7.8
Hamadan	Nahavand	7.0	10.0	17.0
Kermanshah	Sahneh	10.0	10.0	20.0
Khorasan	Bojnoord	-	-	6.5
Khoozestan	Ramhormoz	-	-	14.0

Source: Niazi, 1992.

Another problem is the distances between the different plots of one farm-holding, which sometimes are several kilometers away from each other. In a case study, the plot distances were from 250 m to 2,300 m (Shahbazi, 1988). Another study shows that the sum of distances between all plots of one farm-holding was 2,695 m (Haidari, 1987).

The appearance of such a picture of farm plot fragmentation is a result of sub-division of land in former times, and it has been affected with the following factors (Ebrahimi Looyeh, 1997):

- Crop rotation and diversity;
- Remoteness and nearness to village;
- Remoteness and nearness to water resources;
- Difference in texture and fertility of lands;
- Topographic problem;
- Traditional production instruments;
- Landlord/peasant system;
- Land Reform;
- Increased population;

– Individual ownership principle; and
– Justice in land sub-division.

Today, doubtlessly the fragmentation phenomenon has negative effects on yield and productivity, and is contradictory to modern agricultural development requirements. Meanwhile, the agriculture sector has high responsibility in the following contexts:

– Promoting farmer income;
– Meeting the food requirements of an increasing population;
– Increasing the income parity between rural and urban societies;
– Creation and exploitation of comparative advantages in the sector;
– Increase of competition potential and encouraging effective entrance to world markets;
– Providing effective assistance to the national economy; and
– Basic resources sustainability promotion with regard to environmental considerations.

Therefore, to achieve those improvements, the sector should emphasize investment in the following aspects:

– Utilization system improvement;
– Mobilization and renovation of farms;
– Irrigation and drainage net;
– Mechanization development;
– Application of new farming methods in planting, cultivation, and harvest;
– Optimization of input consumption;
– Conservation of soil fertility;
– Increasing the water yield;
– Improvement of production management;
– Improvement in quantity and quality of agricultural products;
– Developing food and processing industries;
– Increasing the efficiency of the factors of production;
– Reduction of production cost; and
– Consideration of environmental issues.

Land is the basic resource for all these activities; therefore it is true that land utilization is the most important factor affecting the amount and direction of agricultural growth and development. Now that convergence and integration have found its place in socio-economic activities of the world, the fragmentation of farmland plots must be changed by land consolidation.

IRAN'S EXPERIENCES OF FARMLAND CONSOLIDATION

Today, land consolidation is an important component of agricultural development measures in many developing countries that face with excessive smallness and fragmented farmland. Land consolidation is carried out through agrarian structural improvement. In some countries, land consolidation has a very old background (Sweden, 1757; Denmark, 1781; and Japan, 1899). Recently, many countries have paid attention to land consolidation in the period from 1940 to 1970, when land reform was undertaken in those countries.

In Islamic Republic of Iran, after Land Reform (1960s), land consolidation has rarely been carried out by farmer's indigenous measures, but was mainly planned from top-down (exogenous). Some cases will be described below.

Shahn Abad Experience

Shahn Abad is a village in the Khoramrood rural district of Hamadan province (in the west of Iran). Irrigated land in this village was sub-divided into 96 "*Joft-gav*", a basic traditional unit of land in some areas that corresponds to the amount of land that could be plowed by a pair of oxen, approximately about 4-6 ha (Azkia, 1994). The irrigation cycle was 12 days, and for this reason, the farmers were organized in 12 blocks (group). The land of the village is zoned in nine localities and the farm-holding land plots were in these nine localities. Each *Joft-gav* land area contained and average of 50 scattered plots in these nine localities. According to the surface of *Joft-gav*, the average plot surface area was 800-1,200 m^2.

After Land Reform (1960s) the farmers, in consultation with each other, redistributed the land. Farmers of 12 blocks came together in three groups (four blocks in each group). Every new group was allocated one plot in each one of nine localities. Determining of location of plots was difficult because of differences in fertility and some other factors. Despite this, the farmers consolidated their 50 plots to nine enlarged plots. However, the fragmentation of plots still remained. One of the local reliable men had said:

> *Although we had done well, it was better to consolidate everyone's plots in one or two or a maximum of three parcels. It was a very hard work but we now have been successful.*

After a few years, Meshedi Ali Akbar Dahpahlavan, a Shahn Abadish farmer, tried individually to solve the problem by himself and consolidated his own plots of land into one parcel. He said that "*I gave extra land to some friends (farmers) and exchanged other lands with them. Due to some farmers' collaboration with me, now my lands are consolidated into one parcel and it resolved some of my difficulties. I drew lots with Meshedi Taghi, a farmer, for exchange of lands. I gave to Mirza, a farmer, another plot in Tappeh Moorche Abad, a name of a farm zone in Shahn Abad, and took from him a plot in Sarcannel, another zone name. Then I gave to Norooze, a farmer, the same plot and instead of that I took from him a plot in Mahalleh Sheni, another zone name, that was near to my land. I bought a plot from Haj Ali Mirza, a farmer, who did not want to accept plot exchanging*".

In this manner, after 5-6 years Meshedi Ali Akbar decreased the number of plots of his own land from nine to three. He had thought to register these land exchanges with a notary public to establish an official record.

What happened in Shahn Abad was an indigenous process carried out by farmers using their own initiative and was done without any invitation of outside authorities (Mehrabi, 1988).

Sugar Beet Cultivators Experience

In 1970, the farmers, under individual contracts with sugar beet mills in the west of Islamic Republic of Iran, took measures for land consolidation with the encouragement of mill authorities. In fact, the growth of agriculture-related industries and their needs for high volumes of raw materials was a good initiative for increasing agricultural production, and the need to improve the productivity of the land resource was as an important factor of productivity. In Kermanshah and Lorestan provinces, farmers also carried out land consolidation within the boundaries of the different sugar beet industries (Bafekr, 1989).

Tooreh Experiences

The Tooreh district is 40 km from Arak (the center of Iran) and has 75 villages. The farmlands of these villages are sub-divided into units of 13 to 96 *Joft-gav* so that each one is formed into 20 to more than 100 plots with a 1-5-m width and up to 500-m length. The plot borders and the lateral canal have respectively 1 m and 0.3 m width (Farahzad, 1989).

At first, farmers of two villages interchanged their land plots in order to minimize the plot numbers and to enlarge them. This was an indigenous effort. After two years, Rural Agriculture Services Center (RASC) was established in Tooreh district. The extension experts of RASC tried to extend land consolidation in other villages. Ten villages consolidated their lands through a new idea. First, in each village the farmers elected their own representatives. The representatives measured the surface of land of each farmer. Then by assistance of extension experts, they divided the whole land of the village into 3-4 zones proportional with crop rotation patterns and reallocated the lands so that each farmer had a parcel of land in each zone. Finally, the plot numbers decreased, on average, from 100 to 3-4 plots.

The process of indigenous action by some farmers caused some other farmers to follow them with suitable extension activities and innovation, and resulted in qualitative promotion o this land consolidation method in this district. The result of implementation was very satisfactory. As it was reported, there was a 30-percent increase of farmland because of omission of so many large borders and extra canals. This also caused about a 30-percent increase of irrigation efficiency, a decrease of costs, an increase of production about 2-4 times in different crops, and finally a decrease of farmer's conflicts.

Foolad Mahaleh Rural Production Cooperative (RPC) Experience

Foolad Mahaleh RPC is 80 km from Semnan in the north of Iran. The main objectives of such cooperatives are: yield increases and promotion of productivity by land consolidation, in addition to engineering measures such as land leveling, irrigation and roads net, water supply, application of new farming methods, and mechanization development. Therefore in these units, an integrated approach is put into practice.

In Foolad Mahaleh RPC, a land consolidation project was thoroughly implemented in an area of about 200 ha area covering 100 farm-holders' land. The special characteristics of this project were integration of water resources including one deep well (30 liters per second) and one spring (about 60 liters per second average flow) the implementation stages were as follows:

1. A local team of land surveyors, including three representatives of the farmers and one of the cooperative technicians, was formed. This team measured the plots of each farm-holder.
2. Then the topography and soil classification maps were prepared.

3. Then the plan for land parceling and leveling and the irrigation net were prepared on those maps. Considering the location of water resources, the whole land area was zoned into three large pieces of land according to crop rotation, and each zone (piece of land) was divided into 10-16 ha area as being the optimum technical and economical size due to land slope and irrigation, drainage and roads network designs.
4. Finally each farm-holder's land was equally divided and reallocated in these zones.

Table 3 shows that the number of plots were decreased from 788 to 300, and in one case, the 40 plots of one farm-holder were decreased into three plots in the three zones. Also, the farm-holders with only one plot (before land consolidation) agreed to divide their land in the three zones.

Currently, in Foolad Mahaleh RPC, the traditional farming system has been changed to modern farming methods and exploitation of new farm machinery using heavy tractors and combining harvesters has caused the RPC to increase agriculture production and productivity. The yield of irrigated wheat grew from 1.5 mt/ha to 4.5 mt/ha.

RPCs Comprehensive Study and Their Land Settlement

After some years of experiences with land consolidation, MOA approved an RPC comprehensive study project with emphasis on land settlement. In this project, the RPC's plan of action will first be designed. This plan of action is to lead the RPCs managers to implement agricultural improvement and development projects. The main and first objective of this study is land consolidation as the basis for integrated improvement. One study based on this method was done in Zarrin Dasht RPC near to Azna in the Lorestan province (south of Iran). This RPC was established by 173 farmers with 1,300 ha of total land. The project is designed for 1,224.9 ha according to water resource availability. Considering the current highly qualified management and contributions of members, technically progressive measures are forecasted for this project as: farm mobilization and innovation, new machinery allocation, food processing industries, and agro-business orientation. The project pre-assessment shows the yield will be improved by 20-25 percent and the rate of return on investment as 15 percent.

RELATIONSHIP OF LAND CONSOLIDATION AND PRODUCTIVITY

The experiences in Islamic Republic of Iran indicate the positive effects of land consolidation on yield and production factor productivity. This idea is confirmed by many surveys, such as the comprehensive studies done in the Kermanshah province, that previously had serious problems with land consolidation.

In the Kermanshah province, some villages consolidated their land some years ago. The total number of fragmented plots was reduced 79.17 percent and the average area of each plot was increased from 0.59 ha to 3.18 ha (about five times), and the total area of farm-holdings was increased 11.5 percent because of removal of extra borders and lateral canals. These improvement activities have provided for the efficient exploitation of lands, improved input consumption, and use of appropriate technology. For example, the number of farm implements increased from 99 to 200 and the number of tractors increased from 56 to 89 units. Also, the yields of irrigated crops increased between to 23-30 percent and in dry farming crop yields increased up to 16.3 percent. The total production increased 33.6 percent

Table 3. Farm-holding Plots Pre and Post Land Consolidation in Foolad Mahaleh

Stratification	Number of Farm-holders	Ownership (ha)				Number of Plots				Number of Plots per Zone
						Pre			Post (total)	
		Total	Average	Minimum	Maximum	Min.	Max.	Total		
< 0.2 ha	11	1.33	0.12	0.04	0.19	2	1	12	33	11
0.2 < 0.5 ha	21	7.90	0.38	0.21	0.47	9	1	60	63	21
0.5 < 1.0 ha	19	13.00	0.68	0.51	0.96	14	1	107	57	19
1.0 < 1.5 ha	9	11.11	1.23	1.01	1.48	13	2	69	27	9
1.5 < 2.0 ha	7	12.00	1.72	1.53	1.90	11	2	57	21	7
2.0 < 5.0 ha	22	67.19	3.05	2.01	4.60	27	3	267	66	22
5.0 < 10 ha	9	61.82	6.87	5.25	9.58	28	8	153	27	9
> 10 ha	2	27.53	13.77	12.64	14.89	40	23	63	6	2
Total	100	201.88	27.82	23.2	34.07	144	41	788	300	100
Average		25.23				18	5	8	3	1

Source: Semnan Province Agriculture Organization, 1995.

because of the many responsible factors. The result was higher income for the villagers that is reflected in an increase of their social and cultural activities, and for welfare services development. Therefore land consolidation provides a context so that all factors, if integrated together, create a trend of synergic the results in promotion of productivity and income, that in turn causes promotion of life level, self-confidence, and democracy, that is showed in Figure 1 (Haidari, 1996).

CONCLUSIONS

In this paper, the different methods and experiences of Iran's land consolidation are explained, and its role in productivity promotion is discussed. A principle problem that should be taken into consideration is discovering and strengthening the factors that contribute toward sustainability of consolidation. It was noticed in some cases that the farmers who consolidated their land plots returned the land to its former condition. It therefore seems appropriate to establish a mechanism adapted to sustainability. The following points should be taken into consideration:

- Land consolidation is a group activity, so if even one farmer (like Meshedi Ali Akbar) wants to carry it out by himself, he needs other people's cooperation. Therefore he needs an organizing process.
- In the land consolidation process, the role of farmer is very important, so that active group participation will be more effective on land settlement. For this reason, they must organize themselves democratically based on all farmers' viewpoints.
- Farmers need to have an adequate knowledge on the objectives and methods needed to promote the power of decision-making. Here, the role of agricultural extension is very important.
- Management is one of the most important factors in the organizing process as a common boundary between individual and group utilization systems.
- Economic aspects of all activities are important, including paying attention to the balance of costs and income at a suitable rate of return.
- Farm mobilization and renovation and other engineering measures are included with land consolidation and are necessary for a sustainable process.

Islamic Republic of Iran experiences show that RPC is an optimum utilization system that can establish an appropriate socio-economic structure for implementation of agricultural improvement and development projects. Organizing small farm-holders in this system will provide the possibility for the survey and acknowledgement of needs and planning aimed at their ultimate achievement.

Well-planned organizing, while it provides an appropriate atmosphere for integrated farm management, will facilitate mechanization, better farming practices, and commerce. In such a system every activity is measurable and in time challenges aimed at improvements of methods provided for checking the dynamic sustainability.

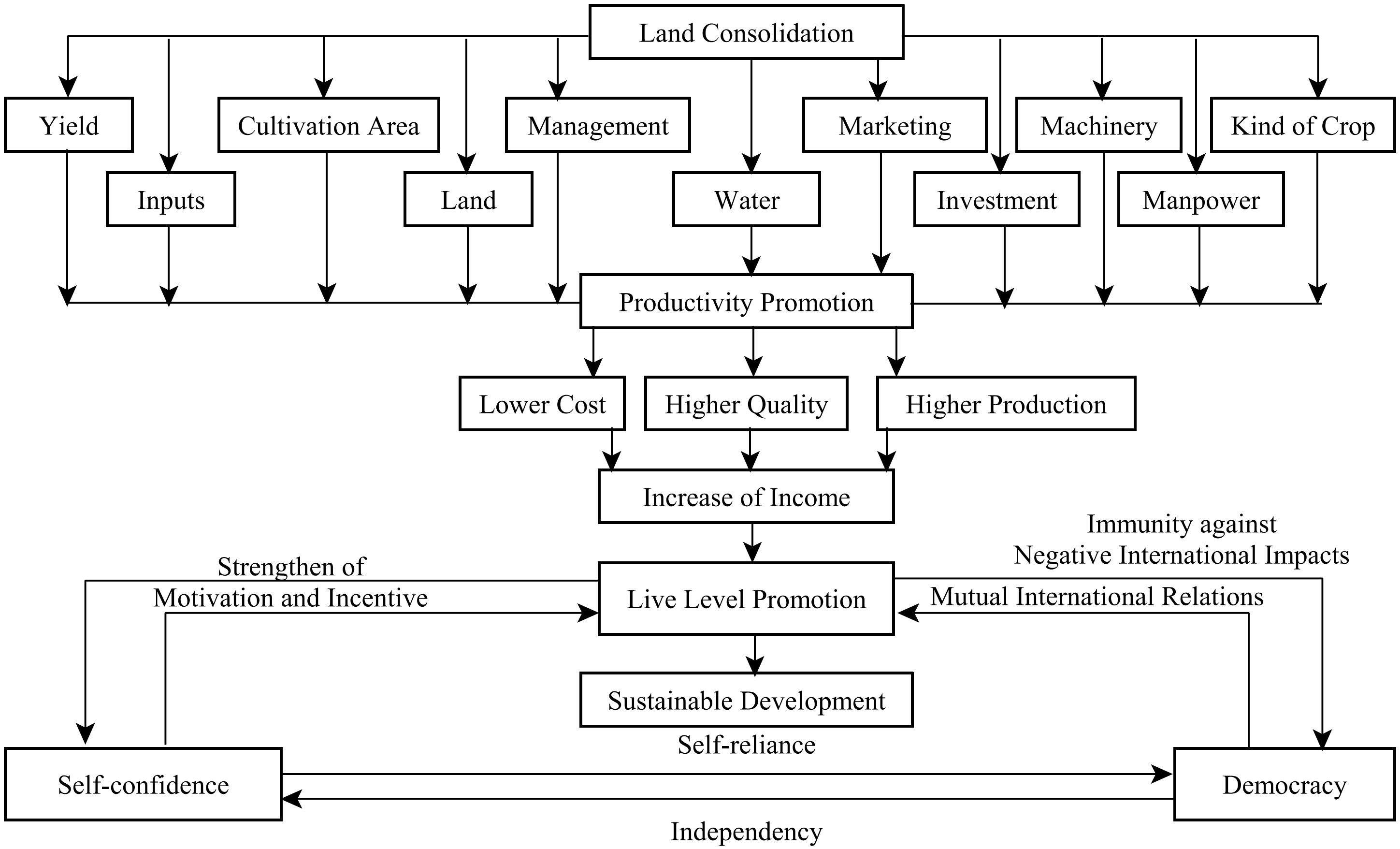

Figure 1. Relation of Land Consolidation and Development

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6. LAND CONSOLIDATION: AN IMPORTANT STEP IN INCREASING OF PRODUCTIVITY (A CASE STUDY AND IMPLEMENTATION)

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INTRODUCTION

Because the major portion of Iran extends into the arid zone, the Caspian Sea coastal area is exceptional. Blessed with water resources, a paddy field zone of about 430,000 ha exists in the area. Paddy production in the area is equal to 1,710,000 mt per annum, which is equivalent to 72.8 percent of the national production of 2,400,000 mt, or equivalent to about 1,500,000 mt of rice. On the other hand, the consumption of rice in Iran is over 2,300,000 mt. So increasing rice production is an urgent requirement of the country.

THE PROJECT AREA

Natural Features

The land consolidation project area is located at the center of the Caspian Sea coastal region. The paddy production zone is in the delta plain of the Haraz River. The gross project area is about 108,000 ha and geographically lies in an alluvial plain bounded by the Caspian Sea to the north, by the Kari Rud and its canals to the south, by the Babol River to the east, and by the Alesh River to the west. The area extends from 35º24'-36º43' North, and 52º12'-52º40' East and covers a distance of 40 km east to west and 25 km north to south.

Compared to the central plateau of Iran, which is a typical arid zone, the project area receives much rainfall, reaching 788 mm of annual mean precipitation. However most of the precipitation occurs in autumn, winter, and spring, and less in summer, which is the rice-growing season. Precipitation is derived from evaporation of the Caspian Sea and is carried mainly by the Siberian or North Wind during winter. Most of the precipitation occurs as rainfall and rarely in the form of snow in the project area. However, most of it falls as snow in the Alborz Mountain range, which is the catchment area of the Haraz basin.

The mean annual atmospheric temperature is 16.3ºC, with the maximum monthly mean of 25.7ºC in August, the minimum of 7.2ºC in February. Relative humidity is high throughout the year with an average of 83 percent from April to August, which are the driest months.

Social and Economic Aspect

The project area includes, administratively, the five cities of Amol, Babol, Babolsar, Mahmoud Abad, and Noor, which includes 490 villages. Rural population constitutes about 64.5 percent of the total population.

More than 40 percent of employed people are engaged in rice culture-oriented agriculture. Employment in rice milling, storage keeping, wholesale of rice, and related sectors make up a large proportion. In other words, the regional economy of the project area is greatly dependent on paddy rice culture.

Considering the availability of land resources, further expansion of agriculture land is hardly possible. On the other hand, the population increase rate has been rather high in recent decades. This means that the rice culture-oriented economy of the project area will encounter serious problems of unemployment, unless it can be avoided by introducing new industries. The total gross area of the project covers 108,009 ha, of which the cultivated area is 84,498 ha, or 78 percent of the total area and 98 percent of the cultivated land.

The paddy fields extend from higher altitude areas of valleys near the mountains to the Caspian Sea coast, where paddy make up the entire field crop in summer. As second crops, winter crops are planted in parts of areas or higher elevation on both west and east districts of the Haraz River, where better drainage conditions prevail to cope with the rainy winter climate. Upland fields occupy only 0.2 percent of the total area. Orchards covering 1.3 percent of the land are mainly located in well-drained areas of the alluvial fans.

Water Resources

Water for paddy irrigation is currently diverted from the Haraz River through a number of canals and distributed by way of a gravity irrigation system. Mean annual precipitation in the area is 788 mm. Seasonal distribution varies from a minimum of around 140 mm (18 percent of annual) from May to August, and a maximum of about 400 mm (50 percent) in autumn and winter.

The Haraz River, which supplies irrigation water to the area, originates in the Alborz Mountains lying south of the project area. The mean annual discharge of the Haraz River is 1,085 million m^3 (MCM). The available flow during irrigation period for the rice crop accounts for about 60 percent of this total. Storage reservoirs for the project area are the Lar dam and same small ponds scattered in the benefitted area. The total available water in those reservoirs equals 276 MCM.

An estimate of the potential amount of groundwater available, obtained as provisional estimate, indicates that more than 200 MCM annually could be extracted from the 6,000 wells in the whole project Area. The current available groundwater for irrigation is around 145 MCM consisting of 137 MCM from shallow wells and 8 MCM from natural springs. The major groundwater area is located in the lowlands and the area near the Haraz River. Water resources other than the above are 36 MCM of pond water.

Agriculture

Rice paddy is by far the predominant crop found in the project area, while upland crop and orchard crops are minor ones accounting for only 2.3 percent of the total cropped acreage.

Rice varieties are roughly categorized into either local or improved varieties. Most of the local varieties currently are long grain, represented by Tarom. Tarom is an early maturing variety that has kept a fairly stable yield performance. Also, its taste satisfies the consumer's preference, holding its prices at higher levels, giving it top priority in the project area. Among the improved varieties, strains of Neda and Khazar are popular.

Berseem clover has been recommended as a secondary crop in rice fields as a strategy for promoting the livestock sector, but the acreage under berseem has tended to level off due to various constraints such as a limited supply of seed, poor drainage during the winter on paddy fields and the customary grazing of cattle in the paddy fields after harvesting the rice crop.

The mechanization of paddy cultivation has been steadily developed, including plowing, puddling, and spraying. Carrying out these works requires approximately 66 hours per ha.

Average acreage in individual landholdings is estimated at 1.66 ha in the area. Smallholders, including landless households, account for 32 percent of the total landholdings. Hence this is one situation that has hampered improvements and mechanization of farming.

The majority of farm plots have been gradually developed by a reclamation process that has changed swamps and deforested land to dried fields. They mostly have irregular boundaries along natural topographic contours with the average area of plot ranging most frequently between 0.1 ha and 0.3 ha. However, smaller size plots with less than 0.1 ha are more often observed in the highlands with steeper topographic gradients. Such smaller size plots are often aggregated to form a block of plot-to-plot irrigation units of several hectares to several tens of hectares.

As the distribution pattern of canals indicates, the project area virtually consists of groups of plot-to-plot irrigation blocks, hence the majority of rice plots are not equipped with direct access roads. The bunds of the rice plots serve as a pathway but have a narrow width barely providing passage for a single person, and as a result farm machinery is very often hand carried in through adjacent plots.

Irrigation and Drainage

Since the topography, soil and climate are congenial to paddy growth and water for irrigation is available from the streams diverting from the Haraz River, paddy cultivation has been practiced for hundreds of years. The present irrigated area of paddy equals about 83,000 ha.

Availability of water resources at the present condition is evaluated through the following table. Several periods of water shortage have occurred even in normal years.

Water Resource	Amount (MCM)	Area (ha)
Surface water	642	50,993
Wells	135	1,674
Spring	8	720
Abbandan (ponds)	36	3,227
Return flow	51	4,572
Sub-total	872	61,186
Shortage	171	21,648
Total	1,043	82,834

Note: Unit water requirement = 1,043 MCM/82,834 ha = 12,600 m^3/ha.

Progress in improvement of canals is slow, and there are few permanent structures at water intakes along the Haraz River. Almost no turnout diversion structures have been equipped at the division points from main canals to secondary or from secondary to tertiary, nor are there particular operation and maintenance facilities to serve the canals. Drainage characteristics of the area can be summarized as follows:

– *Well drained area*: Area in the highland region where drainage of rainfall and excess irrigation water is easy, and the groundwater level is low.
– *Poorly drained area*: Area in the middle and lowland regions where drainage of rainfall and excess irrigation water is difficult, and the groundwater level is high.
– *Slightly drained area*: Exceptionally low-lying area, -24.0 m and below, in the lowland region, especially in the Feridon Kenar area, where drainage is obstructed by the rising of the Caspian Sea level and outflow (estuary) blockage due to sand bar formation. Groundwater levels in this area are usually high and the area is inundated during the irrigation period. Water pumped from shallow wells is sometimes saline.

Issues of drainage have rarely been considered hitherto because of the predominant monoculture of rice. To date, no systematic improvement in drainage facilities has materialized. A part of canals located in and below the middle part of the project area play a role in drainage off-season of the rice crop (rainy season), but their function is limited to prevention of water-logging of roads or residential areas being inundated rainwater from the surface of the rice fields, thus fostering water-logging condition over a large tract of paddy area.

Management of water distribution is performed by the chief *mirab* assigned by the Ministry of Energy (MOE). The chief *mirab* enjoins the 116 zone *mirabs* who are responsible for management of secondary canals. At the terminal level, about 286 village *mirabs* operate water allocation in the tertiary and fourth canals. No water measurement facilities exist at the intakes and turnouts and water distribution is practiced using a traditional measuring unit, namely "*Abdang*".

Abdang means the distribution ratio of water, and it is assigned to and fixed at all intakes and turnouts. Depending on a given *abdang*, intakes and turnouts are operated empirically by *mirabs* to keep a fixed distribution ratio regardless of discharge.

The main water control facilities in the project area are those that divert and convey water from the Haraz River into the secondary canals. The three diversion works on the Alesh River are functionless in the latter half of the irrigation period due to exceptionally low river discharge. The Kari Rud, diverting from the Haraz River at the southern part of the project area, is utilized to irrigate the northeast region. Due to the influence of rural development, relocation and changes, about 100 secondary canals are now functioning.

Since most of the rainfall occurs in autumn and winter, this does not greatly affect crop production. Except for the seven drainage main canals in the lowland area in the north, drainage facilities are much less developed as compared with the irrigation canals. The role of most of the secondary canals is less fixed and they often function as irrigation cum drainage canals.

No clear distinction is made for canals smaller than the tertiary level. Water is supplied to the fields from secondary canals through a network of still smaller canals. These canals also serve to catch excess water and convey it to be stored in small farm ponds or to be reused.

The project area has a complex traditional water right system. When water is abundant in canal, all farmers use it for irrigation regardless of whether they have water rights or not. In dry years, water is allocated only to those with water rights.

Based on 1985 survey, the paddy area with water rights is estimated to be 64,300 ha. The survey conducted by Amol and Babol Water Officers Authority in 1990 shows that the paddy area has been increased to 66,500 ha. The current conditions of on-farm irrigation and drainage systems are observed as follows:

- Diversion works are made of earth bags, brushwood or concrete to raise the water level in mains, secondary or tertiary ones, and canals.
- Irrigation water is led to the upper point of a terminal irrigation block (TIB), which is about 110 ha on average, through an irrigation-cum-drainage ditch.
- In TIB, irrigation and drainage systems are in a plot-to-plot mode.
- Drainage water is discharged into an irrigation-cum-drainage ditch finally.
- It can be said that the present irrigation method is very effective from the viewpoint of re-use of return flow.

With the above systems, the following problems are observed:

- Inundation is caused in the downstream fields during wet periods, making second cropping difficult.
- Ineffective and irrational water distribution occurs during drought periods.
- Washing away of applied fertilizers and chemicals is due to plot-to-plot irrigation.
- It is impossible to control water depth in an individual lot.
- It is difficult to harvest the early, matured rice when different varieties are planted together in a plot-to-plot irrigation unit.

COOPERATION WITH JAPAN

Cooperation between the two countries started in 1984. Since 1984 the cooperation between the Ministry of Agriculture of Iran (MOA) and the Japan International Cooperation Agency (JICA) continued to 1995. In this period the following activities were conducted:

1. Master Plan study for providing a development plan for the Haraz River basin.
2. Feasibility study on the irrigation and drainage development project in the Haraz River basin.
3. Establishment of a center (Caspian Sea Coastal Area Agricultural Development Project-Pilot Implementation Center [CAPIC]) for training and implementation works.
4. Implementation work in three pilot farms (three villages).

MASTER PLAN STUDY

The Master Plan study was conducted on the basis of the idea that the agricultural productivity in the project area will rise to a considerable extent, if an integrated agricultural development is executed to improve the present poor drainage, the insufficient farm roads, and the irregularly-shaped small farm plots from which the project area is suffering, and to improve paddy cultivation methods, increase the cropping intensity by introducing second crops, and to strengthen livestock breeding.

In other words, the Master Plan study has been carried out to formulate an agricultural development project plan centering around paddy cultivation in Haraz River basin area of about 108,000 ha in the Caspian Sea coastal area. The main subjects of study were:

– Cropping intensity;
– Improvement of agricultural infrastructure;
– Cultivation of second crops;
– Livestock breeding;
– Development of agro-industries; and
– Improve farmers' organization and rural social infrastructure.

To accomplish the above-mentioned development concepts (the study subjects), the Master Plan proposed the following six projects and its aim was to solve or improve the existing conditions.

1. ***Area Drainage Project***

The project aims to extend the cultivable area of second crops through improvement of the main drainage system and by providing flood protection facilities. In addition to the improvement of present drainage canals, these canals will be extended to form a rationalized drainage canal network. Simultaneously, the current water storage ponds will be improved to function as regulation reservoirs aiming to minimize the cross section of drainage canals.

2. ***Terminal Facilities Improvement Project***

The project aims to incorporate readjustment in each terminal land consolidation block to about 110 ha, which is a typical size of the service area of one terminal irrigation canal, and to improve irrigation and drainage canals as well as farm roads to facilitate mechanization and induce a high efficiency into farming practices. Labor-saving by farm mechanization and an increase in yield/ha through improvement of irrigation and drainage will be expected.

3. ***Farming Practices and Farm Management Improvement Project***

The project aims to formulate a framework to increase paddy yields/ha by optimum utilization of the farm facilities, taking into consideration the time-consuming land consolidation works which will be made block by block. Simultaneously the project aims to develop and extend new farm practices for the land consolidation area being modified, to rationalize the farm management at the farmer level through cooperative management of nurseries and cooperative operation of farm machinery, to establish model farms for enlightening beneficiary farmers, and to improve the seed center and the facilities for forecasting and controlling pest and insect damage.

4. ***Livestock Farming Promotion Project***

The project aims to improve the environment for livestock breeding by securing adequate fodder through the introduction of second crops, by breeding improvement of livestock, controlling sanitary conditions of livestock, by applying feed preparation techniques including the use of by-products of paddy, and to promote the processing of livestock products.

The project also aims to establish such public facilities at the farmer level as breeding station and animal clinics, as well as drying facilities for berseem and hay-making and forage preparation facilities to utilize paddy straw. Furthermore the project aims to open 60 milk collection depots with dairy plants, and modernize slaughterhouses for effective use of livestock products and for adding to the value thereof.

5. ***Post-harvest Improvement Project***

The project aims to minimize the present milling loss by improving the rice mills, to provide required facilities for introduction of advanced farming practices and post-harvest techniques such as mechanized harvesting and application of a paddy drying system and to make effective use of paddy by-products such as rice bran.

6. ***Village Modernization Project***

The objectives of this project are: to develop a skilled labor supply which is a prerequisite to introduction of high productivity agriculture; to maximize employment opportunities in non-farming activities such as rural industries; and to attract surplus labor derived from the improved farm management. The project will consist of the following: i) improvement of rural social infrastructure; ii) promotion of agro-industries; and iii) strengthening of farmer organizations. As for objective i), some villages will be selected for implementing the infrastructural improvement for active participation of beneficiary farmers, then the results will be applied to surrounding villages.

Although the project area itself shares only 0.06 percent of the territory of Iran, the concept of the project is applicable to other paddy cultivation areas situated around the Caspian Sea coastal area. The project is expected to contribute greatly to the development of national economy of Iran by means of extension of the results obtained in the project to the other areas, with due consideration to the physical and socio-economic characteristics of each development area.

The implementation of the projects will be effective both to elevate the income level and to improve the living environment of rural inhabitants by accelerating their active participation in the development projects. It is sure that the increase in productivity in the project area will exert a considerable impact in achieving the self-sufficiency of rice production in the country.

Taking into consideration the existing conditions of the Caspian Sea coastal area, where the project area is located, the concept is aimed to promote high productivity agriculture through improvement of farm practices and rationalized multi-cultural farm management with improved agricultural infrastructure on the basis of a beneficiary self-supporting system, that can be realized by proper arrangement and reinforcement of technical and administrative supporting organizations.

FEASIBILITY STUDY

For the development of the project area, more detailed development plan shall be provided, and a detailed feasibility study for each project is required. So, for the agricultural development in the Haraz River basin, a more detailed study called the "Feasibility Study on the Irrigation and Drainage Development Project in the Haraz River Basin" has been conducted. The basic concepts of the this study were:

Expansion of Cropping Intensity

The improvement of the soil resource by means of rapid drying of paddy fields and expansion of potential cropping area of second crops are the main objectives of drainage improvement for the project area.

- To avoid any damage to paddy soils due to standing water logging.
- To accelerate mid-summer drying in paddy fields to accelerate the growth of paddy.
- To decrease inundation damage to berseem that will be cultivated in the rainy season.

In principle, the whole project area is subject to such improvement, except the area where the topography or other natural conditions hinder such improvement.

Irrigation and Drainage Facility

Taking into account the two diversion dams on the Haraz and Amol Rivers as well as trunk canals, which have been planned by the MOE, and utilizing the available canals as much as possible, the most appropriate plan of improvement of secondary and tertiary canals is to be provided so that rational water management may be applicable in future.

Land Consolidation

The improvement plan of on-farm facilities is to permit use of farm machinery for mechanized farming of high efficiency and water management at the on-farm level in the future. Most existing paddy farms do not have direct approach roads connecting to the village road; therefore, introduction of farming machinery of larger scale is rather difficult. On the other hand, the prevailing plot-to-plot irrigation system is not only hindering the mid-summer drying of paddy fields, but there is considerable washout loss of fertilizer and agrochemicals.

The on-farm facilities improvement is to be designed in such a manner that each plot of paddy field is in connection with the farm road. Simultaneous separation of irrigation and drainage canals is to be applied if feasible from an economical point of view.

Effective Use of Water Resources

The effects of improving works of basic farmland facilities will be fully realized when a stable water supply is available. Some 40 percent of the annual runoff of the river occurs in the non-irrigation period, viz., about 400 MCM of river water is discharging uselessly into the sea. The effective utilization of this discharged runoff in the non-irrigation period is the sole solution to obtain stable water resources in the project area. Accordingly, the feasibility study on the Mangol Dam Project is urgently requested as a multipurpose water resource development taking into account irrigation, drinking/industrial water, and power generation.

Agricultural Development

The agricultural development plan will be superimposed on the improved basic farmland facilities. Consequently, agricultural development in the project area is to aim at high productivity and higher profitability. To achieve such targets, optimization of cropping intensity and yield/ha of each crop are indispensable. Taking into account those non-controllable factors such as climate and other physical conditions, the promotion of a compound farming system with rice and livestock and second crop cultivation is a very recommendable alternative for the project area even from viewpoint of the national economy. The development plan includes:

1. ***Changing the Land Use and Farming System***

The basis of the changes are: winter crop will be introduced in the paddy field with improved drainage, a joint use of machinery and farm facility is proposed to ensure efficient and economic use of these inputs, and proper water management and farm drainage practices, mid-summer drainage, and timely cropping pattern will be adopted to improve yield of paddy and other crops.

2. ***Farm Mechanization***

Introduction of appropriate mechanization systems complying with the proposed cropping pattern is considered essential for a sustainable and productive agricultural system, and the following criteria for mechanization are recommended, having in view the plot size and other factors. Farm mechanization in principle is as follows:

– The machinery maintenance system will be facilitated by unifying the types of machinery to be employed.
– An agricultural machinery registration system will be introduced to secure the maintenance of adequate numbers of working machines as well as to strengthen the inventory of spare parts.
– In the long run, improvement and exploitation of attachments and specialized machinery, rightly matched to the local conditions, will be established to improve fieldwork efficiency.

3. ***Expansion of Irrigable Area***

The irrigation plan has been prepared for only paddy as a subject crop for irrigation. This area will be extended from 71,187 ha to 78,850 ha. The summer crops other than paddy rice, namely citrus and upland crops, are excluded from the main subject crop.

4. ***Development of Water Resources***

By implementation of development plan the situation of the water supply undergoes the following changes in an average year:

Water Resources	Before Implementation	After implementation
Surface water	642	642
Wells	135	135
Spring	8	8
Abandons	36	50
Return flow	51	87
Total	872	922

From the point of view of water shortage, developing water resources by construction of a storage reservoir dam (Mangol Dam) is proposed.

5. ***Drainage Plan***

The following improvements and measures might be necessary for drainage:

– To eliminate inundation and water-logging or stagnation on farmlands during a period of paddy growth, to increase the rice yield.
– To enable farmers to practice mid-summer drainage, for increasing the rice yield.
– To make farmlands better drained for mechanization.
– To reduce inundation/water-logging and to control groundwater table from autumn to winter, for introduction of secondary crops and for effective land use.
– To remove or mitigate drainage obstructions caused by the tide of the sea, for the protection of the lowland area.
– To equip the adjacent rivers with dams for protection of the project area from floods.

6. ***Land Consolidation Plan (On-farm System Development)***

Land consolidation has the following basic concepts:

– A land consolidation scheme forms part of the long-term regional development plan in the rural area.

- Land consolidation serves to maximize agricultural (land and labor) productivity through comprehensive consolidation of agricultural lands. In line with these concepts, the project should satisfy envisaged agricultural requirements and allow establishment of effective and rationalized farming.
- Land consolidation is to contribute to maintaining a favorable level of rural production and a living environment through comprehensive consolidation of agricultural lands.

To attain further improvement and stabilization of the farm economy under such circumstances, it is necessary to increase cropping intensity and labor productivity. Therefore, the following on-farm improvements are to be carried out:

- Improvement to stabilize the on-farm irrigation system, by means of timely irrigation (water delivery).
- Improvement of on-farm irrigation systems, to increase the yield by means of application of the intermittent irrigation method, to increase cropping intensity (introducing second crops) through draining the water-logged areas due to autumn and winter rain, and to increase operational efficiency of agricultural machinery through improving the bearing capacity of soil.
- Improvement of the farm road network, to facilitate movement of agricultural machinery.
- Readjustment of field lot sizes and shapes, to increase operational efficiency of agricultural machinery.
- Land re-plotting to increase the efficiency of farming works by means of unification of fragmented parcels.

7. ***Farmers Organization***

The functions and activities of farmers organizations needed for planned production are as follows:

- To undertake a land consolidation system to implement the production improvement works.
- To observe orderly and efficient use, proper management and maintenance of jointly owned machinery.
- To facilitate, as a group, operation of a jointly managed box nursery systems associated with mechanized paddy transplanting.
- To produce paddy seed in relation to the joint nursery system.
- To accommodate joint-purchase of farm inputs.
- To operate, as a water users' association, to secure equitable public service such as terminal water management, collection of water fees and repairing of terminal irrigation facilities.
- The comprehensive function as the management unit is to stop livestock from trespassing in the berseem fields, buying of berseem seed, joint use of grass dryers or silos, and group raising system.
- To operate as a joint unit to collect milk coupled with strengthened milking capacity.
- To undertake joint marketing of winter vegetables and citrus fruits.

8. ***Post-harvest Facilities***

As crop production is improved by the project, the need for an improved post-harvest system as well as efficient marketing facilities will arise. The following should be considered, though these sectors should be specifically dealt with by other specific projects.

- Introduction of auto-threshing type combines for paddy harvesting should be accompanied with a device for paddy drying. Presently, farm income is eroded by the high rate of post-harvest loss in the form of broken rice grains caused by current paddy drying and milling practices.

– It is necessary to store berseem in the form of hay or silage to secure feed all year round. Therefore a drying facility or silos are required. Dryers for this purpose may also be used for drying paddy. However, it should be studied separately.
– As for collecting and marketing vegetables in winter, it is necessary to develop marketing facilities within the project area. Thereby rational packaging and forwarding could be realized in closer communication with consumer's markets.
– It is also essential to form a cooperative system for collection, treatment and processing of livestock products such as red meat and milk.

ESTABLISHMENT OF AN IMPLEMENTATION CENTER (CAPIC)

To ensure the successful implementation of the pilot project, the verification of new practices such as terminal facilities improvement, farm practices and farm management improvement, and the training of specialists for the application of practices through the on-farm verification are necessary. The Caspian Sea Coastal Area Agricultural Development Project – Pilot Implementation Center (CAPIC) were, therefore, established by the MOA as an organization to provide the required technical support. CAPIC aims to carry out the on-farm verification of new practices developed by the research experimental institutes, having its own farmland to guide the farmers by means of implementing the pilot project, furthermore, to provide technical support to the ARTSC which is the executive agency of development works for the extension of results from the pilot projects to the surrounding farmers.

IMPLEMENTATION WORKS IN PILOT FARMS

The practicability and profitability of suggested projects should be verified and demonstrated to encourage participation of the beneficiary farmers. From this point of view, the implementation of pilot project will be indispensable. For this purpose, 30 villages were selected as pilot farms by surveying the technical and social aspects. Later, 11 villages and finally three villages (Ejvar Kola, Eslam Abad, and Suteh) having shown the conditions and characteristics of highland, middle land, and lowlands, were selected, and the implementation works were conducted in them in cooperation with the Japanese experts. Upon departure of the Japanese experts from Iran, another village (Kateh Posht) was selected in which implementation works were conducted by the Iranian experts (CAPIC members). Some features of the project area according to the highland, middle land, and lowland are as follows:

* >40 percent employed engaged in rice cultivation

+

* Rice milling, storing, wholesale and retailing

9

* Regional economy dependent on rice
(339 rice milling in 207 villages)

* Area divided:
By elevation: highland, middle land, and lowland.
By drainage:
1. Well-drained: drainage is easy, groundwater level is low.
2. Poorly drained: drainage is difficult, groundwater level is high.
3. Hardly drained: drainage, groundwater level is high and area is inundated.

(Unit: Percent)

Region	Irrigated Area	Upland Area	Orchard Area	No. of Village	Percent Slope of Area
Highland	86.7	7.8	5.4	160	>1
Middle land	93.3	3.2	3.5	219	1
Lowland	92.9	4.5	2.6	110	<1

LAND CONSOLIDATION

One of the major development components of both the studies (Master Plan and Feasibility) is land consolidation. Implementation of land consolidation has two different roles:

1. To increase the knowledge and capabilities of specialists through:
– Organizing beneficiary farmers;
– Canalization of fund resources for farmers;
– Ways of designing;
– Procedural establishment of land reallocation (parcel exchange among farmers);
– Decision on the period of work in adverse climate condition; and
– Construction management.
2. To increase the agricultural productivity through many ways, including:
– Improvement of agricultural infrastructures;
– Increasing of water delivery capacity and effective use of it;
– Water management;
– Development of mechanization;
– Resolving the work hardness;
– Increasing rice production;
– Reducing rice production cost;
– Introducing secondary crop and increasing of agricultural production;
– Providing access to fields;
– Increasing farmer incomes; and
– Organizing beneficiary farmers.

In both the master plan study and feasibility study it has been emphasized that the land consolidation increases the agricultural productivity.

PRODUCTIVITY IN THE PILOT FARMS

There have been many definitions offered of productivity. For example Hatry and Fisk use the traditional output/input definition of productivity. Epstein (1987) described it as “responsiveness to the needs, desires, and resources of community”. Both ‘needs’ and ‘desires’ are in the definition because they represent different component of the demands that drive the nature and amount of service provided. Measurement or evaluation is an important issue in considering the productivity of any service. Also it can be important for day-to-day service management, operational and strategic planning, budgeting, and accountability.

There are many aspects to consider for evaluation or measurement of productivity. In this paper we use five evaluation criteria: efficiency, effectiveness, impact, relevance, and sustainability.

The first land consolidation project in Iran was executed by CAPIC in 1990. Then another four pilot farms were executed (three with Japanese engineers' cooperation and one by Iranian engineers).

Later, land consolidation projects were started at various other locations in Iran. Initially 990 ha of land consolidation were implemented in four provinces in 1992 and this figure was increased to about 20,000 ha throughout the country by 1997. The provinces had implemented their projects following designs as a model, which were executed by CAPIC.

At the first stage of land consolidation projects in Iran, engineers were in charge of infrastructure improvement and extension workers carried out guidance and extension activities for the farmers. The village council (*shora* or representatives of farmers) holds the explanatory assemblies in the village. These are usually held in mosques, which are located in each village. The *shora* is composed of several members elected by village people, and they manage their works by a chief elected among the members.

In the absence of *shora*, when the majority of the farmers have understood and almost agreed on the project and after the assemblies of explanation, the farmers elect their representatives for promotion of the land consolidation effort.

The membership of land consolidation applicants is not regulated in Iran. Elected representatives of farmers, or the *shoras*, have a wide range of duties such as collection of project agreements, applications for project implementation, cooperative activities for promotion of the land consolidation project including bank loans and land re-plotting.

Initially, the representatives collect the agreements from the beneficiary farmers. In this case, the agreement is required to be attached to the application form. This collection of agreements for applying is carried out before planning, and serves as an advantage to know farmers' intention. However, it does not mean final agreement with the project plan. From the viewpoint that the farmers' intention should be respected in the project plan, the collection of agreements from farmers is one of the problems that should be solved in the current procedures used in Iran.

After receiving the project application, project adoption will be decided, taking account the budget and present condition of the project area such as farmers' intention, the actual needs, and so on. Then the topographical and cadastral survey is performed. The cadastral survey is conducted to ascertain the boundaries of land by landowners who attend the survey works, and finally ownership and acreage are confirmed. Concerning the land registration system in Iran, many agricultural lands are not registered and the survey for land consolidation planning seems almost the first accurate steps taken in determination of ownership of land. The survey confirms landowners that are project participants and reports the measured acreage of the lands to the landowners.

After ownership survey works, soil survey, existing irrigation, drainage systems, and so on are conducted. Completion of the project plan and land re-plotting plan before land construction works is made and explained to the beneficiary farmers. Construction works start when 100 percent agreement is obtained, after negotiating and coordinating of the project plan with farmers.

It is desirable that the farmers be offered such minimum information for the agreement on the project plan as follows:

1. Beneficiary farmers should be able to know the procedures and outline of the project.
2. Beneficiary farmers should be able to know about burdens imposed on them and how they are to be paid.
3. Beneficiary farmers should be able to know the way for management of facilities after completion of the construction and their new individual duties and roles.

Four pilot farms were executed by CAPIC, three of them without farmers' being burdened in regard to the objectives of transfer of technology on land consolidation, and in Kateh Posht 40 percent of the project cost was paid by farmers.

Efficiency

Efficiency generally implies the output/input ratio. In assessing efficiency, achievement level of the output in comparison with efficient use of financial, human, and material resources will be examined. If the outputs are achieved through the appropriate implementation processes, with the optimal timing, the minimum duration of time and resources consumed, the project can be categorized as quite efficient.

According to feasibility studies and pilot implementation from the point of view of efficiency, the following changes will happen in providing better use of inputs or producing more outputs:

– Fourteen thousand ha will be protected from water logging.
– The water capacity of abandons (ponds) increased from 36 MCM to 50 MCM.
– The possibility of using of return flow increased from 51 MCM to 87 MCM.
– Total, the water capacity increased about 50 MCM.
– Since every farmer can manage his water usage, the amount of water used per ha decreased.
– With the possibility of application of machines and transplanting in rows, the yield of rice increased by 10-15 percent. Table 1 shows the results of two systems (traditional and mechanized) for a one hectare area.
– The amount of pesticide and fertilizer usage and their waste decreased.
– Reduction in the cost of providing transplants in comparison with cost of the traditional providing of a seed bed (for example the amount of seed used decreased from 60 kg to 40 kg).

Table 1. Comparison between Traditional and Mechanized Cultivation in One Ha after Land Consolidation in 2000

(Unit: Rl. 000)

	Traditional	Mechanized
Labor cost	3,700	1,250
Input and other cost	1,420.5	2,038.5
Total cost	5,120.5	3,288.5
Income	16,500	18,150

According to study of Amir Nejad and Chizari, the effects of land consolidation on rice production at Haraz River basin are:

A. The production function analysis showed that the rice production increased by 23.8 percent and 15.8 percent in local and improved varieties, respectively.
B. The expenses function analysis showed that the production cost of rice decreased by 35.2 percent and 18.6 percent in local and improved varieties.
C. The land fragmentation decreased by 47.6 percent.

Research undertaken recently showed that a one percent increase in acreage of a plot caused a 0.4-percent reduction in cost, and a 1-percent decrease in land fragmentation caused 0.44 percent drop in production cost.

Effectiveness

Effectiveness concerns the extent to which the project objectives have been achieved, or are expected to be achieved, in relation to the output produced by the project. Interviews with farmers of the area indicated different aims on their part in acceptance of land consolidation. The most important aims are:

- Decreasing of land fragmentation;
- Enlargement of plot size;
- Changing of plot-to-plot irrigation and decreasing the water disagreements among farmers;
- Construction of drainage facilities and providing suitable conditions for secondary crop cultivation;
- Introducing of agricultural machinery; and
- Construction of farm roads.

All of the above subjects are also the main targets of land consolidation, and each of these problems is a big obstacle to development. For example, land fragmentation (it implies that the land of each farmer is divided in several parts and that each of them is located in a different part of village) has many adverse effects, such as:

- Hindrance of technology application;
- Wastage of manpower, water and other inputs, and time;
- Loss of opportunity;
- Increasing of production costs;
- Making supervision difficult;
- Causing inefficiency in farm management;
- Restriction of mechanization;
- Inefficient use of investment;
- Disagreement among farmers;
- Crippling of social cooperation and correlationship in the village; and
- Reducing of productivity.

Kreketta (1992) in a research about the adoption of new technology by rice farmers in India, showed by regression analysis that the land fragmentation is a big barrier to efficient production. Table 2 shows the specification of pilot farms before and the changes observed after land consolidation.

Table 2. Specification of Pilot Farms Before and After Land Consolidation

	Ejvar Kola		Eslam Abad		Suteh		Kateh Posht	
	Before	After	Before	After	Before	After	Before	After
No. of farmer	93	93	52	52	119	119	85	85
Area (m^2)	913,350	881,750	605,992	580,570	1,236,492	1,137,430	744,304	669,390
Mean of ownership (m^2)	9,821	9,481	11,654	11,165	10,391	9,558	8,757	7,875
No. of plot	305	215	559	165	402	230	297	189
Mean of No. of plot per farmer	3.28	2.31	10.75	3.17	3.38	1.93	3.49	2.22
Plot area (m^2)	2,995	4,101	1,084	3,519	3,076	4,945	2,506	7,521
Plot enlargement (percent)	-	137	-	325	-	161	-	300
Decreasing of No. of plot (percent)	-	70	-	30	-	57	-	64
Irrigation canal (m^2)	10,950	14,200	10,191	10,054	-	19,620	-	17,424
Drainage canal (m^2)	-	-	2,367	8,241	-	40,050	11,502	15,814
Road (m^2)	6,700	35,050	9,692	24,702	-	54,441	7,490	35,625

Impact

Impacts of land consolidation are intended or unintended, direct or indirect, positive or negative as a result of the project. Effectiveness of the project merely covers the project objectives that connote the positive, immediate and intended results of the project. By contrast, the concept of impact is far broader, as it include negatives, long-term and unforeseen consequences. These many be economic, social, technological or environmental effects, locally, regionally, or at the national level. Impacts of a project also may appear at varying times, and attention should be paid to both the short-term and long-term impacts.

There are many different positive impacts from the land consolidation in the pilot farms. Some of them are:

– Every plot has a farm road and access road, and these facilitate the access to the field, introducing of machines and transportation.
– The sizes of plots become bigger and the economy of scale has been attained.
– Land fragmentation decreased and it provides a better condition for improvement and development.
– Irrigation and water management is improved and it encourages the farmer's independent decision-making.
– Drainage condition is improved, so a better condition for rice and secondary crop cultivation will be created.
– The disagreement among farmers is reduced, which promotes group cooperation, morale promotion, and social relationship.
– It provides a better condition for investment and mechanization in the rural area.
– Land consolidation provides farm roads, which in turn bring about social welfare services such as school, electricity, drinking water, sanitary and healthcare or medical service, and different shops.

Relevance

Relevance is to question whether the output, project objectives and overall goals are still in harmony with the priority needs and concerns of the farmers and the government. The assessment of relevance covers the questions of whether the direction of the project is still relevant to the needs of the recipient society or nation, and whether the socio-political changes that may have taken place during the lifetime of the project have altered the justification for the project. Relevance is therefore basically a question of utility and in turn leads to higher-level decisions as to whether the project ought to continue or not. If the project benefits are not accepted by society any more, there is no meaning in continuation of the project, even though the objectives of the project may have been achieved.

At this time, the land consolidation is emphasized by the government and its development has been mentioned as an important strategy in the Third Five-Year Development Plan, and as noted before, the implementation of land consolidation, especially in the rice-growing area, has increased. So it is considered an important development factor by both the government and the farmers. A study that was done in Mazandran province showed that the majority of farmers are eager for land consolidation implementation.

Sustainability

Sustainability is to question whether the project benefits are likely to continue after it comes to an end. Sustainability is concerned with what happens after the project is completed. Therefore, the assessment has to be carried out based on suppositions about future development, and providing recommendation for future activities necessary to ensure sustainability.

In other words, sustainability will depend to a large degree on whether the positive impact justifies the required investment and whether the target society values the project highly enough to be willing to devote scarce resources to continuing it.

All of the expenses of land consolidation in three of the pilot farms were paid by the government (Ejvar Kola in 1992, Eslam Abad in 1991, Suteh in 1994, respectively), because the main aim of the pilot project was transfer of technology and extension of land consolidation among farmers. The expenses of next project (the fourth or Kateh Posht in 1996) was paid 60 percent by government, and 40 percent by farmers. At the present time, the share of the farmers was increased to 70 percent and the share of government decreased to 30 percent, and many of farmers are eager to implement the land consolidation at their own expenses, but they need credit with low interest.

CONCLUSION

According to the above discussion, we can conclude that land consolidation, as a system, improves the land-use system especially in the paddy field area and promotes agricultural productivity in different ways (according to the Haraz Case Study).

7. NEW APPROACHES TO LAND-USE PLANNING

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INTRODUCTION

In 1798, when Malthus proposed his thesis that population increases geometrically while food for subsistence increase only arithmetically, there were still vast areas in the world that could be developed relatively easily. This is no longer the case, and the actual cultivated area of the world is far from providing the calculated minimum adequate diet for the present world population.

Nowadays, the limitation of land resources is more critical than ever before. Increasing the area under cultivation by traditional farming systems is not an efficient way to enhance agricultural production since the more fertile lands have already been brought under cultivation and the new areas are mostly marginal lands. Bringing more land into cultivation for agricultural development is, therefore, no longer possible for many of the world's regions. However, increasing productivity of currently cultivated lands is an alternative that entirely depends on application of improved farming inputs and techniques, implying increasing food production by technology and capital.

Both development approaches, to increase land area or to intensify the farming practices, are not mutually exclusive. If improperly adopted, both will bring about serious adverse impacts on the resources. This has actually resulted in loss of productivity of huge land areas by irreversible processes (Arnon, 1987). Hence, land resources are not only limited, but could also be degraded in the absence of appropriate land-use planning (LUP). Like any plan, the objectives for land-use planning have to be clearly determined and defined. This is very important since a reasonable approach for land-use planning must be in conformity with a clear objective or a set of objectives. Food security is an example of a definable objective. What many commentators use, as the definition of food security in a region, is that food security is attained when the people of the region have access to the amount and variety of food products they need or want. If access means only physical access, then the planning procedures would have aimed at simply increasing the production of proposed food staples. Whereas, if both physical and financial access to food are proposed, the task of land-use planning is aimed at maximization of financial profit from the farming activities which can possibly be achieved by producing some crops other than conventional staple food crops.

Adoption of new and modern techniques for land-use planning is important because not only are land resources scarce, but the desires and objectives of people are different from those of the past.

LAND-USE PLANNING, PRODUCTIVITY AND SUSTAINABLE DEVELOPMENT

The term *Land-use Planning* may generally be thought of as the attempts that are made to find answers to two basic and simple questions: what types of goods and services have to be produced by land resources?; and how can these goods and services be efficiently produced?

Human needs and desires for subsistence and well-being determine the answer to these questions. In other words, the needs constitute the objectives of the resource utilization plan and define the right things that have to be done to make the resources sustainable. "Doing right things" implies **effectiveness**. On the other hand the needs of mankind are not temporary or finite, whereas natural resources are limited and must be conserved for future uses. Therefore rational ways must be adopted to properly exploit the resources and keep them productive. This notion can be simply expressed as "doing things right". The idea of doing things right denotes **efficiency**.

Where right things are selected and right approaches are adopted, sustainable productivity is achieved – productivity has been defined as "*efficiency plus effectiveness*". Literature offers a wider view of this simple definition which encompasses not only the hard aspects of production, but also the human aspects of the process by which higher productivity is achieved. Productivity is viewed as an attitude of mind. It has been said, "productivity is the point where human skills and interests, technology, and the social and business environment all converge" (APO, 1998).

We may conclude that several economic, technical, social, and environmental attributes must be taken into account whenever achieving higher productivity is proposed by land-use planning. In order to enhance this concept we refer to definitions of land-use planning.

Land-use planning is defined as "the systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land use" (FAO, 1989).

We may derive from this definition that the land is not a sole resource. Almost all other renewable resources, including water, are either embodied in the land or directly affected by the land use. The definition also emphasizes the economic, social, and environmental aspects of land use. It is also clear that the efforts of land-use planning are aimed at converting a conventional state to a more effective and efficient state that is more productive. The ways by which the objectives and technical aspects of land-use planning can be met are also explicit in the definition. Land-use plan is further defined as "a coherent set of decisions about the use of land and ways to achieve the desired use. It includes: a definition of goals; an ordering of land and human and material resources; explicit statements of the methods, organization, responsibilities and schedule to be used; and agreed targets" (LUP II-1, 1995). Finally, we need to take into account that land-use planning is an extremely complex subject, combining physical, social, and economic aspects of land use with an assessment of potential future needs" (Murray, 1993).

Refinement of the definitions of land-use planning denotes that not only the technical and economic aspects of the prescribed activities are considered but that the social and environmental aspects of the plans play vital roles in subsistence, well-being, and welfare of the stakeholders. These are exactly what characterize "*Sustainable Development*" that many people consider it to be a philosophy. "Sustainable agricultural development is a philosophy based on human goals and on understanding the long-term impacts of our activities on the environment and on other species. Using this philosophy guides our application of prior experience and the latest scientific advances to create integrated, resource-conserving, equitable farming systems. These systems reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short and long term, and maintain stable rural communities and quality of life" (Francis and Youngberg, 1990). It appears from this notion of philosophy that maintaining agricultural productivity is the principal task of sustainable agricultural development.

In order to explore the common key words of productivity, land-use planning, and sustainable agricultural development, we refer to the definition of sustainable agricultural development presented by FAO, albeit there are hundreds of more or less similar definitions in the literature. "… the management and conservation of the natural resource base, and the orientation of technological and institutional changes in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, plant and animal genetic resources, is environmentally non-degrading, and is technically appropriate, economically viable and socially acceptable" (FAO, 1991).

The common characteristics of productivity, sustainable development, and land-use planning, therefore, concerns economic, social, technical, and environmental attributes. Productivity is a multiple dimensional endeavor where the level of its achievement depends on economic, social, technical, and environmental states of the proposed region. Sustainability is a phenomenon compatible with development that focuses on economic viability, social acceptability, technical appropriateness, and environmental soundness of the goals. And finally, land-use planning provides a coherent set of decisions in order to achieve such goals. "A spatial and temporal understanding of the relationship between different land uses is one contribution towards striking a balance between economic development and environmental conservation, the problem which lies at the heart of sustainable development" (O'Callaghan, 1995).

A brief assessment of what we discussed regarding the productivity, land-use planning, and sustainable development shows that these three categories, if not coincident, are in a close conjunction. So that *productivity, sustainable development*, and *land-use planning* can be considered as a **Target**, a **Strategy**, and a **Tool**, respectively (Figure 1). Therefore, it is not surprising that all the three categories come to the fore when discussion is focused on one of them.

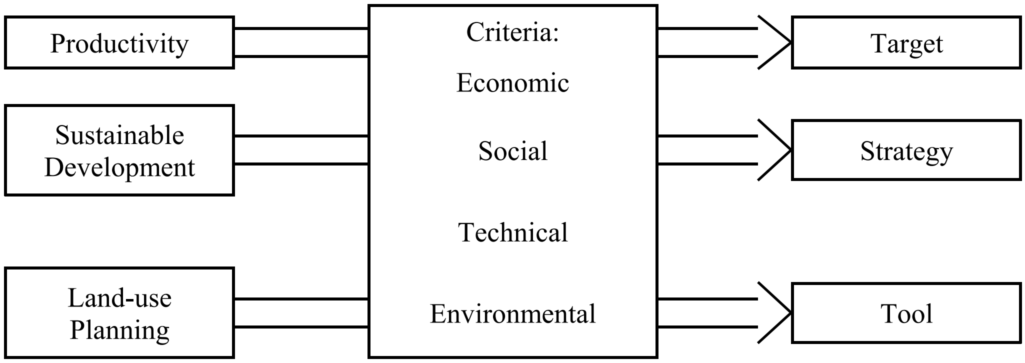

Figure 1. Common Characteristics of Land-use Planning, Sustainable Agriculture and Productivity

CHARACTERISTICS OF MODERN APPROACHES TO LAND-USE PLANNING

Common perception about land-use planning and its coincidence with productivity and sustainable development, help us to identify its basic characteristics. We will observe later in this paper that almost all the modern approaches to land-use planning have emphasized these characteristics, whereas, many of the guidelines in the 1970s and early 1980s were lack of all or part of these characteristics.

Multiplicity

Land-use planning pursues *multiple economic, environmental, and social objectives* where each objective or goal has to be monitored and measured by appropriate criteria. The goals may be conflicting, so that for some commentators "land-use planning implies weighing trade-offs among conflicting goals" (FAO, 1993). This means that for a sound land-use planning approach, application of *multiple criteria* decision-making systems must be considered a rule rather than simple conventional systems. Since unlimited needs and several objectives have to be met by a limited set of land resources, *multi-functionality* of land uses plays an important role in the decision-making process. In other words "agriculture and related land uses are not only for increased production, but have several major functions: food security, environmental, economic, and social functions" (FAO, 1999).

The multiplicity of objectives, criteria, and functions stimulates the need for collaboration of the experts from different disciplines making land-use planning a *multidisciplinary* work. "While economists, ecologists and sociologists would all agree that the other's concerns matter, they do not see these concerns through each other's eyes. An economist, for example, would readily acknowledge the importance of social and environmental factors but would interpret these concerns through an economist's lens. Social concerns tend to be reduced to questions of inequality and poverty reduction, and environmental concerns to questions of natural resource management" (Serageldin, 1993). Therefore we will fail in our efforts unless better progress is made to integrate the viewpoints of the three disciplines. The need for a multidisciplinary approach of land-use planning is not only important from the viewpoints of the three general economic, environmental, and social disciplines, plus, the branches and sub-branches of each discipline must be taken to account.

Multiplicity of the agent in the agriculture sector is another important characteristic, especially where policy analysis is proposed. The term *agent* is applied to much more than individuals. Russell and Norvig (1995) have defined agents as "anything that can be viewed as perceiving its environment through sensors and acting upon that environment through factors". This is a very general definition. "Accordingly, agents may be persons, computer programs, or even thermostats" (Balmann, 1999). It clearly denotes that agriculture is a *multi-agent* system. We will later argue that a common language will be needed in any model in order to facilitate communications among the large number of agents, including the experts of different disciplines.

Systemic Approach

A system, according to dictionaries, is an assemblage of objects united by some form of regular interaction or interdependence. This definition focuses on two major entities; the assemblage and the regular interaction or interdependence (Innis, 1975). As discussed above, the objectives of the many factors involved in land-use planning and the diversity of their interests cover a wide range of disciplines and point to the need for a general systems framework.

"Land-use planning can be considered as part of agriculture sector and/or regional planning, where the effects of economic policies on pattern of, and changes in land use are studied" (Tinbergen, 1956; Thobecke and Hall, 1987; and Van Keulen, *et al.*, 2000). Agriculture as a whole is "a system consisting of a group of interrelated components that interact for a common purpose and react as a whole to external or internal stimuli" (Spedding, 1988). Where land-use planning is the subject matter, the agriculture sector is the center of the decision-making process, whereas other sectors act as external stimuli. This is not a prejudicial idea of agronomists or agricultural economists, but a rule in land-use planning. The human systems (social system), natural resources systems (ecological system), and economic systems are subsystems of agricultural systems. A subsystem shares much of the definition of a system but it does not rule out the fact that any component can be viewed as a simple system and any system can be a component of another system. "The subject of agricultural systems is envisaged as one that combines the relevant economics and social science with the essential underlying biology" (Spedding, 1979).

The nub of the systems approach is a belief that the whole is more than the sum of its parts. This implies that an isolated study of the components that make up a subsystem is inadequate to understand the complete system. This is because the separate parts are linked in an interacting manner and it is the interactions and interrelationships between the various components that give the system its identity and organizational integrity (Dent and Anderson, 1971; Rountree, 1977; and Spedding, 1979). Thus, systems theory is primarily concerned with the systematic study of interactions between the different factors that make it up.

Potentially the system approach, in which the biological, economic, and social aspects of a problem are examined in an integrated way, is very relevant to production and resource decisions in agriculture. Doyle (1990) argues that adoption of a systems approach has presented new insights into:

a. The concept of a resource;
b. The relationship between economic and technical efficiency;
c. The time-dependence of resource allocations;
d. Stochastic influences on resource allocation decision;

e. The consequences of multiple objectives in decision-making; and
f. The opportunities for process control.

It becomes, therefore, apparent that we may get less reliable results by studying different components of an agriculture system in the absence of a general systems framework. "Such a general systems approach should aim to tie relevant disciplines together in a meaningful relationship which would facilitate communication between them and especially help in transferring the result of research across discipline boundaries" (O'Callaghan, 1995).

Dynamism

Time is an important factor in agricultural and natural resource processes. It is apparent in discussions about land-use planning, productivity, and sustainable agriculture that all the past and present actions and future desires share in defining the trends of development. "Land use is an evolutionary process, where the present potential and limitations on use are conditioned by development in the past" (O'Callaghan, 1995). Pearce, *et al*. (1990) argued that "the emphasis of sustainability implies a greater concern for the future and inhabitants of the future than has characterized past models of the development process". Dynamic system theory is concerned with the changes of a system in time either internally or externally.

Since dynamism is defined as a *state pace* property of systems, the time factor in a systematic approach is one of the most important characteristics of dynamism. Operations research, especially in the field of engineering, defines the state of a system based on the condition for the assemblage of the objects of the system. "The condition of the assemblage of objects at any point in time is the state of the system. This condition may be the amount of a thing, a logical condition, a more qualitative condition, or a combination of such things. The regular interaction or interdependence guarantees that the change of condition (change of state) with time of any object in the assemblage depends on the state of all the other objects in some degree" (Innis, 1975). Therefore, simulation of system dynamics focuses attention on the interactions of the mechanisms whereby the states change. The systemic nature of agriculture as well as continuous interactions and interrelations among its elements makes adoption of a dynamic system approach inevitable. Any attempt to use a static device to analyze dynamics could be misleading.

Modeling

The human mind is not capable of capturing all the interrelations and interactions between numerous components of a huge system, such as agriculture, by itself. It is, therefore, not easy to understand the behavior of a complex system through a direct study of its individual components. The means that help humans to overcome this challenge are models. On the other hand, as was discussed earlier, different specialists may have different viewpoints and consequently different approaches to a system. Therefore, it is very problematic to deal with a system separately through different perceptions. Spedding (1988) argues that "the basic description of the system, and thus the means of communication between all those involved, is a model. All specialists ought to be able to relate to, and improve, such a model. If a specialist operates in isolation from others, he is operating in isolation from the system".

The term *model* is usually used for a structure which has been built purposely to exhibit features and characteristics of some other objects (Williams, 1990). In a broader sense "a system is part of reality that contains interrelated elements and a model is a simplified representation of a system" (De Wit, 1982). Models are a form of synthesis and word, model picture, and mathematical models are found in today's literature on agricultural systems. "A synthesis is the combination of separate elements or parts into a whole" (Van Dyne and Abramsky, 1975). For an agricultural system the subsystems, as described earlier, act as the components or parts of the whole system. This means that any subsystem must be illustrated through an appropriate sub-model. The outputs of the sub-models must be synthesized by the main model.

Hierarchically, one level of a system can be nested within another. This principle must be adopted in model building as well. Figure 2, which is derived from Van Dyne and Abramsky (1975), represents the hierarchies of systems. A general principle in this hierarchy is that new behavioral characteristics arise at each level of a system nesting that cannot be predicted directly from the levels below. For example, when various economic firms (farms) are assembled to form a region (i.e. catchment), the dynamics of the region may not be predicted from the dynamics of the farms. It is the interactions of the individual components of subsystems that help account for this difference.

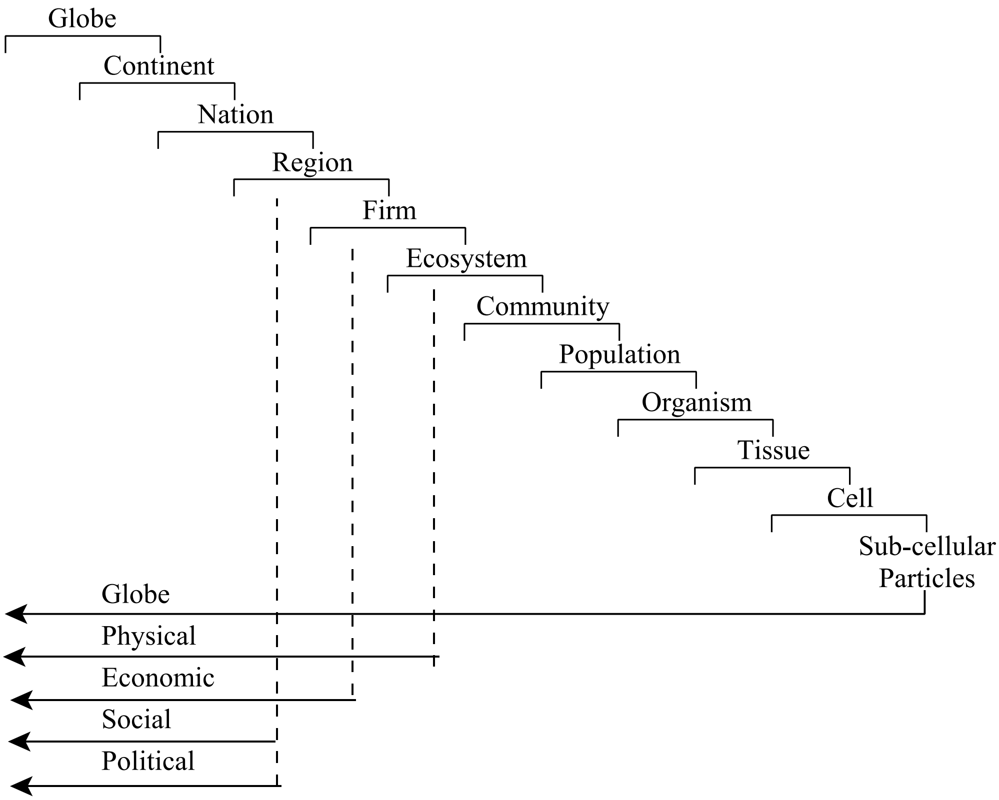

Figure 2. Hierarchies of Systems and Models

Source: Van Dyne and Abramsky, 1975.

In such a modeling structure, outputs of the model(s) in one level may become inputs to the model(s) in other level(s). In other words, driving variables in one level or echelon may become state variables in another echelon model. State variables at one echelon may become output variables at another.

The literature offers several classifications of models based on views and perceptions of the different authors. Discussion of this matter requires a great deal of time. In Figure 3, we present an early type of classification suggested by Forrester (1961). Selected classes of models will be described later in this paper.

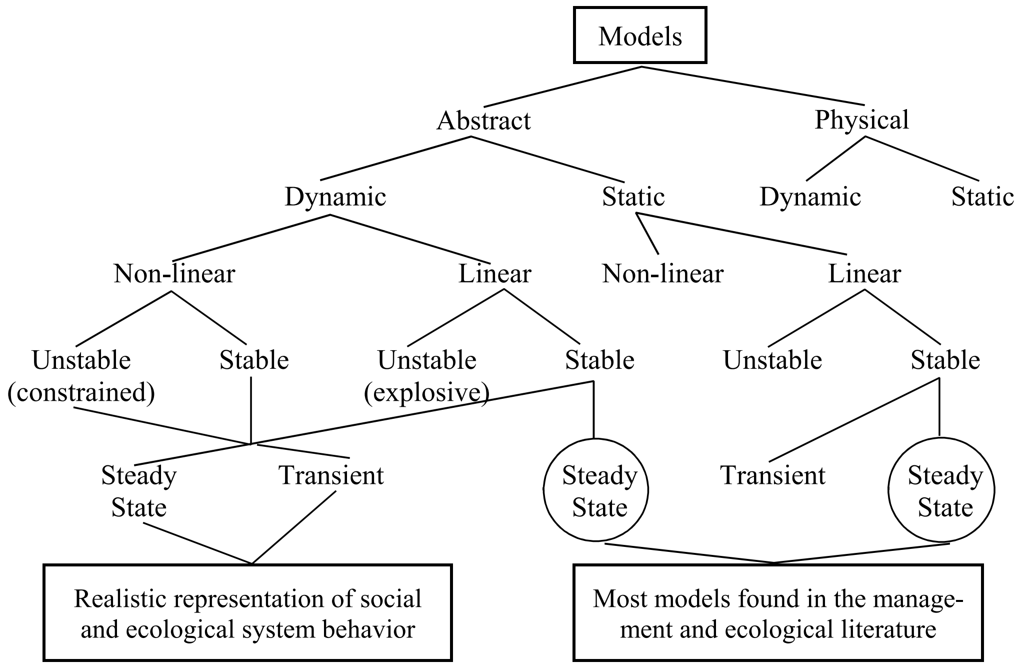

Figure 3. A Classification Scheme for Models

Source: Adopted from Innis, 1975.

It can be concluded that a set of hierarchically interrelated models is necessary to form a precise land-use planning approach; thus it is not reasonable to think about and look for a unique simple model for the purpose. Nevertheless, a specific model is needed which must be capable for integrating the outputs of the set of conjunctive models.

Geographical Boundary

Quantitative and qualitative states of land and land-based natural resources in an area, as well as their relative independence, play a key role in the decision-making process of an agricultural system. It is, therefore necessary to consider some characteristics regarding the geographic boundaries of areas that have to be used as the blocks for planning. An appropriate geographic boundary needs to have at least the following properties (Moghaddam, 1999):

- Absence of external effects;
- Relatively uniform climate;
- Relatively uniform landscape structure;

– Relatively homogeneous fauna and flora; and
– Uniform social and cultural attributes.

By the "absence of external effects" we mean the possibility of no interchange of resources among the neighboring geographical blocks, so that any changes in quality and quantity of the resources can be assigned only to the activities in the same block. Relatively uniform climate, landscape structure, fauna and flora imply the *in-region* similarities and inter-regional dissimilarities of these factors. These properties enable the system's models to capture the changes in quality and quantity of the attributes under consideration. Without selecting an independent geographic boundary based on the above-mentioned properties, monitoring and evaluating the proposed dynamics are almost impossible.

According to the literature, the entire area covered by a branch or sub-branch of a river can have the proposed properties. Scientists have used different terms such as *basin, watershed*, and *catchment* for these geographic frameworks based on their topics of interest.

A *watershed* is a topographically delineated area that is drained by a stream system. The watershed is a hydrological unit that has been described and used both as a physical-biological unit and as a socio-economic and socio-political unit for planning and implementing resource management activities (Dixon and Easter, 1986). A river *basin* is similarly defined but is of a large scale. For example, Cohon (1978) applies the term *River Basin Planning* when the allocation of limited water resources to different sectors is concerned. River basin planning is directed at the development of water body to allow the beneficial use of its water. A *catchment* is the basin of a branch or sub-branch of a river including its entire habitat, inhabitant and resources.

LAND-USE PLANNING PROCEDURE

Land-use planning is a normative approach, aimed at prescribing the way(s) of using land and land-based resources whereby the proposed objectives can be achieved. In order to carry out this task, it is necessary to recognize possibilities, to study the trends of changes, to forecast the results of changes, to define the activities for achievement of the proposed goals, and to assess the impacts of proposed activities. Therefore, a perfect approach has to adopt a set of explorative and predictive procedures. As was discussed earlier, this requires not only the participation of the experts of different disciplines, but also the involvement of users and all other stakeholders is essential.

In practice land-use planning consists of several steps associated with continuos feedback between each step and prior steps. Van Keulen, *et al*. (2000) consider six steps for land-use planning procedure that can be listed as:

1. Describe and analyze the current situation and problems (descriptive, projective and predictive studies).
2. Identify the objectives to be considered for the future (objective formulation).
3. Identify the technically feasible options (explorative studies, biophysically oriented).
4. Identify the socially acceptable and economically viable options (explorative studies economically oriented).
5. Identify the desired situation and policy development (predictive and intervention studies).
6. Formulate, implement, and monitor policy (implementation support).

These steps define types of specialized models as well as integrated models. Since a large number of interrelations and interactions do exist in agricultural systems, an iterative process must connect all the steps together. This means that most of the steps are parallel and should partly be executed simultaneously. Figure 4 presents a cycle consisting of the above-mentioned steps used for land-use planning.

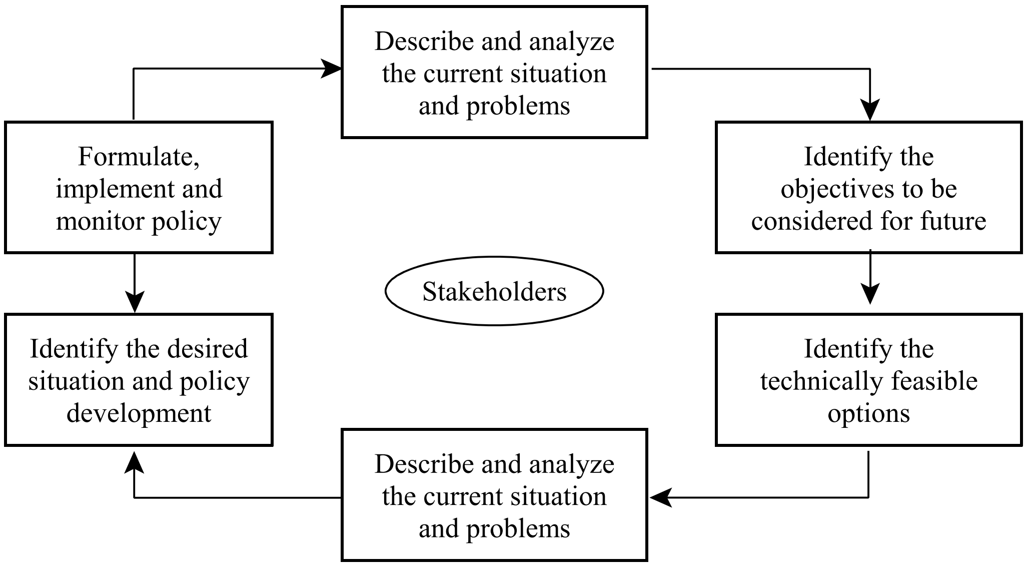

Figure 4. Schematic Presentation of Land-use Planning

Source: Van Keulen, *et al.*, 2000.

Role of Data

Picturing the current situation as well as recognizing the circumstances is clearly the first step for decision-making. This implicitly emphasizes the role of data and information regarding a wide range of disciplines. Nevertheless, since decision-making on land use is a dynamic and evolutionary process, a historical review and chronological examination of data is necessary. Information from different disciplines is characterized by different levels of complexity increasing from a description of geology and soils at one end to the development of policies at the other. Organizing information about land use is a complex and essential task. O'Callaghan suggests six hierarchical levels for organizing information regarding land use:

Level 1: Description of the land and its uses within the region under consideration. Much of the information in this level deals with geography of the area but it also includes socio-economic surveys, employment patterns, housing stock, records of archaeological sites, wildlife resources, mineral deposits, etc.

Level 2: Static physical models with classical natural science input-output (I-O) relationships of the kind, which link rainfall, runoff, and river discharge.

Level 3: The feedback control systems in which the performance of an operation may be predicted through the interpretation of information by a physical model. An example of feedback control systems is the use of dams and reservoirs for regulating the flow in rivers in order to control flooding.

Level 4: The open or self-maintaining systems. This is the level at which living organisms with all their complexity of growth, decay, and adoption are considered separately from inorganic matters.

Level 5: Individual human being, is the most complex system of all. The key characteristics of such a complex system are self-organization that is the spontaneous emergence of structures at the aggregate or macroscopic level from the seemingly uncoordinated behavior of individual agents at the microscopic level.

Level 6: The final level is that of social organizations at which groups of individuals act and express their aspiration.

It can be derived from the levels of information that a small part of the information known as raw data is likely to be directly collected from the land, whereas most of information needed for land-use planning must be generated by specialized models. All the models belong to one of the three groups that can be named as: *Eco-biological* models; *Hydrological* models; and *Economic* models. The latter covers all the markets and policy aspects. Obviously, data generated by one model may be used as entry within another. The output of all the models forms the set of data for a decision support system (DSS) that generates executable results for policy-makers and other stakeholders. Any type of data, either raw or those generated by the models must be stored in a database in order to make them accessible for all the disciplines. Nonetheless, in some stages they may need conversion and manipulation.

Structure of the Land-use Planning System

Based on the above-mentioned characteristics of models and data, a land-use planning process consists of the following activities:

- Data collection;
- Data processing;
- Database establishment;
- Data manipulation and correction;
- Specialized models building;
- Making up DSS; and
- Transferring the results to the users.

The activities may be schematically presented as shown in Figure 5. This scheme is almost in conformity with the integrated holistic picture of an agricultural system: “The understanding of whole agricultural systems thus requires a synthesis of several biological disciplines, management, and economics. The risk of over simplification and superficial treatment are obvious. The most common solution, of studying the constituent parts separately, leaves the essential synthesis to be undertaken by those engaged at the level of enterprise studies… but all relevant disciplines are required to integrate the results of both research and practice into useful models” (Spedding, 1975).

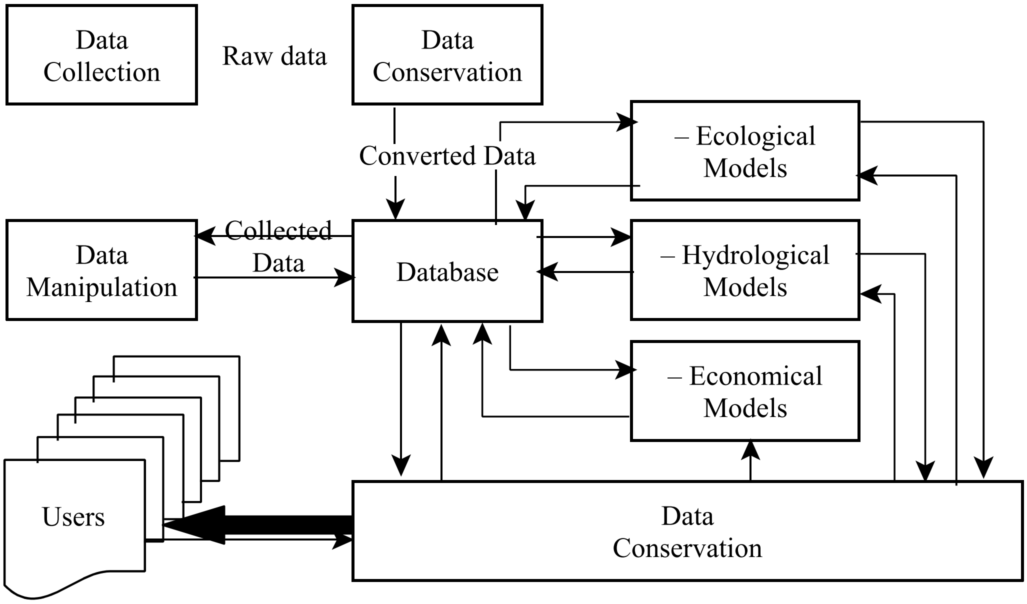

Figure 5. Schematical Presentation of Land-use Planning

We have advisedly used the word 'approach' throughout this paper. Land-use planning is not "a particular algorithm in the sense that Euclid's algorithm is a well-defined procedure for finding the greatest common divisor of two integers; or in the sense that Dantzig's simplex method is a well-defined set of rules for solving a linear programming (LP) problem" (Cooper and Cooper, 1981). Thus different parts of the scheme pictured in Figure 5 can be performed by different methods. We will try to introduce some practical ways to perform different constituent tasks of land-use planning through the review of international as well as Iranian experiences on the topics of concern.

INTERNATIONAL EXPERIENCES

FAO Guidelines

The late 1970s and early 1980s witnessed the commencement of attempts to adopt systematic approaches to land-use planning. FAO (1978) introduced the method of Agro-Ecological Zones (AEZ) that was widely applied for assessing land resource use potential, firstly in Africa. This method was also applied respectively in Southwest Asia, Central and South America, and Southeast Asia between 1978 to 1991. The AEZ method consists of 15 activities that can be grouped in four categories:

1. Listing the current land-use types including farming, horticulture and animal husbandry, and essential uses for the purpose of environmental conservation.
2. Establishing a database for land resources, land covers, and land uses.
3. Evaluating the productivity of land for any of the land-use types.
4. Planning the sector development; defining the potentials of food security and estimating the needs for inputs; and formulating appropriate policies.

Following the AEZ studies, FAO published its guideline of *land evaluation for rainfed agriculture*. Land evaluation was defined as "the assessment of land performance when used for specified purposes. As such it provides a rational basis for taking land-use decisions based on analysis of relations between land use and land, giving estimates of required inputs and projected outputs" (FAO, 1983). The principal objectives of land evaluation were to select the optimum land use for each defined land unit, taking to account both physical and socio-economic considerations and the conservation of environmental resources for future use. This statement more or less consists of the sustainability criteria.

Guidelines for land evaluation for irrigated agriculture (FAO, 1985) and land evaluation for extensive grazing (FAO, 1987) were two other scientific references that have been widely applied as an important component of land-use planning by governmental and non-governmental agencies and consultants. Nevertheless, these guidelines do not yet reflect a perfect task force for land-use planning.

A relatively effective approach to land-use planning was developed by FAO in 1989 under the title of "Guidelines for Land-use Planning". These guidelines, which have been enhanced repeatedly, propose 10 steps to perform a land-use planning procedure as follows (FAO, 1993):

1. ***Establish Goals and Terms of Reference***

Ascertain the present situation; find out the needs of the people and of the government; decide on the land area to be covered; agree on the broad goals and specific objectives of the plan; settle the terms of reference for the plan.

2. ***Organize the Work***

Decide what needs to be done; identify the activities needed and select the planning team; draw up a schedule of activities and outputs; ensure that everyone who may be affected by the plan, or will contribute to it, is consulted.

3. ***Analyze the Problems***

Study the existing land-use situation, including in the field; talk to the land users and find out their needs and views; identify the problems and analyze their causes; identify constraints to change.

4. ***Identify Opportunities for Change***

Identify and draft a design for land-use types that might achieve the goals of the plan, present these options for public discussion.

5. ***Evaluate Land Suitability***

For each promising land-use type, establish the land requirements and match these with the properties of the land to establish physical land suitability.

6. ***Appraise the Alternatives: Environmental, Economic, and Social Analysis***

For each physically suitable land use and land assess the environmental, economic, and social impacts for the land users and for the community as a whole. List the consequences, favorable and unfavorable, of alternative courses of action.

7. ***Choose the Best Option***

Hold public and executive discussions of the viable options and their consequences. Based on these discussions and above appraisal, decide which changes in land use should be made or worked towards.

8. ***Prepare the Land-use Plan***

Make allocations or recommendations of the selected land uses for the chosen area of land; make plans for appropriate land management; plan how the selected improvements are to be brought about and how the plan is to be put into practice; draw up policy guide lines; prepare a budget and draft any necessary legislation; involve decision-makers, sectoral agencies and land users.

9. ***Implement the Plan***

Either directly within the planning process or, more likely, as a separate development project, put the plan into action. The planning team should work in conjunction with implementing agencies.

10. ***Monitor and Revise the Plan***

Monitor the progress of the plan towards its goals; modify or revise the plan in the lights of experience.

Although the preceding guidelines were still applied within some steps of this approach, a distinctive characteristic of this guideline was prescription of efficient use of models and data processing techniques such as remote sensing (RS) and geographic information system (GIS). GIS is a computer system for storage, analysis, and information retrieval, in which all data is spatially referenced by their geographic coordinates (north, east). In addition to primary data, such as climatic and soil characteristics, a GIS can be used to calculate derived values; such as erosion hazard, forest yield class, or land suitability for specified land-use types. Data are usually derived from maps and derived values can be printed out as maps.

FAO has developed a computer software package named Agricultural Planning Toolkit (APT). The package has been progressively revised and developed and represents a technology transfer package in support of the above mentioned guidelines. The APT contains several systems including:

- **CDA** (Climatic Data Analysis system);
- **BIO** (Biomass and yield estimating system);
- **CRO** (Crop modeling system);
- **AEZ** (Agro-Ecological Zones system);
- **PPP** (Productivity and Population Potentials system); and
- **LECS** (Land Evaluation Computer System).

The most recent FAO proposal regarding land-use planning concerns the Multi-Functional Character of agriculture and Land (MFCAL). This proposal, that provides a policy oriented analytical framework, is inspired by the Agenda 21 that was issued at an United Nations conference for sustainable agriculture and rural development (Agenda 21, United Nations, 1992). The key functions of MFCAL are stated as food security, environmental, economic, and social functions (FAO, 1999). Multiplicity of the functions of agriculture and land, as was mentioned earlier, necessitates application of Multiple Criteria Decision-Making (MCDM) systems such as goal programming. The MFCAL approach can be summarized as shown in Figure 6.

Several follow-up actions were undertaken by the national and international institutions in different regions in order to develop proper methodologies for the sustainable land-use planning. In the following section we will give two examples of such efforts in developing and developed countries, respectively.

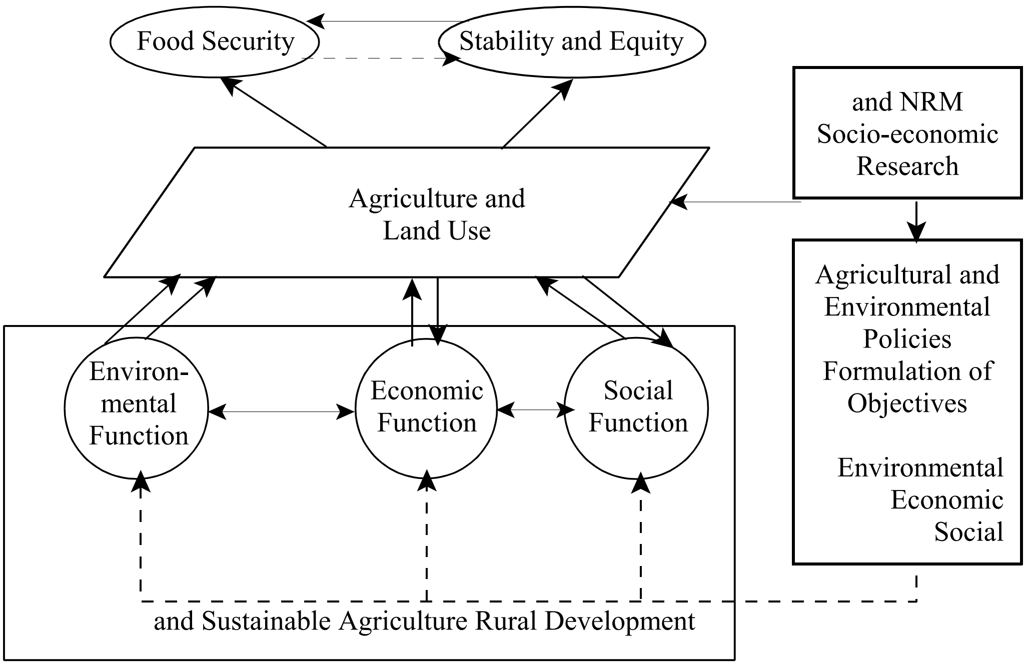

Figure 6. MFCAL Approach

Experiences of Developing Countries (Example: SysNet)

The System Research Network for Eco-regional Land-use Planning (SysNet) is one of the methodology development projects under the umbrella of the International Rice Research Institute's (IRRI) eco-regional initiative for the humid and sub-humid tropics and subtropics of Asia (Rotter, *et al*., 1999). SysNet was designed to develop a scientific methodology for identifying land-use options using crop models and expert systems and to evaluate these for generating recommendations for policy and technical changes in selected regions. National Agricultural Research Systems (NARS) of India, Malaysia, Philippines, Vietnam, and IRRS are the partners of this network. The reports of the implementing institutions denote the application of advanced models and techniques to perform the purpose. GIS is included in several simulation models, Multiple Goal Linear Programming (MGLP) and Technical Coefficients Generator (TCG) models are the important constituent tools that have been linked together through an innovative system called *Land-use Planning and Analysis System* (LUPAS). Further models and expert systems used within the SysNet methodology are WOFOST as an improved generic crop growth simulation model, CASS and AGROTEC as the technical coefficient generators, and MAPLING as a component linking model outputs and inputs to GIS.

The overall methodology consists of three major parts as follows:

– Land evaluation including assessments of resources availability, land suitability, and yield estimation;
– Scenario construction based on policy views and development plans; and
– Land-use optimization in the form of MGLP.

Figure 7 presents the interrelations of the above components.

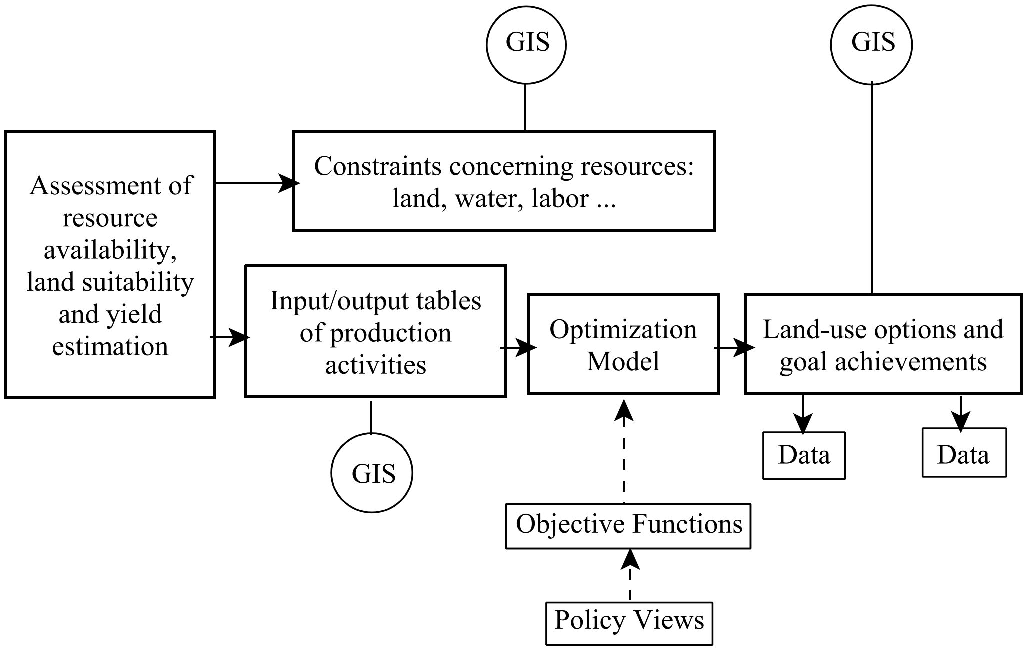

Figure 7. Methodology Framework Underlying SysNet-LUPAS and Operational Computer System Links

Source: Rotter, *et al*., 1999.

SysNet methodology has been applied in four case studies India, Malaysia, Philippines, and Vietnam. The regions selected for the studies are relatively different in many aspects including size of the study area, biophysical conditions, socio-economic settings, as well as nature and availability of information (Ismail, *et al*., 1999).

Despite its proper technical and innovative characteristics the SysNet seems to be an ambitious methodology. Reliance on the mathematical techniques like MGLP for decision-making in the complex agriculture and natural resources system appears to be rational. The case study of India, nevertheless, indicates that the results of interactive MGLP model are exploratory and, therefore, often appear to be far from reality (Aggrawal, *et al*., 2000). The Malaysian and Philippines' case studies have come up with the fact that the methodology does not show a dynamic nature and undermines the claims on resources from other sectors (Tawang, *et al*., 2000; and Lansighan, *et al*., 2000). The case of Vietnam is more promising than other cases. The LUPAS could identify the conflicts in the selection of objectives for land-use planning at a regional level. Whereas traditional land-use planning, based on a quantitative land evaluation, could not indicate these conflicts clearly (Lai, *et al*., 2000).

Experiences of Developed Countries (Example: NELUP)

A major research program, supported by the Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC) of the U.K. has been undertaken at the University of Newcastle Upon Tyne since 1988, based on a system view and approach to land use. The NERC-ESRC Land-use Program (NELUP) uses a general system framework for organizing large amounts of information that are relevant to decision-making in land use. The objective of the NELUP has been stated as: "to investigate techniques to produce a DSS for land-use planning comprising the socio-economic mechanisms of land allocation constrained by our scientific understanding of physical and ecological environments. The synthesis of understanding is to be achieved mainly through the use of modeling approaches, which will form the basis of the decision support system" (O'Callaghan, 1995).

Hierarchical organization of information, as was described earlier, has been taken into account by the NELUP. Three main components provide the necessary information that has to be synthesized within the DSS. The components are economy, ecology, and hydrology. Consequently, three groups of quantitative models have been developed to describe the interlinked process between a land-use decision and its impact on the environment. The NELUP adopts the catchment (Tyne catchment as the pilot area that covers 3,000 km^2) as the geographical framework. So far, it seems that the NELUP has most of the characteristics of a modern land-use planning approach.

Decision Support System

There exists no set view of either what a DSS must be able to do or how a DSS should be developed (McClean, *et al.*, 1995). Nonetheless DSS in the context of NELUP has been defined as "computer-based information systems that combine models and data in an attempt to solve poorly structured problems with extensive user involvement" (O'Callaghan, 1995).

DSS requires the creation of a large centralized database containing information about the physical properties of the land surface, as well as information on the ecological and socio-economic activity that occurs upon it. The lowest level of abstraction considered has been the general description and inventory of the historical and current land-use situation. The major aim of DSS is allowing access to this data, in a suitable form for a decision-maker who may not be familiar with all of the data. The proposed database is also in use by quantitative models that are referred to as the highest level of abstraction, which in turn provide the system with more specialized information and 'derived' data. A simple representation of a DSS can be seen in Figure 8.

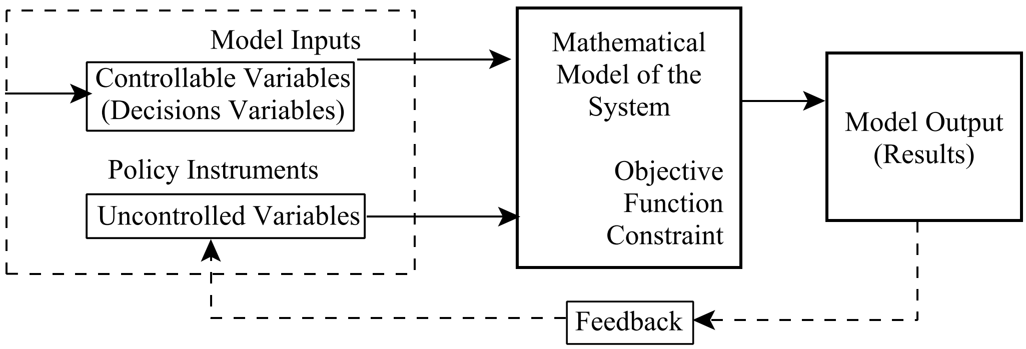

Figure 8. The Decision Support System

Source: McClean, 1994.

The NELUP's database has been implemented by utilizing three large software packages:

- The Geographical Resource Analysis Support System (GRASS) that provides a Database Management System (DBMS) for raster maps.
- ARC/INFO as a popular GIS system that has been used primarily with vector maps.
- ORACLE that is a large-scale Relational Database Management System (RDBMS).

The Economic Models

The economic component of NELUP occupies a key position within the DSS, modeling the response of agricultural land use to changing market and policy conditions. LP has been adopted as an appropriate modeling technique, satisfying constraints imposed by the objectives and structure of NELUP (Moxey, *et al*., 1995).

The objective of the economic component of NELUP is to forecast, quantitatively, patterns of agriculture and forestry land use, and associated resource use, under different scenarios created by users of the DSS. The user interacts with the economic component through a graphical user interface that allows alternative policy measures to be explored. These measures include prices, quotas, and subsidies on a range of inputs and outputs.

The core of the model consists of mathematical programming techniques, or more specifically, a recursive LP model. The activities in the proposed LP model are based on historical land uses reported in agricultural censuses, commonly observed land uses on different MLURI (Maccaulay Land Use Research Institute) capability land classes, biophysical constraints on biological production systems, commonly observed land uses on different soil associations, and even expectations of the farmers and other experts about likely future agricultural land uses. Technical coefficients that indicate production possibilities are presented in the form of an I-O matrix. The model was designed for sub-divisions of the catchment based on MLURI classification system. The elements of I-O matrix were adopted from the Farm Business Survey (FBS) for Northern England. FBS data present average I-O relationships for a given activity and do not reflect differences across land classes or alternative intensity levels. To overcome this problem, a biophysical simulation model based on agronomic, soil science, and hydrological principles was used to estimate nitrogen response I-O coefficients for different land classes. The model used was the Erosion Productivity Impact Calculator (EPIC).[1] Figure 9 illustrates the economic component of NELUP.

The Ecological Models

Within the NELUP program, ecological change is assumed to be driven principally by agronomic activity. Land-use change is defined as being of two types depending on whether there is a complete change of cover or a modification of an existing cover. Some agronomic activities lead to quantitative changes between land cover types and others to more subtle qualitative change within land cover types. A modeling system based on three distinct models is described for predicting the effects of the two types of changes in land cover on the distribution of plants, invertebrates and birds. The potential use of the system for analyzing problems of land-use change is illustrated using a simple scenario based on changing nitrogen fertilizer regimes in lowland agriculture (Rushton, *et al*., 1995).

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[1] Developed by United State Department of Agriculture (USAD).

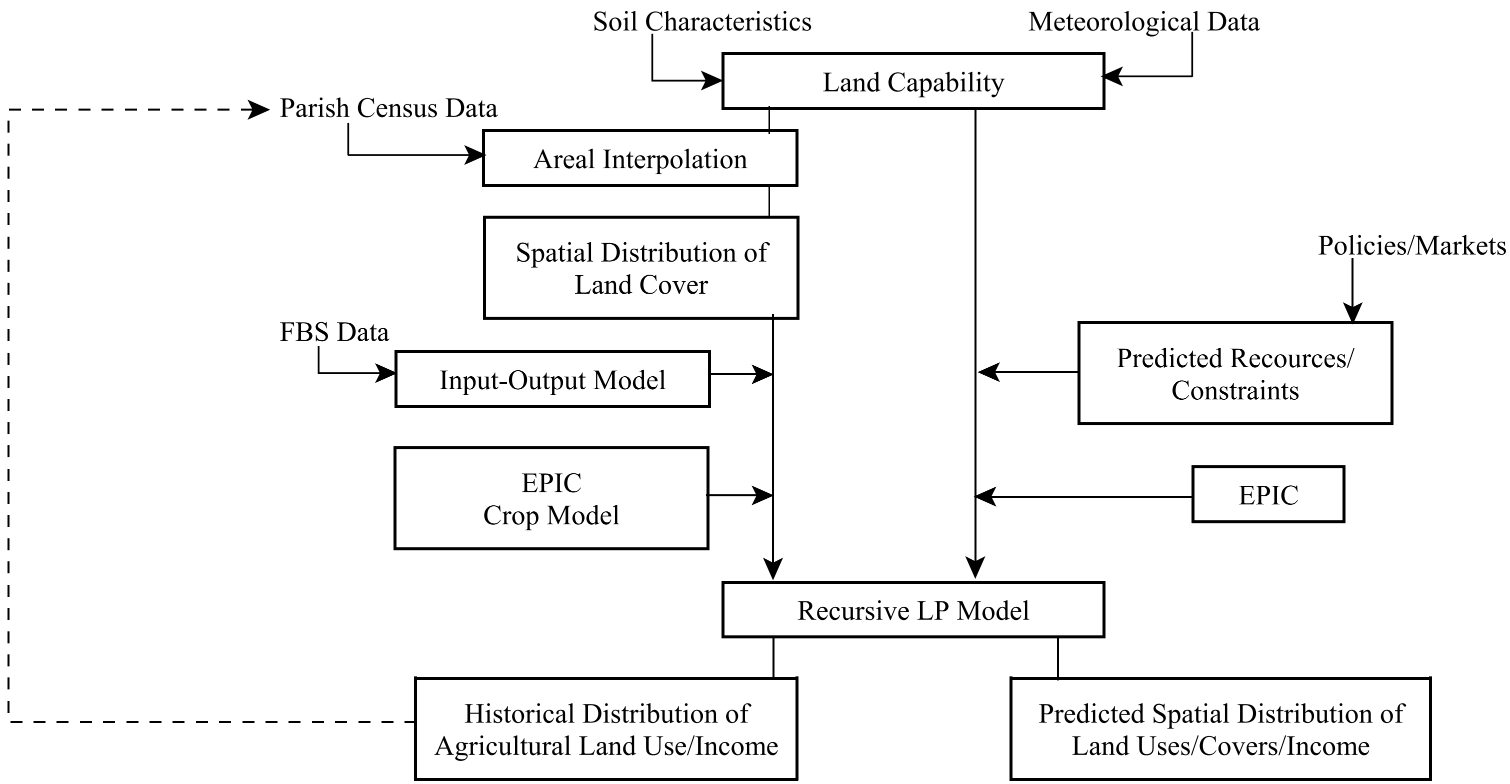

Figure 9. The Economic Model of NELUP

Source: Moxey, *et al*., 1995.

The main aim of the ecological modeling component of the NELUP is to develop generalized models for predicting the consequence of land-use change at the level of a river catchment. It is assumed implicitly in the modeling approach that ecological changes are driven by agro-economically-mediated land-use change.

The basic ecological unit is that of the individual species. The main aim of the ecological modeling can therefore be rationalized into achieving two objectives – predicting where species are found in the landscape and predicting what effect land-use change has on specie distributions.

Thus, ecological modeling can be seen as a large-scale multi-attribute response model linking the distribution of species to change in agronomic activity (Figure 10).

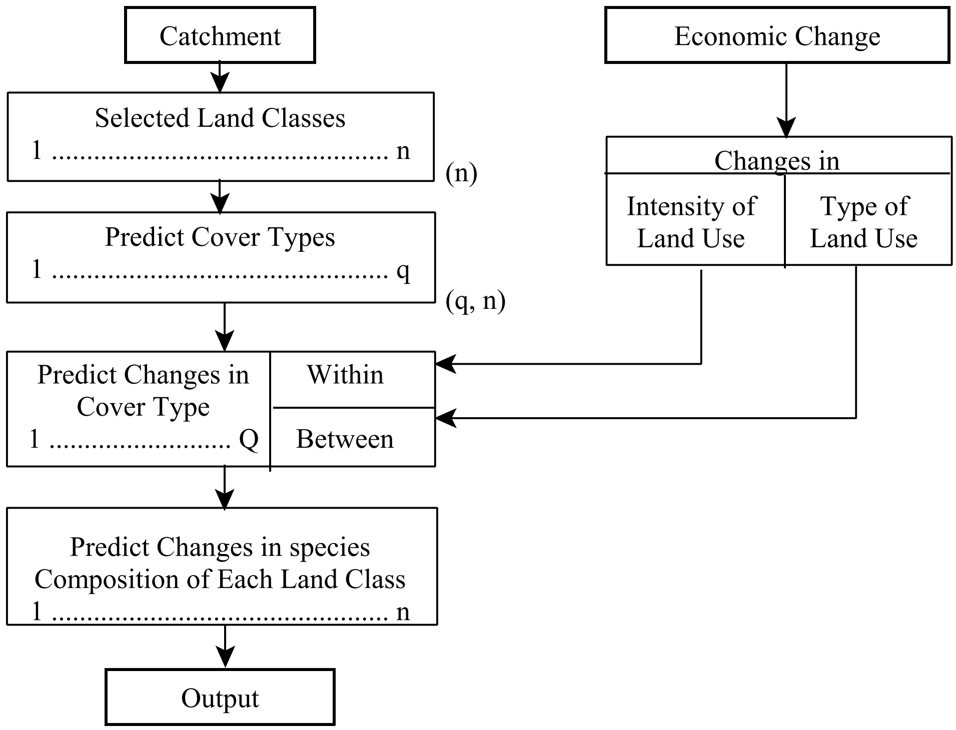

Figure 10. The Associative Ecology Model of NELUP

Source: O'Callaghan, 1995.

A simple associative matrix model was developed for plants and invertebrates. The distribution of species is predicted on the basis of their known occurrence in land cover types. The method relies on the use of a nested ecological hierarchy of land cover, community and species. The relationships between levels are formalized algebraically in a matrix form. The highest matrix contains information on the proportional contribution of land cover types within 1 km grid squares. The second matrix summarizes data on the occurrence of an assemblage of species within land cover types. A third matrix contains data on occurrence of species within the assemblages. In the proposed model, changes in land use are represented in terms of changes in the composition of the highest matrix in the hierarchy.

These changes are then carried through to the lower levels of the hierarchy by matrix multiplication algorithms.

The Hydrological Model

The hydrological modeling capability within the NELUP program is built around two simulation codes, SHETRAN and ARNO. Together these provide a comprehensive tool for analyzing the potential impacts of land-use change on the hydrology of catchment. Both models have been validated for five-year flow simulations on the prototype Tyne catchment (Adams, *et al*., 1995).

The numerical simulation code SHETRAN is a physically-based, spatially distributed, catchment modeling system. It is a derivative of the *System* ***Hydrologique*** *European* (SHE) flow modeling system but has been substantially revised and extended over recent years to include sediment and contaminant transport components. It has been designed to model the spatial and temporal variation of water, sediment and contaminant transport throughout a part or all of a river basin and to resolve response of these phenomena to land-use change. However, results are produced relatively slowly and at a considerable computational cost. Its counterpart, ARNO, is designed to give much more rapid but lower spatial resolution results using semi-analytical methods. The ARNO code employs a conceptual lumped modeling approach to describe water flow at the river basin scale. Although developed originally to model the surface water hydrology of the River Arno, the ARNO code can be easily applied to model most river basins. The ARNO code provides a screening tool while SHETRAN provides a more detailed analysis tool. Figure 11 represents a schematic diagram of ARNO.

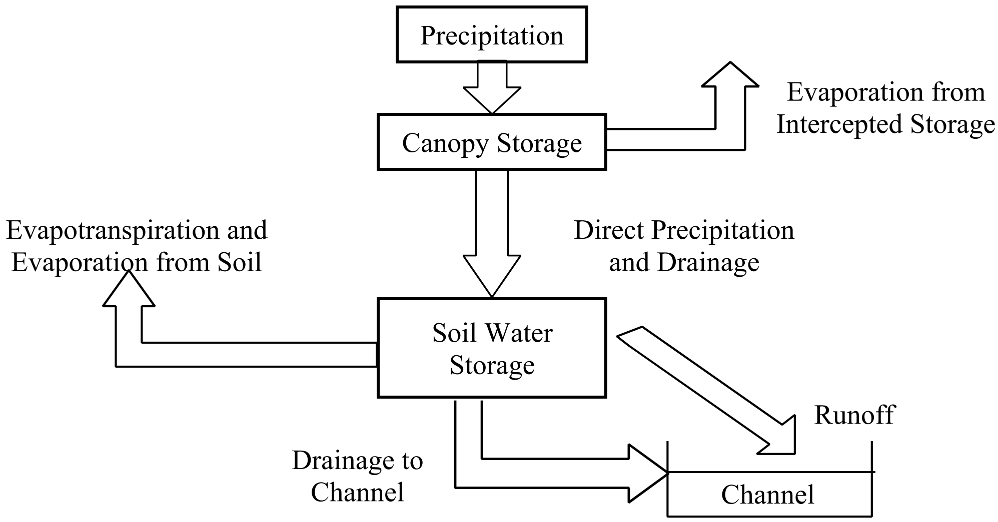

Figure 11. Schematic Diagram of ARNO Model

Source: Adams, *et al*., 1995.

Both hydrology codes have been integrated into the DSS to permit the user to carry out extensive hydrological analyses in conjunction with analyses based on the GIS, economic and ecological models. Both SHETRAN and ARNO require spatial data describing the land surface, land cover, soils, underlying geology and stream network.

The characteristics described by these data together control the land phase movement of water. In addition, both codes require data describing the temporal distribution of precipitation, air temperature, sunshine hours, and wind speed to characterize the climate. These data are held in the DSS database and can be extracted for use with any hydrological simulation. An intermediate software package, SHE-SHELL, performs the integration of relevant data sets for each simulation. It is resident in the background of the DSS and its operation is fully automatic.

IRANIAN EXPERIENCES ON LAND-USE PLANNING

Climatic conditions of Iran have been classified as arid and semi-arid. About three-fourths of the country receives less than 250 mm of rainfall per year. Only a tiny part of the country at the vicinity of the Caspian Sea receives annual rainfall of more than 650 mm, whereas many areas in the central and southern regions have an average rainfall of less than 100 mm. These circumstances have caused the chronic problem of water resource scarcity. Three decades ago, water resources were reported to be the only limiting resource for agricultural development. Land area, on the other hand, was not considered as a limiting factor, albeit one-fourth of the total geographic area of the country was assessed as being lacking of any value for agriculture (Bookers and Hunting-1, 1974).

Today's conditions do not validate the above mentioned arguments about the land. This can be confirmed by the following facts: 45 percent of arable lands are classified as water eroded and 20 percent as wind eroded, average soil loss from arable land is estimated at some 10 mt/ha/year. Of the 105 million ha of watersheds, 78 million ha are potentially suffering from increased erosion. As a result, and also because of the degradation of watersheds, the frequency and severity of floods and the damages they cause have increased. Groundwater recharge has also been affected. Sixty-five million animal units are now being grazed on the rangeland with sustainable carrying capacity of only 26 million animal units. The total area of suitable rangeland has decreased to 90 million ha from 110 million ha, due to degradation and to ploughing for expansion of rainfed agriculture during the last 30 years. In the same period, Iran's forests have decreased to 12 million ha from 18 million ha. The annual deforestation rate has been estimated at 130 thousand ha, while afforestation is only 10 thousand ha per year (UNDP-MOA, 1997).

These alarming facts have been taken into account by the agriculture sector decision-makers and planners, stimulating them to search for appropriate scientific tools in order to counter and to solve the problems. The first sign of a systematic approach and application of models to land use and agriculture sector planning was observed in the early 1970s in two sister projects titled *National Cropping Plan* (NCP) and *National Animal Husbandry Plan* (NAHP). With the advent of the Islamic Revolution in 1979, agricultural development was adopted as the base and directive sector for overall economic development of the country. In the light of this strategy, the Ministry of Agriculture (MOA) commenced a program of Comprehensive Studies for Rehabilitation and Development of Agriculture and Natural Resources (CSRDANR) in 1984. Following this broad project, several pilot projects and case studies have been carried out to explore sound development approaches and to formulate appropriate land-use planning methodologies for Iranian conditions. We will describe some of the completed and ongoing projects in this section.

National Cropping Plan[2]

NCP was the first scientific approach to land-use planning, or in a broader sense, to agriculture sector planning. NCP was conducting by MOA through a joint venture of two consultant companies, Bookers Agricultural and Technical Services Limited and Hunting Technical Services Limited (B&H). The NCP studies were aimed at two objectives: to define the attainable levels of agricultural development and productions, and to recommend suitable cropping patterns in order to achieve the proposed development and production objectives (Bookers and Hunting-1, 1974). Overall activities were categorized in six steps, including:

1. To estimate demand for food in the projected year (1992) based on the population growth rate and changes in the income levels.
2. To define the current state and future potentials of natural resources.
3. To identify possible improvements in crop production and animal husbandry systems.
4. To estimate likely levels of achievements to meet the proposed levels of demands.
5. To justify the appropriateness of the recommended plans.
6. To present institutional changes required to realize the plan.

The approach adopted by B&H was similar to that of the FAO-AEZ program for land-use planning. B&H identified 10 AEZs over the entire area of the country as shown in Figure 12 (Bookers and Hunting-6, 1974). For the first time, linear programming was used as an integration tool within this project. Objectives such as self-sufficiency in food products and maximizing the value-added component of agricultural production constituted the objective functions of the proposed LP model (Bookers and Hunting-9, 1974).

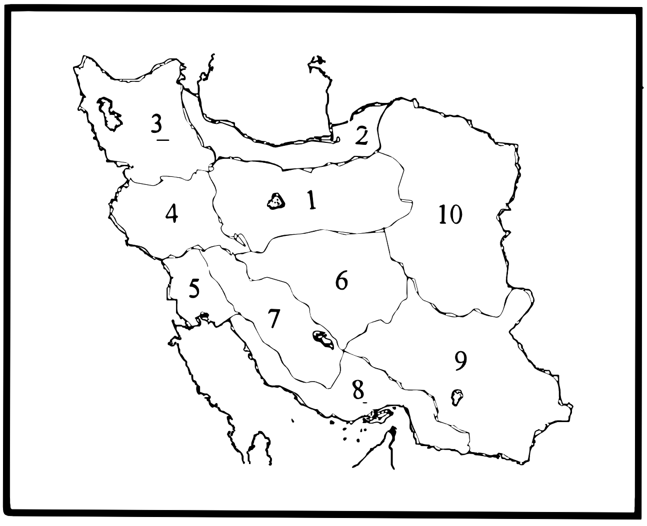

Figure 12. AEZs of the Country

Source: Bookers and Hunting-6, 1974.

[2] The reports referred to in this part are Persian versions.

At the time of implementation the NCP LP methodology, computer systems, and computerized software packages had not reached today's level of advancement. Therefore B&H partly revised the results of the LP model based on the views and judgements of the professional contributors (Bookers and Hunting-1, 1974). Further adding to the problem, single crops were chosen as decision variables that are not likely to reflect economic, biological, and technical balance among the crops. This weakness could have been overcome if crop rotations, for instance, would have been adopted as the activities. B&H's decision on classifying the rangeland in only two classes, rainfed land to only three classes, and irrigated lands to only three classes based on water availability (Bookers and Hunting-4, 1974) is not in conformity with present LP standard guidelines. Nevertheless NCP was evaluated as an advanced methodology at the time.

Comprehensive Studies for Rehabilitation and Development of Agriculture and Natural Resources

In order to identify the possibilities and potentials of agricultural development on one hand, and to recognize the constraining problems and bottlenecks on the other hand, MOA commenced the CSRDANR project in 1984 (MOA, 1984). This nation-wide multi-disciplinary project was proposed to be carried out in three consecutive phases including reconnaissance, provincial synthesis, and national synthesis. A committee consisting of senior experts from different disciplines under the title of Comprehensive Planning Council (CPC)[3] was established to conduct the project. In conformity with the latest scientific guidelines, CPC decided to base the studies on *hydrological units* as the geographical blocks. Therefore, 37 river *catchments* were identified over the entire area of the country. Every catchment then divided into several *sub-catchments* each containing one or more *plains*. A total of 147 sub-catchments including 618 plains were identified for the studies (Figure 13). CPC also identified 25 resource-related subjects that had to be accurately studied. These subjects can be categorized under three broad fields as follows (APERI, 2000):

1. Resources, including:
   - Soils and land resources;
   - Erosion and soil conservation;
   - Watershed management and de-desertification;
   - Hydrology;
   - Hydro-geology;
   - Water resource development;
   - Irrigation and drainage;
   - Climatology;
   - Geology;
   - Forest and rangeland;
   - Population and communities;
   - Manpower and employment;
   - Rural and tribal sociology; and
   - Rural women in development.

[3] CPC primarily was proposed to work within the planning and budget office of MOA. Later in 1986 it formed a bureau namely Comprehensive Planning Bureau (CPB). By the establishment of the APERI the CSRDANR has been one of its ongoing tasks.

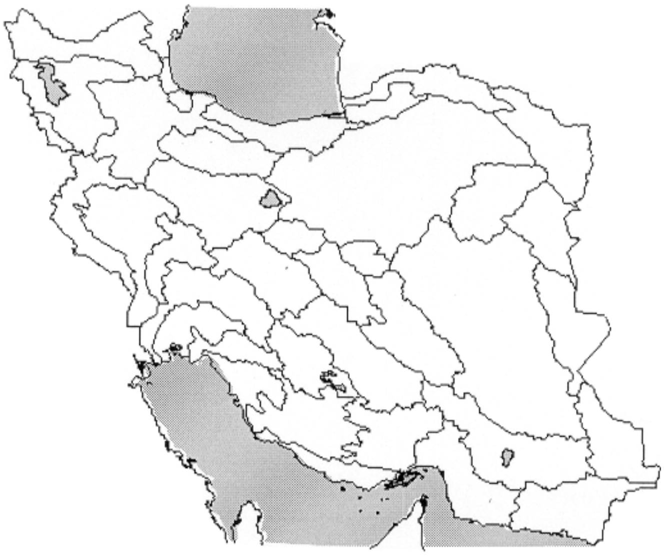

Figure 13. The Catchments of the Country

2. Production, including:
   - Crop production and horticulture;
   - Animal husbandry;
   - Poultry;
   - Fishery;
   - Bee-keeping; and
   - Apiculture.
3. Services, including:
   - Research;
   - Training and extension;
   - Agricultural credits and cooperatives;
   - Utilization systems; and
   - Agricultural organizations and institutional systems.

These studies have been carried out through tens of consulting companies each serving one or two sub-catchments; they, however, had to complete studies of all the fields or disciplines. The reconnaissance studies lasted for 10 years culminating in the generation of a huge amount of valuable information with reasonable accuracy and a meaningful disaggregation regarding all the disciplines covering an entire area of the country.

The second phase of the studies was a comprehensive provincial synthesis. Since the administrative divisions of the country do not coincide with the natural divisions, it was necessary, firstly, to take some action for adjusting information to coincide with the administrative divisions. As was mentioned earlier, the natural divisions consist of catchments, sub-catchments, and plains – whereas country, province, township, district, and village are the administrative units. The boundaries identifying these two systems of divisions are quite different. Secondly, provincial synthesis provides a long list of alternative projects based on the possible land-use options and resource capabilities. So far, provincial syntheses have been completed and reported for five provinces. Results of the rest of the provincial syntheses are in the final stages of preparation.

The most important phase of the CSRDANR project is a complete national synthesis. By means of the completion of reconnaissance studies, adjusting data into administrative divisions and a long listing of the feasible projects, some way must be found to incorporate macro and administrative sector policies into the agriculture sector planning. A national synthesis, therefore, was proposed to carry out this task. Three main stages are guiding the phasing of the national synthesis:

1. ***To Update and Harmonize Data***

   Although the consulting companies have been advised to apply standard guidelines for studies and to use uniform formats for documentation (APERI, 1997), it seems that an overall review would be necessary to increase the accuracy and uniformity of the data. This is also necessary since generating data and information has occurred over a period of 15 years that necessitates dealing with and rectifying the likely gaps and inconsistencies in the data. Furthermore, the information has been tabulated and archived, mainly in none-electronic formats, which necessarily must be converted to an electronic format and prepared to be used with modern techniques such as GIS.

2. ***To Establish a Nation-wide Database***

   Implementing data on database systems will certainly be a step forward in the national synthesis. The proposed national database will enable the experts and decision-makers to have access to all the sets of data, to apply them in their analysis, and will provide a database for the newly derived data and results. The database is also proposed to give some services to other users as well.

3. ***To Integrate Information and Synthesize Data through Appropriate Mathematical Models***

   A very critical stage in the project will be to insert an appropriate link between all the available data and to the set targets. The development and adoption of suitable models will significantly contribute to the process of decision-making within the context of the national synthesis.

We are now at the threshold of the third phase of the project for which the task force is preparing. Several proposals have been assessed in order to formulate a detailed methodology. The outlines of a general approach will be similar to the one shown in the Figure 14.

Land-use Planning II (LUP II)

The first attempt to construct a methodology for land-use planning was made through a joint FAO-MOA project under the title, Land-use Planning I (1987). The FAO contribution to the project was to provide consultant services to assess the current procedures for studies and the steps taken towards land-use planning by the MOA. At that time, the CSRDANR project was newly started. The reports of a few pilot catchment studies were reviewed by the FAO mission which came up with the need to develop a structured, planned approach to the development and use of land and water resources. Consequently a broader pilot project was suggested for the purpose of methodology development, namely, Land-use Planning II (LUP II) in 1991. The LUP II project was commissioned by the MOA and sponsored by the United

Nations Development Program (UNDP). The Western Australian Department of Agriculture was subcontracted as the implementing agency.

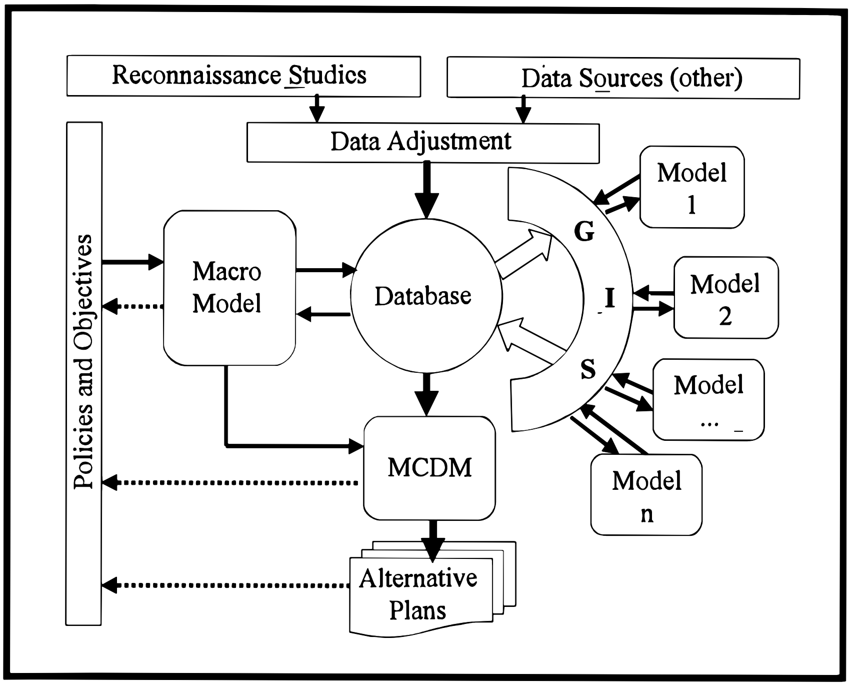

Figure 14. Tentative Approach for National Synthesis

The LUP II project was intended to enhance the planning methodologies and planning skills of the MOA through providing training and work experiences to the staff of APERI. The project was to serve as a model for agricultural land-use planning and was undertaken in the Mazandaran province, one of the most important agricultural regions in Iran and an area under the certain threat from competing land use and rising water levels in the Caspian Sea (Figure 15).

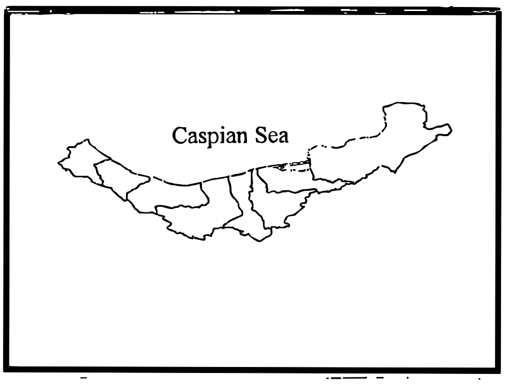

Figure 15. The Land-use Planning II Projects Area

The broad objective of the project was to construct a methodology for defining current, potential, and preferred land uses at regional and local levels of planning (LUP II-2, 1995). The outcome of the project is a systematic and integrated approach to agricultural land-use planning which uses appropriate technology to analyze and present relevant data in ways which are responsive to various clients' needs in Iran (LUP II-1, 1995).

The LUP II project has employed most of the newly developed advanced data analysis techniques within its procedure. GIS and RS as well as mathematical programming play central roles in the procedures of the project. Almost all the standard guidelines regarding land-use planning have been taken to account during the project implementation process. Three milestones, determining the current, potential and preferred land uses, can guide the overall land-use planning process. Several disciplines contribute to determination of current, potential and preferred land uses that are as follows (LUP II-1):

1. ***Current Land Use***
   - RS/air photo interpretation; and
   - Sociology.
2. ***Potential Land Use***
   - Soil survey;
   - Climatic data analysis;
   - Agronomy (crop production);
   - Environmental planning;
   - Sociology;
   - Farming systems; and
   - Integrated land evaluation.
3. ***Preferred Land Use***
   - Agricultural economics

Models developed and used by each discipline in the land-use planning process require data from many sources. The GIS approach provides some of that data and integrates outputs for use by other disciplines while providing analytical methods of its own. A data flow diagram (Figure 16) shows the overall data relationships of the different disciplines in a land-use planning approach using GIS.

As can be observed in the Figure 16, GIS centralizes a variety of data to facilitate the updating process and data accessibility. The primary step in the process is, therefore, building up accessible databases. Data should be captured in the order of their usage and listed respectively as: soil and land evaluation (soil series and soil profile data), geological data, climatic data (isohyet and isothermal lines), surface water data (surface streams and watershed boundaries), administrative and geographic boundaries, vegetation data comprising forests and range lands, urban and industrial data, and finally agro-economic zones defined by the economists.

LUP II has benefited from the application of a large set of advanced models to different disciplines within the several development stages. The process has efficiently interfaced different models through the databases. It would not be in the scope of this paper to describe the properties of all the models and the states of interrelations among them. A listing of some of the models, systems, and techniques may, however, be helpful to reflect the extent of the work.

- PC ARC/INFO GIS;
- Automated Land Evaluation System (ALES);
- Crop Evaluation Model (CE2);
- FAO-ISRIC soil database (SDBII);
- FAO Agricultural Planning Toolkit (APT);
- Climatic data analysis module (CDA);
- Land evaluation computerized system (LECS);
- Social Impact Assessment models (SIA); and
- Mathematical programming models.

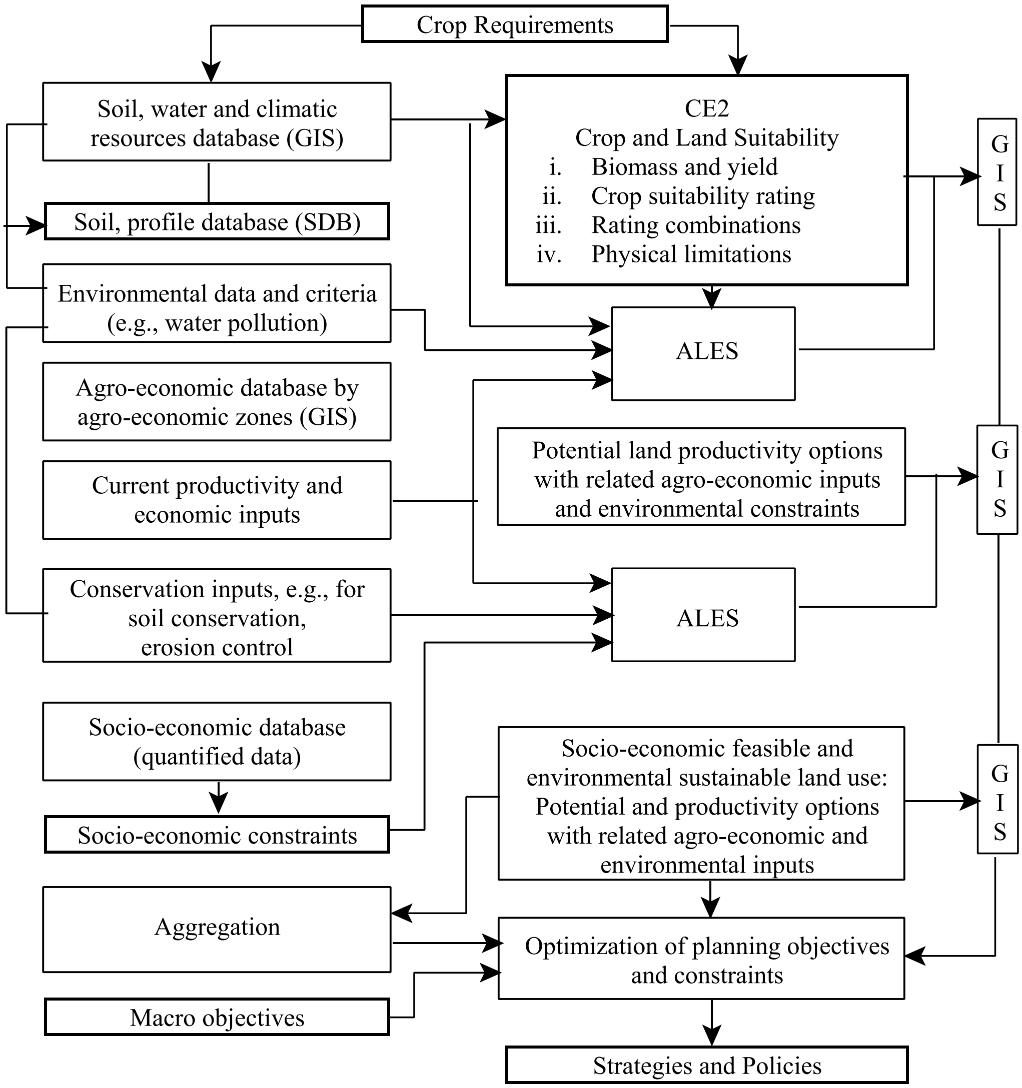

Figure 16. Assessment of Potential Land Productivity Options by Map Unit

Source: LIP II-1, 1995.

The LUP II project introduced a set of techniques, new to the Iranian staff, in order to assist future land-use planning. “The disciplines and their techniques discussed are by no mean exclusive. They have been drawn from experience gained over a 3.5-year implementation of the project in the Mazandaran region. They make use of appropriate technology and have been structured in such a way as to allow multidisciplinary assessment of planning issues at the regional and local level. Central to the approach has been the capture, storage, analysis, manipulation, and presentation of data using GIS, expert systems, and applicable models in order to satisfy a wide range of client needs” (LUP II-1, 1995). LUP II seems to lessen the role of economics as an information provider that helps decision-makers define preferred land use rather than to develop tools which provide land-use plans. It has also been argued that the responsibility for final land-use decisions will always remain with the decision-maker, not with the output of models. This argument is likely to reduce the effectiveness of the proposed procedure.

Sustainable Management of Land and Water Resources National Action Program (NAP-SMLWR)

The objectives of this program, that consists of three projects, is to improve productivity of land through rehabilitation, conservation, and sustainable management of land and water resources in Islamic Republic of Iran, leading to improved living conditions, in particular at the community level (NAP-SMLWR, 1997). One of the specific projects, titled “The Garmsar Plain Sustainable Agriculture Development”[4] commenced in 1998 by the MOA in a watershed (Hablehrud) with a geographic area of 650,000 ha including the Garmsar plain.

There were two feasible primary activities that can be technically justified against the goals envisioned in the project document. The first activity involves a comprehensive study of the whole project area in order to identify the potential for agricultural and natural resource development for the long-term perspective. The other was the obvious need for a pilot project to solve the immediate problems threatening the sustainability of an area downstream the existing irrigation scheme in the Garmsar plain. Both of the activities were to be undertaken using the qualified national and international consulting groups.

The comprehensive studies are based on the application of GIS that enables the studies to incorporate the interactions of almost all the disciplines into a dynamic planning process. The results of this component are to be presented by the end of the current year, 2001.

The immediate actions pursue a holistic approach to sustainable planning and the water resources in an environmentally fragile plain. Once the salt and water balance of the plain is identified using a state-of-the-art model, a full range of farm improvement measures and water resource management works will be formulated and implemented. The key assumption is that the farmers are involved in all of these stages. To this end, a pilot community development program is ongoing, based on the methods of Participatory Rural Appraisal (PRA) and Farmers Field School (FFS).

CONCLUSION

This paper has attempted to indicate the characteristics of modern approaches to land-use planning which have been thought to be an efficient tool for the achievement of

[4] The authors gratefully acknowledge the assistance of Mr. H. Fathi who provided them with the information regarding this project.

reasonable levels of productivity in the context of sustainable development. Modern land-use planning approaches are characterized by a systemic view of the whole agriculture system. This system consists of several subsystems, is time dependent and dynamic in the sense that it is in a constant state of change and evolution. Applications of a set of interrelated dynamic models are, therefore, necessary for analysis of the agricultural system. Database management and geographic information systems, RS techniques, as well as mathematical programming methods, are the integral components of the modern approach. The successful performance of a modern land-use planning process depends on the involvement of all the experts of different disciplines as well as the farmers and other stakeholders.

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1. BANGLADESH

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INTRODUCTION

Scarcity is the ever-present imbalance between human desires and the ability to satisfy them. The problem of scarcity arises because all resources are limited in some way and in choosing to use resources for one purpose, we sacrifice the opportunity to use them for alternative purposes. The scarcity of land makes it an invaluable economic resource for any nation. In the context of developing countries, land is an essential productive asset and a means to sustain a livelihood. In Bangladesh, where agriculture plays a key role in the overall economic performance of the country, the contribution of land and water resources is undeniably consequential. Bangladesh has a land area of about 14.4 million ha and the current population of the country is close to 130 million. At present, the population density is about 850 persons/km^2 and is projected to increase to 913 persons/km^2 in 2002, which will adversely affect the current man land ratio of 1:18 decimal.*

The pervasiveness of poverty and the high population density in Bangladesh make land issues very significant for economic growth and poverty reduction. Access to land is crucial to reducing poverty because it allows poor farm households to make productive use of family labor, to smooth consumption and to improve their income and well-being. The present land utilization systems serve as the prime generators of income and employment in rural Bangladesh.

Bangladesh achieved impressive gains in food grain production in the 1970s and 1980s by increasing fertilizer use, investing in irrigation, and adopting modern seed varieties. Subsequently, the acceleration of the growth rate was slowed down. Again in the current fiscal year Bangladesh has experienced an increase in the food grain production with a surplus of 0.9 million mt. Studies have shown that Bangladesh has a strong potential to increase agricultural growth even with limited or declining land for agriculture. To harness this potential and to sustain the current achievement, an appropriate land-use policy is under formulation. Implementation of such a policy may lead Bangladesh to achieve self-sufficiency in food and alleviate poverty through generation of more employment.

LAND-USE PATTERNS AND SYSTEMS IN BANGLADESH

Land Uses

At the time of emergence of Bangladesh as an independent sovereign state, through the War of Liberation in 1971, its population was 70 million. Two-thirds of the total land area

* 1 decimal = 0.01 acres = 40.52 m^2.

of approximately 14.4 million ha were under cultivation. With the increasing population pressure, cultivable area has been reduced and now stands at 59 percent of the total land area. The remaining areas are covered by water bodies, human settlement, forest, and roads etc. The major uses of land in Bangladesh are shown in Table 1 below.

Table 1. The Major Classification of Land Uses in Bangladesh

Land-use Type	Area (million ha)	Percentage
Agriculture	8.50	59.0
Forest (classified and unclassified)	2.01	14.0
Water bodies	0.94	6.5
Tea gardens, rubber plantation, orchards etc.	0.07	0.5
Urban areas and rural settlement	2.39	16.6
Others	0.49	3.4
Total	14.40	100.0

Source: Bangladesh Bureau of Statistics (BBS).

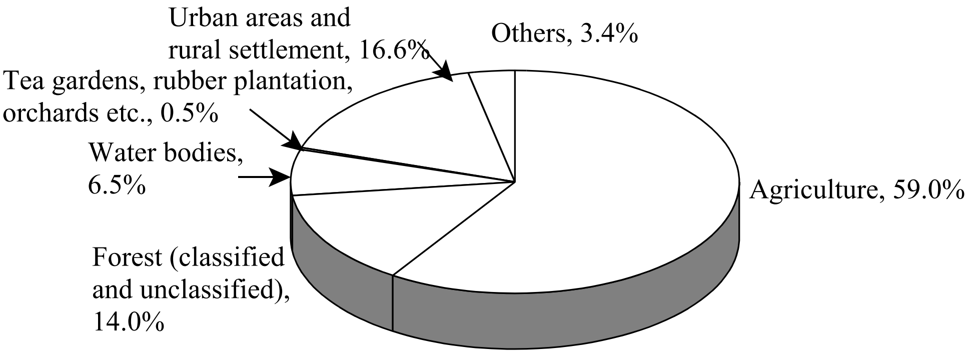

Figure 1. Major Classification and Land Uses in Bangladesh

Land Availability

The total land area of Bangladesh is about 14.4 million ha. Of this, about 59 percent is cultivable land, 14 percent is forest area, and 27 percent is not available for cultivation. The significant factor influencing agricultural activity in Bangladesh is its location in the basin of several major rivers. These rivers make the land highly fertile and cause continuous loss and gain of alluvial land through riverbank accretion and erosion. As a result, the total cultivable area varies, changing the baseline for calculating land availability and land use. The char lands (new lands) and adjoining bank lines account for about 6 percent of total land area in Bangladesh and support 4 percent of the total population. Land lost due to erosion leads to emergence of other char lands, but it takes several years for the land to become suitable for cultivation. The land available for cultivation has shrunk from about 66 percent in 1974 to 59 percent in 1995, mostly because of urban and residential encroachment. Table 2 shows land availability and utilization in Bangladesh from 1974 to 1996.

Table 2. Land Availability and Utilization in Bangladesh, 1974-96

	Land (000 acre)			Percent of Total Area		
	1974	1990	1996	1974	1990	1996
Net cropped area (A)	20,977	21,837	19,280	59	58	53
Current fallow+culturable waste (B)	2,221	1,372	2,281	6	4	6
Culturable land (A + B)	23,198	23,209	21,561	66	62	59
Forest	5,508	4,591	5,315	16	12	14
Not available for cultivation	6,576	9,721	9,788	19	26	27
Total land area	35,282	37,521	36,664	100	100	100

Source: Bangladesh Bureau of Statistic, 1998.
Note: Current fallow is the area already brought under cultivation but not cultivated during the year. Culturable waste is an area suitable for cultivation but lying fallow for more than one year.

The time trends in land availability over the 22 years (1974-96) show 'land not available for cultivation' increasing from 19 percent to 27 percent of total land area. Most of this land can be presumed to have shifted into urban use, with the increasing demands for residential, municipal, and industrial space. Such increasing pressure on land becomes more apparent when population growth is taken into consideration. The net cropped area has, during the same period, decreased in total land acreage by 6 percent from 59 percent to 53 percent, and forestland decreased by 2 percent from 16 percent to 14 percent. It shows that in terms of alternative land use, urbanization offers the greatest substantive threat to total land available for agricultural use. Table 3 reflects the decline in cultivable area and changes in the utilization of cultivable land from 1983-84 to 1997. During this period, an 11-percent decline in total cultivable area and, specifically, a 14-percent decline in cultivated area were observed. The fall in cultivable area can again be attributed to land transferred for urban use.

Table 3. Utilization of Cultivable Land in Bangladesh, 1983-84 to 1997
(Unit: 000 acres)

	1983-84	1997	Percent Change
Cultivated crop land	20,238	17,449	-13.78
Non-cultivated land:			
Homestead area	857	1,027	19.80
Ponds	741	862	16.33
Others	838	871	3.94
Sub-total	2,436	2,760	13.30
Total farm area	22,674	20,209	-10.87

Source: BBS.
Note:
1. Cultivated crop land includes land currently fallow and non-cultivated land includes land not available for cultivation.
2. Others include culturable waste, and area under bamboo and homestead trees, roads, pathways, non-dwelling structures etc.

Size Distribution of Farm Holdings

The average holding size in Bangladesh is declining over time due to a decline in land availability per capita and the tendency towards the splitting up of existing holdings. The trend features of farm sizes over the last two decades are shown in Table 4.

Table 4. Size Distribution of Farm Holdings, 1983-84 and 1996-97 Census

(Unit: Percent)

Size of Holdings (acre)	Holdings		Owned Area		Operated Area	
	1983-84	1996-97	1983-84	1996-97	1983-84	1996-97
Small farms (0.05-2.49)	75.4	83.1	18.2	26.2	14.8	23.3
Very small (0.05-0.5)	(34.4)	(43.9)	(5.0)	(6.9)	(2.7)	(4.4)
Medium farms (2.5-7.49)	19.9	14.3	56.2	56.3	59.3	59.4
Large farms (7.5 and above)	4.7	2.6	25.6	17.5	25.9	17.3

Source: Computation of data from 1983-84 and 1996-97 Census of Bangladesh.

There was a general decline reflected among small, medium, and large farms. The most recent size distribution from the 1996-97 census shows the small farm proportions increasing in number and in operated area – now accounting for 83 percent of farm holdings and 23 percent of the operated area, up from 75 percent of farm holdings and 15 percent of operated area in 1984. This has been matched by a decline in the number of medium-sized farms and a decline in both the area and number of large-sized farms. Small farms and plots pose obvious problems of scale including difficulty in applying machine-based techniques, loss of land for boundaries and management of scattered plots.

Land Tenure System

Considering the tenancy status of farmland, 58 percent of the land is operated by owners (i.e. those who do not rent any land), 40 percent by owner-tenants, and just 2 percent by pure tenants. About one-fifth of total operated area is under some kind of tenancy arrangements with sharecropping covering about one-half of such land. Although sharecropping is the dominant form of tenancy arrangement, accounting for about 12 percent of area in 1983-84 and 13 percent in 1997, other arrangements have become correspondingly more frequent over the same period. In the case of large farms, sharecropping area is lowest in importance and by 1997 other forms of tenancy accounted for nearly as much area as sharecropping. The two most recent censuses provide a useful picture of systems of tenancy in Bangladesh. The key information is summarized in Table 5.

As shown in Table 5, all size classes have seen pronounced growth in alternative arrangements. Especially noteworthy is the small but growing use of mortgages in certain areas as means of taking in land in which the lender cultivates the borrower's land until the loan is repaid.

Landlessness

The present per capita land availability in Bangladesh is under 20 decimals (approximately 500 m^2). If the present population growth trend continues, it will further come down to 12 decimals. Land scarcity and landlessness are integrally linked. According to the 1983-84 agricultural census, the most recent national level statistics on landlessness, 9 percent of households own no land what so ever, neither homestead or arable land. By adding those who own homesteads but no arable land, the proportion of landlessness rises to 28 percent. However, the common definition of landlessness also includes those considered functionally landless, that is those owning up to 50 decimals only. According to this definition, total landlessness stands at 56 percent.

Table 5. Percentages of Farms Under Various Contractual Arrangements, 1983-84 and 1997
(Unit: Percentage of total operated area)

	All		Small		Medium		Large	
	1983-84	1997	1983-84	1997	1983-84	1997	1983-84	1997
Sharecropping	12.4	13.4	15.3	15.4	13.9	13.6	6.7	7.5
Total others	4.9	8.2	7.1	10.1	4.1	7.3	3.2	6.1
Fixed rent	1.7	2.5	2.3	2.8	1.6	2.4	1.2	2.0
Lease	0.2	0.6	0.2	0.5	0.2	0.7	0.2	0.8
Mortgage	1.3	3.2	2.2	4.7	1.2	2.5	0.6	1.4
Khai Khalasi free of charge	0.7	1.2	0.8	1.2	0.6	1.1	0.6	1.3
Others	1.0	0.7	1.5	0.9	0.6	0.5	0.6	0.5

Source: Rabbani, BBS.

Table 6. Landlessness in Bangladesh

Land Ownership	Percent of Rural Households	
	1983-84	1995
0	9.5	-
0-0.05	19	22
0.06-50	28	28
Total landlessness	56.5	50

Source: Bangladesh Institute of Development Studies (BIDS), 1995.

Micro evidence from the 1990s appears to suggest that the increase in the rate of rural landlessness might have slowed down in recent times in part as a consequence of the escalation in the pace of rural-urban migration.

Land Management System

The Ministry of Land has the overall responsibility for the management of land, collection of land development taxes (LDT), maintenance of land records, formulation of policies on land management, land-use planning, and land reforms and their implementation. This Ministry is also responsible for state land distribution, undertaking and implementing the cluster village project for the landless, accreted land development, land-based poverty alleviation projects and other development programs related to land.

The Ministry of Land has three attached departments, namely the Land Appeal Board (LAB), the Land Reforms Board (LRB), and the Directorate of Land Records and Surveys (DLRS). The LRB is entrusted with the responsibility to supervise the functioning of the field offices and implementation of land management and reform measures. The LAB deals mainly with the ever-increasing volume of quasi-judicial appeals against the decisions of the Divisional Commissioners/Additional Commissioners on land matters. LAB also provides advice and recommendations to the government on laws, orders, and rules pertaining to land whenever asked. The functions of the DLRS are carrying out cadastral surveys, and the preparation and maintenance of the Record of Rights (ROR) for every parcel of land in the country. The Directorate has 12 zonal settlement offices and 209 *upazila* settlement offices. At the lowest level is the *upazila* survey and settlement office.

The land management functions at the field level are carried out through the Commissioner at the division level, the Deputy Commissioner at the district level, the *Upazila Nirbahi* Officer (Circle Revenue Officer) and the Assistant Commissioner (Land) at the *upazila* level (police station) and the *Tehsildar* (Commission Revenue Collector) at the union level.

Preparation of ROR

There are two stages in the preparation of a ROR. The first stage is to draw a revised *mouza* (county) map showing changes in location, area, and characteristics of land. The second stage is to prepare the *Khatian* indicating the ownership, the plot number, *Khatian* number, classification of land, area of land, crops grown, the name of the owner, and some other information on agricultural activities. These two parts are together called the ROR.

The present recording system reflects present and past land use and changes thereon in a very general way. So the change in land classification over a certain period of time can be ascertained from these records.

In Bangladesh there are about 40 million landholdings (to be represented in *Khatians* or land serial numbers) divided into almost 100 million fragments/plots. There are about 80 thousand maps to be maintained, mostly of a scale of 16 inches: one mile, showing the position of all plots and forming an integral part of the *Khatian*. After the abolition of the *Zamindari* (landlord) system in 1950, compensation assessment rolls were prepared hurriedly but the maps could not be updated at that time. So, programs of revisional settlement operations were undertaken commencing from 1965. Since then about 5.5 million *Khatians* have been finally published.

To address various problems faced in the present Land Management Systems, the government has taken up a technical assistance project “Modernization of Land Administration of Bangladesh” with the assistance of the Asian Development Bank. The project aims at carrying out studies and recommend measures for achieving the objectives for improving the efficiency of land administration; providing better security to landowners by issuance of accurate of ROR; bringing about an improvement survey, mapping, assessment and realization of the LDT; and introducing computerization of all data relating to land management.

Cropping Pattern

The cropping pattern in Bangladesh is dominated chiefly by rice, which accounts for three-quarters of the domestic cropped area. Wheat and jute accounts for most of the rest. During the period 1974-97, rice acreage increased by 3.3 percent; wheat, by 473 percent; and pulses, by more than 100 percent, while jute, sweet potato and tobacco registered decreases in acreage. Within the rice acreage, a considerable shift occurred, with a 49-percent decrease in *aus* (highland rice) acreage and a 165 percent increase in *boro* (short season paddy) acreage.

Another determinant of the cropping pattern is land elevation, which affects the annual extent and duration of flooding. Soil types and climatic factors are also important but are highly correlated with land elevation. On lands with normal shallow flooding, about 71 percent of the total cultivable land, farmers grow two to three crops. In the lowlands, land use and cropping intensity is lower.

Cropping Intensity

In 1996-97, the cropping intensity achieved was about 185 percent. Out of the net-cropped area of 7.60 million ha, about 55 percent are double-cropped and approximately 15 percent are triple-cropped. However, about 30 percent is still single-cropped. Since all the suitable land is already under cultivation, raising the intensity of land use is needed. It is expected that cropping intensity will reach 192 percent by the terminal year of the Fifth Plan. Cropping intensity charges from 1992-93 to 2001-2002 are shown in Table 7.

Table 7. Cropping Intensity of Bangladesh

(Unit: 000 ha)

Year	Net Cropped Area	Total Cropped Area	Percent of Cropping Intensity
1969-70	8,883	13,404	151
1979-80	8,506	13,014	153
1984-85	8,841	13,656	154
1989-95	8,421	14,183	168
1991	8,474	15,423	182
1992-93	7,640	13,700	179
1996-97	7,600	14,080	185
2001-02	7,500	14,410	192

Source: *Statistical Pocket Book of Bangladesh 1994* and National Plan Documents (1997-2002).

Cropping intensity increased by about 20 percent between the mid-1970s and the mid-1990s. While this is attributable principally to investment in irrigation, the influence of declining holding sizes and the resulting desire to increase cropping intensity is also important. Cropping intensity is constrained by flooding in the wet season and lack of irrigation in the dry season. Thus, flood management and proper irrigation is the key for accelerated agricultural growth.

CONTRIBUTIONS OF THE PRESENT LAND UTILIZATION SYSTEM TO DIFFERENT AGRICULTURE SECTORS

Achievements in Food Production

Despite various shortcomings in the land utilization system as discussed above, by increasing fertilizer use, investing in irrigation and adopting modern seed varieties, Bangladesh achieved a tremendous improvement in food grain production in the 1970s and 1980s. Subsequently, the acceleration of the growth rate was slowed down. Again, in the current fiscal year, Bangladesh has experienced an increase in the food grain production with a surplus of 0.9 million mt. Table 8 shows actual food grain production against consumption requirement up to 2000 and projected production against consumption requirement up to 2010 based on existing facilities and trends of production. If the present Land-use Policy under formulation can properly address the shortcomings in the existing land utilization systems and implement the solutions effectively, hopefully Bangladesh would able to sustain the surplus food grain production.

Table 8. Food Grain Production and Consumption Requirement

(Unit: Million mt)

Year	Population (million)	Food Grain Requirement[1]	Food Grain Production (Rice, Wheat)	Deficit of Supply
1985	100.2	16.59	15.83	-0.76 (4.58)
1990	108.9	18.03	18.74	0.71 (3.94)
1995	119.0	19.70	18.79	-0.91 (4.62)
2000	129.0	21.36	22.26	0.90 (4.21)
2010[2]	188.3	31.18	30.00	-1.18 (3.78)

Source: Computed from data available with BBS, Food Planning and Monitoring Unit, Ministry of Food and Ministry of Agriculture.

Note: [1] Food grain requirement calculated on the basis of consumption around 454 gm/person/day.
[2] Projection.
Figures in parentheses are percent.

Contribution to GDP from the Crop Sub-sector

The present land utilization system, as discussed in the foregoing paragraphs, contributed significantly in agriculture sector. This plays a key role in the growth and stability of the country's economy in the form of a higher contribution to GDP, providing employment, and as a source of export earnings. At present, agriculture accounts for about one-third of the GDP and employs about two-thirds of the country's labor force. Exports of agricultural primary products accounted for about 12 percent of total exports in 1997-98 and if exports of agriculture-based intermediate and industrial products are taken into account, its contribution comes to nearly 24 percent.

Contribution to GDP from Non-crop Sub-sector

The agriculture sector is composed of crop and non-crop sub-sectors. The non-crop sub-sector includes livestock, fisheries and forestry. The crop sub-sector represented a share of about 24 percent of total GDP and about 73 percent of agricultural GDP in 1997-98. The non-crop sub-sector, particularly the livestock and fisheries, have of late taken off largely through private sector initiatives, showing robust growth of 7.98 percent and 8.60 percent, respectively, in the same period.

Poverty Alleviation

Land utilization directed toward agricultural development served as the prime generator of income and employment in rural Bangladesh over the past two decades. There is no doubt that the modern high-yielding variety (HYV) seed-fertilizer-irrigation technology has made a significant impact on rural poverty alleviation. Modern agricultural technology for proper utilization of land has also helped generate employment in the rural areas of Bangladesh, particularly for the landless. The diffusion of technology in the agriculture sector has also helped change the nature and terms of the tenancy market, impacting income distribution, and poverty.

MAJOR CONSTRAINTS HINDERING THE CONTRIBUTION OF THE LAND UTILIZATION SYSTEM TO AGRICULTURE

The Declining Man-Land Ratio and Fragmentation of Land due to Population Growth

The growing population puts a lot of pressure on the available cultivable land that adversely affects productivity. The average holding size has been declining overtime as a result of declining per capita land availability. The tendency towards splitting up of existing holdings poses problems in applying modern techniques, increases loss of land to boundaries and forces management of scattered plots. This also magnifies rural poverty by increasing the number of marginal farms and landless people.

Use of Agricultural Land for Purposes Other than Cultivation

In Bangladesh agricultural land is used for alternative purposes other than cultivation. A study completed by the Planning Commission reveals that during the 1980s the amount of cultivable land which was used for housing and other purposes stood at 15 percent of the agricultural land and presently it stands at 30 percent. As discussed earlier the use of available land for urbanization, industrialization, roads, and other infrastructure developments have caused immense pressure on the available cultivable land.

Misuse of Land Acquisitioned for Development Projects

In most cases, while going for acquisition of land for development projects and other activities, the amount of land required for the purpose is not determined with austerity. Consequently, a large amount of alluvial land has become either out of bounds or useless for cultivation. The unplanned use and misuse of the acquisitioned land is also quite common. About 25 percent of land acquisitioned at various times for different development projects is now left either unused or is used for unproductive purposes.

Widespread Land Degradation

The 1996 National Environment Management Action Plan (NEMAP) estimated that soil degradation costs Bangladesh 1-2 percent of GDP each year. The recent evidence seems to suggest widespread land degradation resulting from both natural and man-made causes. A large proportion of agricultural land is said to be degraded by erosion, water-logging, desertification, and chemical retrogressions (for example, unbalanced fertilizer use, increase of salinity of water, and air pollution). Natural causes include droughts, land erosion, and the replacement of mainland by char land. Man-made soil degradation is mainly due to continuous rice monoculture, inadequate soil conservation measures, and unbalanced fertilizer use. About 250-300 kg of nutrients are depleted annually from each ha of soil due to intensive cropping without balanced replenishment.

Declining Soil Fertility

The results of long-term trials by the Bangladesh Rice Research Institute (BRRI) indicates that intensive rice cultivation can result in declining yields, even under good management and with full recommended doses of all nutrients being applied. Stagnant or declining yield in the context of rising inputs indicates that land degradation is reducing productivity. This evidence is consistent with patterns of yield change in other Green Revolution countries.

Lack of Knowledge

Among farmers, lack of basic knowledge of modern cultivation practices such as use of agricultural machinery, preparation of HYV seeds, timely and actual quantum of irrigation, proper use of pesticides and fertilizers etc. impedes the process of achieving higher productivity and efficient land management.

SOME SUGGESTED MEASURES REQUIRED FOR IMPROVING THE CONTRIBUTION OF A LAND UTILIZATION SYSTEM TO INCREASE AGRICULTURAL PRODUCTIVITY

Optimum Use of Land Resource

Available cultivable land, as far as possible, should be restricted to agricultural uses only. Land belonging to the absentee owners should be brought under proper utilization. Subdivision of holdings and plots should be restricted to a reasonable limit for mechanization of agricultural farming for higher productivity.

Use-based Zoning of Land

The local government institutions, like city corporations, *pourosobhas*, municipalities, and *upazilas* should be entrusted with the task of preparing maps with use-based zoning of land. Zoning regulations should be enforced effectively by the local government institutions. No changes should be made in the zoning maps unless approved by competent authority. However, in unavoidable circumstances, the authority may give permission for changes.

Planned Housing

Construction of multi-storied buildings should be encouraged both in rural and urban areas in view of the optimum utilization of land for the purpose of housing. Construction of model houses in rural areas should be encouraged.

Maintenance, Preservation, and Extension of Forest

Areas declared as forests by the Ministry of Environment and Forest should be turned into forests. Initiatives should be taken for proper maintenance, preservation, and extension of existing forest areas. Programs should be taken for effective green-belt afforestation in coastal areas. Intense population pressure is causing Bangladesh's forestry resources to dwindle quickly. Planned agro-forestry would let households manage land according to their particular needs for food, fuel, livestock and other resources.

Preservation of Water Bodies

Existing water bodies must be preserved and should not be filled up. The responsibility of preservation, maintenance, and re-excavation should lie on the individual owners in case of privately owned ponds/tanks. In the case of large water bodies like rivers, canals, lakes, haors, baors, etc. this responsibility should be on the government and the users. All these water bodies should be properly utilized for fish culture scientifically.

Multiple Use/Productive Use of Fallow Lands on Either Side of Roads/Embankments

As far as possible, flood protection embankments should be used as roads. Programs for planned plantations on both sides of flood protection embankments, roads, and railway lines should be taken up. Ditches excavated for construction of flood protection embankments, roads, and railway lines should be used for fish culture and poultry etc.

Austerity in Acquisition of Land

Fertile cultivable and homestead land should be avoided for construction of roads and highways and implementation of other development projects. Minimum requirement of land should be determined before an acquisition proposal for any development project is submitted.

Diversification of Agricultural Production

Faster agricultural growth in the future will depend on rapid growth of non-rice crops and non-crops including livestock, fisheries, and certain other sub-sectors such as fruits and vegetables etc. This will mean shifting resources from rice to other high return crops and non-crops for which have a comparative advantage.

Intensive Production of Existing Crops

In order to meet the increasing demand for existing crops, especially rice, with projected population and income growth, the following two things can be done:

1. Crop yields can be raised by developing better rice varieties, importing adaptable HYVs, improving extension efforts, using water more efficiently, and liberalizing exports which will ensure that domestic prices would not go below export parity levels.
2. Planting two or three crops a year can increase the cropping intensity. This means the land area committed to rice production will increase through multiple cropping.

Improvement of Non-crop Agriculture

The non-crop agriculture sectors like fishery, poultry and livestock have the potential to play an important role in agricultural growth and contribute significantly to a person's diet. Bangladesh should improve technological and marketing gaps that cause the country to remain behind some Asian neighbors in production and export of both marine and freshwater fishes. Bangladesh can expand shrimp production and exports if the government takes the following steps:

A. Make and enforce regulations on land and water use and quality control by applying modern technology.
B. Arrange for better dissemination of information inside and outside the industry.
C. Invest in strengthening necessary infrastructure with port facilities.

CONCLUSION

Even five years back, Bangladesh was considered one of the food-deficit countries in the world. The agricultural development programs, land reforms, efforts for better land management systems, and proper utilization of land along with a favorable weather have contributed to a steady increase in production in the agriculture sector during the last two to three years. If "the Land-use Policy", under formulation at the moment, can take proper care of the lapses/shortcomings in the existing land utilization systems, and if it can be implemented effectively, Bangladesh would hopefully be able to sustain the surplus food grain production and would earn a reasonable amount of foreign currency by exporting food grains in the near future after meeting internal requirements.

2. FIJI

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INTRODUCTION

Fiji lies in the heart of the Pacific Ocean, midway between the Equator and the South Pole, approximately 2,120 km from Auckland (New Zealand). Fiji enjoys a tropical South Sea maritime climate without great extremes of heat and cold.

The Fiji group contains 300 islands, of which about one-third are inhabited. Fiji's total land area is 18,333 km^2. There are two major islands – Viti Levu, which is 10,429 km^2, and Vanua Levu, which is 5,556 km^2.

Eighty-three percent of the land is owned by indigenous Fijians, while 9 percent is state land and 8 percent is freehold land. Only 16 percent of Fiji's landmass is suitable for agriculture and it is found mainly along the coastal plains, river deltas, and valleys.

Population

The population of Fiji on 25 August 1996 stood at 772,655. Of the total population, 51 percent were Fijians and 43.6 percent were Indians.

CURRENT LAND UTILIZATION SYSTEMS IN FIJI AND THEIR CONTRIBUTION TO AGRICULTURAL PRODUCTIVITY

Agriculture remains the largest sector of Fiji's economy, accounting to 43 percent of Fiji's foreign exchange earnings. It provides 50 percent of the country's total employment and contributes 19 percent of Fiji's GDP.

Fiji's total land area is 1.8 million ha, with only 16 percent suitable for farming. This land is found mainly along coastal plains, river deltas and valleys of the two main islands of Viti Levu and Vanua Levu.

The indigenous people own about 83 percent of the land in Fiji. Through the Landlord and Tenants Act (ALTA), the Indian farmers have had the privilege to farm on arable land through long-term leases.

Sugar

Sugarcane covers 24 percent of Fiji's arable land with 22,337 farmers and covering an area of 73,900 ha. Sugar dominates the agriculture sector by being the country's largest single export, accounting for 40 percent of total export in the last three years. The industry directly engages about a fifth of the total labor force.

An improvement in yields through effective use of fertilizers and cane quality, together with favorable weather and increased investment, collectively contributed to the annual rise in output of cane and sugar.

The 1997 forecast for sugar production stands at a low 460,000 mt from cane production of four million mt. Sugar manufactured for export in 1998 was sold and shipped to the following destinations:

Destination	Quantity (million ha)	
United Kingdom	186,770	(protocol)
	4,225	(special preferential sugar)
Portugal	14,155	(special preferential sugar)
France	15,900	(special preferential sugar)
Japan	17,000	
Rep. of Korea	15,000	
Total	253,050	

Source: *Annual Report 1999*, Fiji Sugar Corporation.

Foreign exchange earnings are around 70 percent of the total receipts from sugar exports, averaging around $250 million annually.

The sugar industry aims to increase mill output to 4.6 million mt, by improving farm productivity, by growing an additional 20 percent more cane, by lowering controllable farm and mill production costs by 20 percent, and by the extension of Fiji's sugar market (90,000 mt/year) to Malaysia.

Copra and Coconut Oil

Coconut remains a major crop in Fiji, covering 23 percent of arable land. Forty-thousand households rely on coconuts as a source of cash income. Coconuts are grown throughout Fiji and according to the 1991 agricultural census, Fiji has 65,000 ha of coconut trees with approximately six million trees. Annual production of coconut oil for export has declined steadily from 25,000 mt in 1960 to now just 9,000 mt. Copra production has also declined from 40,000 mt in 1950 to a low 8,000 mt in 1994, although it has subsequently recovered to 10,000 mt.

The Taveuni Coconut Centre has been able to provide selected hybrid seed nuts. These hybrid nuts have doubled the yield over the traditional variety. Under the current coconut rehabilitation program, the industry is targeted to produce 25,000 mt of copra by 2000 and coconut oil export earnings have increased from $4 million in 1996 to $8 million this year (2000).

Table 1. Whole Nut Export, 1999

	New Zealand	Australia	Canada
Green coconuts	3,985	46,402	556
Dry coconuts	82,304	52,573	3,401
Total	86,289	98,975	3,957

Source: Ministry of Agriculture, Fisheries and Forests (MAFF) Quarantine.

Table 2. Exported Copra, 1999

Bangladesh	England	Total
1,448,290	265,000	4,101,290

Ginger (*Zingiber officinale*)

Ginger has proven to be the most successful diversification crop in Fiji. It has emerged as a major growth industry and strong contributor to the national drive for increased export. Ginger has a high labor absorption capacity and contributes significantly to value-added output.

Table 3. Ginger Production, 1996-99

(Unit: mt)

	1996	1997	1998	1999
Mature	1,476	1,601	2,169.2	1,143
Immature	927.8	1,082	1,330.3	1,465
Total	2,403.8	2,683	3,499.5	2,608

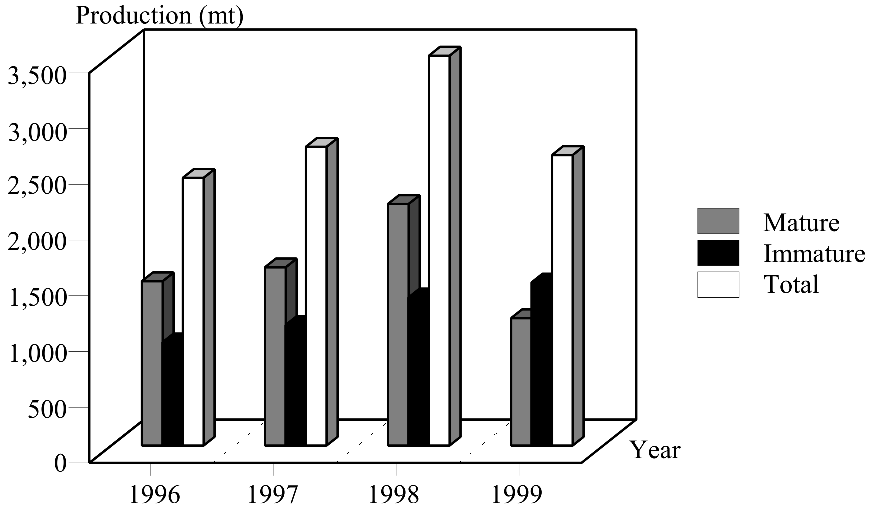

Figure 1. Ginger Production Trend, 1996-99

In recent times, ginger production has declined due to pests and diseases such as nematodes and bacterial wilt. Additionally the lack of good planting material is constraining the cultivation of the ginger crop.

Despite the slight reduction in production, fresh mature ginger exports increased from 760 mt to 1,000 mt in 1995. Total export value for 1995 was approximately $2,950,000. It is forecast that the yield will be doubled in year 2000.

Table 4. Fresh Ginger Export by Destination, 1992-99

(Unit: mt)

Destination	1992	1993	1994	1995	1996	1997	1998	1999
New Zealand	205	197	189	174	159	114	118	146
Canada	215	113	53	45	113	112	107	185
U.S.A.	1,727	658	533	601	517	546	425	277
Others		23	1		9			
Total	2,147	991	776	820	798	772	650	608

Dalo (*Colocasia esculenta*)

Dalo, or taro, is a commonly grown root crop for both domestic consumption and export. It is a staple food, high in carbohydrates, and a good source of calcium. The main crop is usually planted from September to November while the off-season crop is planted from March to June.

In the wet zone of Fiji, planting is possible throughout the year. The crop takes 12 months to mature. There has been a significant increase in dalo exported overseas over the years due to the increased demand by the Pacific Communities overseas.

According to the 1996 census, approximately 5,500 ha were under dalo in 'pure stand' while another 7,266 ha were mixed or inter-planted with other crops. The target for 2000 is to increase the value of dalo from $8 million to $15 million.

Table 5. Annual Dalo Production, 1994-99

Division	1994	1995	1996	1997	1998	1999
Central	4,530	3,716	9,067	9,864	11,707	11,629
Eastern	858	1,770	5,773	3,349	3,351	-
Northern	2,070	5,230	4,780	8,570	9,108	8,360
Western	1,352	2,257	2,994	1,567	1,459	200
Total	8,810	12,973	22,614	23,350	25,625	

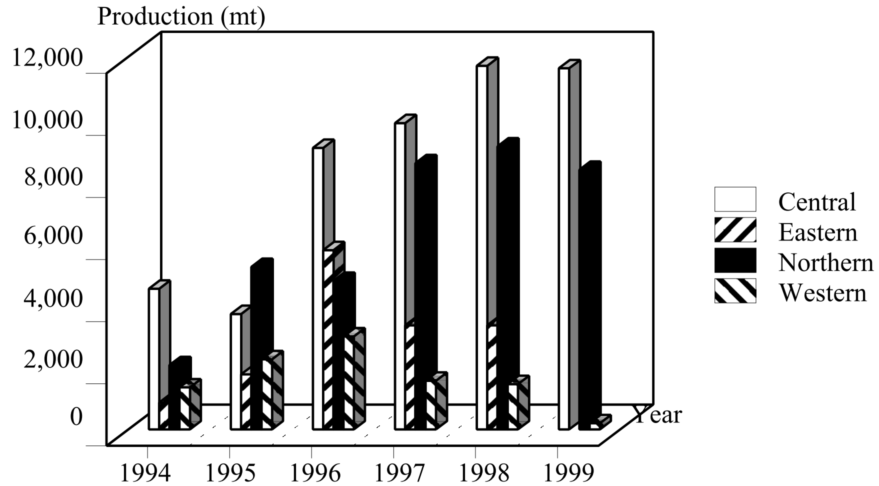

Figure 2. Annual Dalo Production, 1994-99

Table 6. Dalo Export and Destination

(Unit: mt)

	New Zealand	Australia	U.S.A.	Canada	Others	Total
1996	5,060	984.4	438	41.4	0.3	6,524.1
1997	4,506	1,147	415	18	1.4	6,087.4
1998	5,237.4	1,321.2	809	15.3	9.12	7,392.0
1999	5,657.3	1,411	975	15.4	-	8,058.7
Total	20,460.7	4,863.6	2,637	90.1	10.82	28,062.2

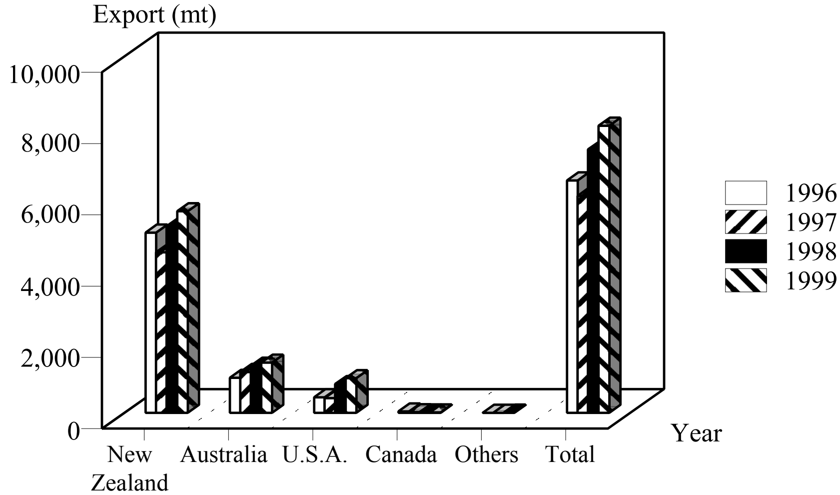

Figure 3. Dalo Export and Destination

Yaqona (*Piper methysticum*)

Yaqona is an important cash crop for the rural developers. It has an important place in the cultural and traditional life of the Fijian people. Fijians, and other nationalities, use it as a traditional drink. Consequently, there is a considerable local demand for the product.

Yaqona is grown as a cash crop at a semi-subsistence level and takes 4-5 years to harvest. It can be grown on a wide range of soils and often intercropped with dalo, cassava, vegetables, and coconuts.

According to 1996 Census, 3,745 ha was planted to Yaqona ‘pure stand’ and another 6,912 ha was mixed or inter-planted with other crops.

Table 7. Yaqona - Annual Production, 1995-99

(Unit: mt)

Division	1995	1996	1997	1998	1999
Central	190	1,062	705	950.6	498.5
Eastern	1,546	944	825	681.3	404.1
Northern	832	1,220	1,678	1,538.3	2,264
Western	51	59	102	33.4	49.9
Total	2,619	3,285	3,310	3,203.6	3,216.5

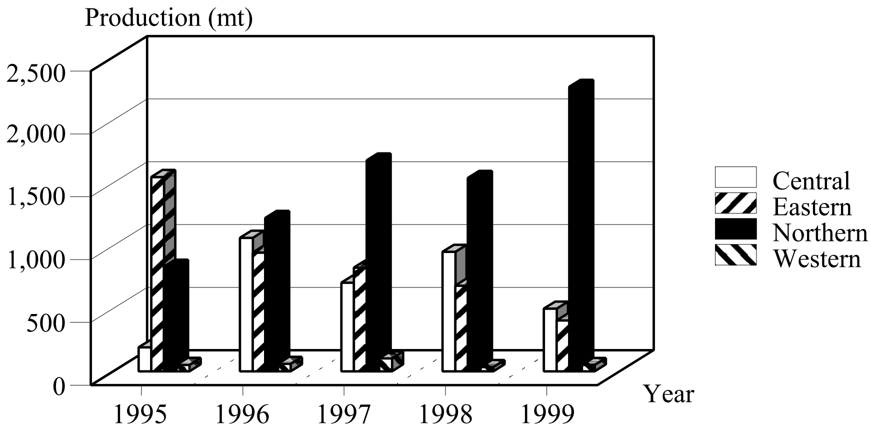

Figure 4. Annual Yaqona Production, 1995-99

FORESTRY

The development of Forestry Agency is committed to the development of forestry resource management strategies and the enforcement of sustainable forestry practices aimed at maximizing the contribution of the sector to the country's economy, thereby improving the standard of living of all people throughout Fiji.

Forestry Department, Corporate Plan 1997-99

The forestry sector contributes 2.5 percent of GDP, making forest products now the fifth most important export commodity. The sector is expected to earn around $100 million in foreign exchange by 2000 and employs over 4,000 rural workers.

Fiji's forest cover is approximately 897,298 ha, in relation to a total land mass of 1.8 million ha and almost all forests are on communally owned native land with 27,570 ha on private freehold and 10,270 ha on government land.

Table 8. Forest Cover Area in relation to Total Land Mass

Total land area	1,827,200 ha
Total forest cover	897,298 ha
Here of:	
Natural forest area	802,900 ha
Softwood plantations	43,686 ha
Hardwood plantations	50,712 ha

Almost five decades ago, substantial investments in industrial plantations nationwide have been sustaining Fiji's forest development. The country has been self-sufficient with the surplus being exported.

The pine plantations, including pine schemes, have an estimated area of 43,700 ha and contributed significantly to export under the Fiji Pine Limited with earnings accounting for over 50 percent of the total export. These plantations have been supporting our local timber consumption with the surplus exported as wood chips.

Under the Fiji Hardwood Corporation Limited (FHCL), the maturing of hardwood plantations will provide high value decorative timber which will generate substantial foreign exchange earnings.

It is estimated that over 180,000 cm^3 of native timbers are harvested from Fiji's forests annually from some 4,000-5,000 ha, providing the country with a major sustainable source of exports.

Table 9. Management Practices in the Different Forest Types

Multiple use natural forest	514,680 ha
Protection forest	233,220 ha
Reserved forest	55,000 ha
Total	802,900 ha

Source: Forest Facts and Figures Fiji, 1998.

Maintenance and Planting

The two main organizations responsible for industrial forest plantations in Fiji are:

1. Forestry Department for Hardwood – mainly mahogany.
2. Fiji Pine Limited for Softwood – mainly pine.

Table 10. Mahogany Plantations

Year of Planting	Total Planted (ha)
1991	2,321
1992	4,424
1993	676
1994	2,514
1995	2,853
1996	1,788
1997	979

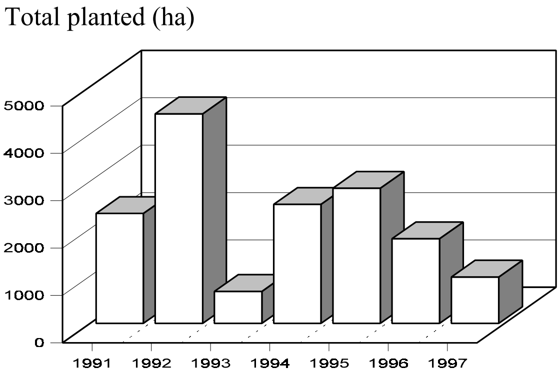

Figure 5. Mahogany Plantations

Table 11. Fiji Pine Planted

(Unit: ha)

Year of Planting	Total Planted	Total Planted Estate
1991	2,685	35,632
1992	2,929	37,566
1993	1,978	37,291
1994	3,603	35,819
1995	3,307	42,583
1996	3,126	43,686
1997	2,368	43,201

LAND-USE CAPABILITY CLASSIFICATION

Land-use capability (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 LUC is used in the sense of suitability for productive use. The Land-use Section, MAFF assesses LUC based on its LUC Land Inventory System. This was developed in 1997, and is based on the USDA LUC and has been adapted to the Fiji environment. Soil is an essential element in determining land capability as most forms of land utilization ultimately depend on soil as the medium for plant growth.

The capacity of soil 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 the type of land use. The degree of the limitation is assessed and the following factors are evaluated:

– Susceptibility to erosion;
– Steepness of slope;
– Susceptibility to flooding;
– Liability to wetness or drought;
– Salinity;
– Depth of soil;
– Soil characteristics (texture, structure, fertility, etc.); and
– Climate.

As a basis for 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 classification is conducted. It groups the land inventory units into one of the eight LUC classes. A description of the eight Fiji LUC classes is given in Table 12.

Table 12. Fiji Land Capability Classes

Class I	***Versatile multiple-use land***: It is flat (0-3); has deep, easily worked, fertile soils; no erosion risk; well drained but not seriously affected by drought, and the climate is favorable for the growth of a wide range of crops. No special soil conservation measures required.
Class II	***Good arable land*** with slight limitations that make it more difficult to manage than Class I. The land may be flat to gently undulating (0-7), well-drained to moderately drained, deep to slightly shallow, and fertile to moderately fertile soils. Simple management and conservation practices to overcome soil limitations are easy to apply.
Class III	***Fair arable land*** with moderate limitations that restrict the choice of plants and/or require intensive soil conservation measures. The land may be flat or gently sloping (0-11); slightly unstable; of moderate to severe wetness; subject to frequent damaging floods; and have shallow moderately stony and/or infertile soils.

... To be continued

Continuation

Class IV	***Marginal arable land*** with severe limitations that restrict the choice of crops grown, or require intensive soil conservation measures and very careful management. Limitations may affect land use in both of these ways. Class IV may be flat to rolling (0-15) and may comprise one or more of the following – poor to very poorly drained; stony or bouldery soils; very shallow soils; infertility; coarse textured soils with very low moisture retention capacity; or mangrove or peat's that can be drained and reclaimed for cropping.
Class V	Land is unsuitable for arable cropping but suitable for pastoral or forestry use. Steepness (slopes 16-20) or stoniness are the main limitations. Only slight erosion risk under pasture or forest trees.
Class VI	***Marginal pastoral land*** with moderate to severe limitations. Land is too steep (21-25) for pastoral use; or has a high susceptibility to erosion, or there is evidence of severe past erosion. Soil limitations include shallowness, low moisture retention, and low fertility. Production or commercial forestry is the preferred land use.
Class VII	Unsuitable land for pastoral use and marginal for commercial forestry land is either very steep (26-35); highly susceptible to erosion; there is evidence of severe past or present erosion; or soils are either very shallow, very boulder, or with very low fertility.
Class VIII	Land is generally unsuitable for productive use in both agriculture and forestry. This is primarily very steep mountain land, mostly above an altitude of 800 m. It also includes lowland areas in unfavorable situations, such as extreme erosion or high susceptibility to erosion (particularly mass movement), or extreme stoniness, shallowness or infertility. Class VIII land is best protected and/or reserved for watershed and environmental purposes.

There are dangers in adopting an unchanged/modifying system like the US LUC that was developed for a temperate zone farming system (viz., extensive mechanized arable production of cereals) to, for example, the Fijian humid tropical system in which subsistence agriculture involves complex multiple-cropping, as an important component. The results can be irrelevant to the type of agricultural development taking place in the country, that is adopting or modifying the system.

Over the last 20 years, FAO has endeavored to find a solution to this problem by developing a framework for land evaluation whose principles, if followed, produce outcomes that are appropriate in all farming systems and all soil environments. The underlying philosophy is matching land utilization types with soil and climate characteristics to determine soil suitability classes on a specific crop basis.

To reflect limitations or hazards, sub-classes can be recognized for some of the above major LUC classes. The four general kinds of limitations recognized are erodibility (E), wetness (W), soil limitation within rooting zone (S), and climate (C).

Limitation classification and standard for LUC classes factors, both physical and environmental, which affect or limit the land-use capability or productivity of the land, are classified into groups in a manner that suits the capability classification best. For example, slope is classified (according to its steepness) into eight groups, one for each capability class, from group A for major class I to group G for major class VIII.

Table 13. Slope

Group Symbol	Slope Range	Description	LUC Class
A	0-3	Flat to undulating	I
B	4-7	Undulating	II
C	8-11	Gently rolling	III
D	12-15	Rolling	IV
E	16-20	Moderately steep	V
F	21-25	Steep	VI
G	26-35	Very steep	VII
H	35	Extremely steep	VIII

Use of Modern Technology

Some of the modern technologies being introduced to the MAFF, and also other departments of the government, that relate to land utilization are:

1. ***Land Use Section (Agriculture Department)***

The introduction of a Geographic Information System (GIS) in 1996: Through PLANTGRO program, suitability ratings of crops are used to determine the land capability classification. This information is available to farmers, land-use planners, and managers at their request. This new technology has proven to be very efficient when compared to aerial photograph interpretation and mapping.

2. ***Department of Forestry***

Forest monitoring and forest land management are major applications of remote sensing GIS activities in the Forestry Department. Hazard mapping, water catchment monitoring, and disaster assessment uses this forest monitoring data and mapping as major input.

At 1:50,000 scale, a Forest Monitoring System has been established containing three main components:

– *Digital image analysis system (ERDAS VGA, ERDAS PC, ERDAS Imagine)*: A digital layer of the up-to-date forest cover divided into dense, medium, and scattered forest; hardwood, pine plantation, and mangrove are available for the area of Fiji. A full coverage with Landsat TM data from 1991/1992 is available on optical disks. Additional SPOT scenes recorded in1994 are available on CD-ROM.
– Relational data bank holding information from over 500 sample plots distributed randomly over Fiji's natural forests. Detailed information is stored about woody biomass, species, regeneration potential, minor forest products such as medicine plants etc.
– *Forestry GIS (ERDAS, ARC-INFO)*: The system was developed in Germany and holds spatial information such as a digital terrain model (DTM), the soil map of Fiji, slope map, seasonal and mean annual rainfall, declared reserved areas, e.g. water catchments, areas of high biodiversity. GIS is being used to analyze and map forest function areas. A further data bank is available for hardwood plantations.

At 1:10,000 scale, an analytical photogrammetric instrument is available (Visopret, ZEISS) to map contour information and rivers etc. to provide maps for the planning of logging areas. The map production and map editing is carried out by a different GIS software (MicroStation, INTERGRAPH).

For detailed mapping of logging areas, a GPS, main station, and 'hand-held' receiver are available (Trimble Navigation). These projects have been established by Australian aid. In addition, a European Commission funded a Plantation Survey Project (spatial database) established to map the outline of plantation areas using Global Positioning System (GPS) technology.

Further, the Japanese Government provided 'hand-held' GPS receivers and digitizing facilities for mapping and updating logged-over areas in natural forest cover. All project areas are linked by network and users can access data remotely with a modem and hopefully by 'e-mail' in the near future. A wide range of output and input formats as well as other devices such as streamers, optical disk drives, and tape drives are available for use.

3. ***Mineral Resources Department (MRD)***

Satellite remote sensing was introduced first in 1998 with a pilot study on the coastal area of Ba Delta in cooperation with SOPAC. Processing was done jointly in SOPAC using Microbrian and partly with Station Polynesienne de Teledection (SPT) in Tahiti.

Satellite imagery and a DTM was used in the South East Viti Levu Hazard Landslide Mapping Project conducted cooperatively with the British Geological Survey (BGS). This project is designed to end in mid-1995 with the implementation of the system in MRD with necessary training.

MRD is also the process of storing and distributing, in digital form, geophysical data concerning mining exploration and other types of data such as SLAR (Side Looking Aperture Radar) data. To process this exploration data, MRD is now equipped with a Mine Resources Assessment Package (GDM) which will be closely linked with MRD GIS.

Projects (e.g. Suva Peninsular Coastal Mapping Project) targeted on specific areas at larger scales (1:50,000 and larger) have already been set up in addition to the continuation of the more general database developments despite a limitation in human resources. MRD supports MapGrafix GIS software in connection with the FoxPro database to digitize and capture data on earthquake epicenters, oil exploration, seismic surveys, marine geophysical and bathymetric data in Fiji Exclusive Economic Zone (EEZ), geological drill hole and geochemical analysis data (water sample rocks).

Once the Digital Topographical Database (DTDB) is developed by FLIS, MRD would be looking at the possibility of using the DTDB and subsequent digital topographical maps as a base for the production of digital geological mapping series.

4. ***Department of Meteorology***

The Meteorological Department is charged with providing meteorological services to the nation and with continuing its function as a regional weather forecast center for the surrounding nations in the Pacific.

5. ***Native Land Trust Board (NLTB)***

The NLTB introduced its Land Information System (LIS) in January 1988. It was given the task to capture digitally all land-related data on customary ownerships of native land, the various developments and resources pertaining therein.

With limited manpower, the NLTB LIS project team had managed to complete this major exercise in April 1994 and further went on to organize the database to facilitate data extractions on any required scale and locality. This was completed in December 1994.

The NLTB information system will shortly embark on a major restructure and redevelopment program. One of the main areas of focus is the availability and accessibility of data derived from remote sensing/GIS technologies to assist the management in the decision-making process and to provide better control of the administration, development, and use of the natural resources on Fijian-owned land for the benefit of the NLTB stakeholders, the tenants, and business partners.

6. ***Department of Environment***

The Department of Environment is a new specialized entity within the Ministry of Housing, Urban Development and Environment and is responsible for enormous tasks. Cooperation and support from all concerned agencies is necessary in order to maintain and develop a total approach to its heavy duties.

The development of remote sensing applications and a GIS/Environmental Information System has been identified as a priority project for the Department. An environmental database would be developed, linking it to other operational systems with forestry, FLIS, SOPAC, mineral resources, the Bureau of Statistics, and the regional pacific countries.

Constraints of Land Utilization in Fiji

Fiji does not have a rural land-use policy or a national land-use plan. This is a major constraint for wise resource allocation and management in the rural sector. The current administrative and institutional framework responsible for resource allocation and management is highly sectoralized. Attempts at coordination have proved to be ineffective. These factors have constrained the development process, increased inter-ministerial friction, and, in many cases, promoted unsustainable resource use.

There have been many discussions and a number of papers written since 1960 about the need for a national land-use plan policy. Several attempts have been made to establish a national body that could effectively deal with coordination and proper use of land resources in Fiji from 1970 and early 1980s involving government and NGOs. The committees were as follows:

1976	National Land Development Committee.
1978	National Land Conservation Board, need for a coordinate national land-use plan.
1982	Western Division Land Use Coordination Committee.
1984	Fiji Institute of Agricultural Science discussed the need of national land-use plan and policy.
1985	Revival of National Land Use Coordination Committee.
1988	An agro-forestry working group was formed to coordinate and steer all agro-forestry activities in Fiji.
1993	The National Environment Strategy (NES) of Fiji (Watling and Chape, 1983). Cabinet approved in 1995 the concept for a comprehensive and integrated new Sustainable Development Bill which would revise and consolidate existing environmental and resource management legislation and create new legal frameworks, among others, for integrated resource management.
1994	Many individuals (Seru, Nagatalevu, Inoke and Swarup) pointed out that not having a national land-use planning process, plan and policy is a stumbling block to attaining a process for the wise allocation and sustainable development of Fiji land resources.

1995 David Howlett, Pacififcland Network Regional Coordinator and Inoke Ratukalou of the Land-use Planning Unit of the MAFF prepared a proposal that was endorsed by MAFF Department of Environment, NLTB, Lands Department and Forestry Department. This paper sought FAO assistance to support Fiji in developing a land-use planning process that eventually will lead to the formulation of a national land-use plan and policy.

1996 Evelyn Reigber, Team Leader for the Pacific Regional Forestry Project, coordinated an effort comprised of Extension Officers, Researchers and Farmers. The group discussed and prepared a two-part draft Agroforestry Policy Paper for Fiji. After further discussion and review of the draft policy, the group realized there was a vital need for a land-use plan and policy as an umbrella to ensure adoption of the agro-forestry policy.

1998 In 1998, Joeli Vakabua, the Director of Research MAFF, Evelyn Reigber and Inoke Ratukalou discussed the need to have a national land-use plan and policy. However, they saw it important to review current rural land-use practice, previous studies, legislation, issues and constraints in advance of developing policy. David Leslie from Landcare Research of New Zealand Limited was contacted in November to undertake the study and develop a rural land-use policy for Fiji.

2000 A draft of the Inoke Ratukalou and David Leslie Report has been released for comments before the final Land-use Policy Paper of Fiji will be submitted for Cabinet approval entitled "*A Land-Use Policy for Fiji: Opportunities for the New Millennium*".

Measures to Improve Land Utilization Systems in Fiji

The first and foremost priority of the country is to have a Natural Land-use Plan or Rural Land-use Policy as a guideline for sustainable development. This will also create an atmosphere of coordination among administrative and institutional entities in the framework responsible for resource allocation and management.

Demands on land resources are increasing. If the ongoing expansion of commercial cropping on fragile soils without land conservation practices is not in place, deforestation and burning of grasslands will continue, then Fiji will experience further land degradation, lower yields, and an increase in poverty. It is not too late to reverse the current trends but it will require a farsighted government with determination to implement land-use policies for sustainable development, supported by technical teams providing sound information and operating integratively with commitment accorded to farmers and others such as rural stakeholders having an ownership in sustainable land management.

Fiji needs to emphasize policy in addressing soil and land management at the MAFF and ALTA to quote from the Ministry's Policies and Strategies Section (Government of Fiji, 1993):

> To enforce soil conservation and social and sound land-use practices for the long-term sustainability of agricultural development … MAFF is responsible for and committed to sustainable development of land and marine resources through applied research, training and dissemination of information with an aim to increase production of food, wood and fisheries products to satisfy both domestic and export requirements of the country in ways most friendly to the environment for the ultimate purpose of improving the quality of life of the people.

Improvements Required for Fiji's Land Utilization Systems

1. ***Proper Land-use Planning***

Significant housing, airports, and industries, etc. have been developed on good arable land, as is evidenced by non-agricultural growth in major towns around the country. Arable land is only of limited extent and its allocation to other uses, other than agriculture must be monitored and preferably controlled through zoning and a national land-use plan.

2. ***Land Tenure***

The present land tenure system (85 percent native land) often inhibits sustainable rural development.

3. ***Training and Creating Farmers Awareness***

Over dependence on the sugar industry encourages farmers to cultivate steep slopes without proper soil conservation measures and this could be overcome by farmers education and awareness program on the effect of soil erosion and the development of soil conservation methods that are farmer oriented. Another option is to encourage crop diversification. Uncontrolled burning which results in high percentage of bare ground and exposure to rainfall impact also affects indigenous forests and pine plantation.

4. ***Lack of Physical Infrastructure***

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

5. ***Weak Institutional Infrastructure***

– There is serious under-resourcing by government for line ministries having responsibility for agriculture, forestry, and land use, in general.
– The public sector commonly lacks effective funding, resources, and technical staff to undertake environmental planning, management, and enforcement.
– Fiji Sugar Cooperation have no staff designated as soil conservation officers and the institutional memory about land husbandry practices is poor due to the current age structure.
– The NLTB receives poor technical support from Land Use Section of the MAFF, in the way of expertise about soils and land capability, and field inspections relating to the land husbandry clauses in NLTB leases. This is a resource issue not an unwillingness to cooperate.
– The Land Conservation Board is not acting on the powers vested in it and while the Board has ownership of the problem 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.
– Expertise in the area of agricultural extension, soil conservation, land-use planning, management and enforcement is needed in responsible line ministries.
– Reluctance by the NLTB to exercise its legal rights with respect to bad land husbandry practices.
– The resources devoted to soil conservation are inadequate for the implementation of significant measures, either in terms of providing information or incentives.
– The Land Use Section, MAFF, 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.

6. ***Inappropriate Land-use in Watersheds***

Erosion resulting from inappropriate land-use and land management practices in watersheds has lead to progressive siltation of rivers resulting in deterioration of drainage on flood plains, frequent inundation, and the formation of shallow bars across river mouths. Dredging of rivers has become a most 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 and crops.

There are inadequate controls of the disposal of all types of waste onto the land into waterways. This is resulting in serious pollution problems throughout the country. It is not a problem confined to the urban area.

7. ***Inappropriate Lowlands Land-use Change***

Large-scale reclamation of mangroves for rice production, in particular, has proven to be economically unviable with significant net financial losses. This national loss is in addition to the loss of benefits from the mangrove removal for subsistence villages.

8. ***Inadequate Knowledge***

There is a very poor public understanding in the rural sector about the various legislation that pertains to land, land-use practices and soil conservation.

9. ***Target Holistic/Participating Rural Approach***

The question is, who is targeted for soil and land management? Is it the commodity that is the issue, or is it the farmer? Many agricultural projects have failed because the needs of the farmers were not considered. As a result, farmers have often failed to adopt recommended technologies. There has to be integration of biophysical and socio-economic factors to ensure success. The two important questions are: was the farmer involved from the beginning?; and did the farmer contribute towards finding solutions to unsustainable use of soil and land?

IMPROVEMENTS NEEDED FOR FIJI'S LAND UTILIZATION SYSTEMS

By Governments

- Develop a policy for wise land use according to land suitability for different types of utilization and the needs of the country.
- Incorporate principles of rational land use, management, and conservation of soil resources into appropriate resource legislation.
- Develop an institutional framework for monitoring and supervising soil management and soil conservation, and for coordination between organizations involved in the use of the country's land resources in order to ensure the most rational choice among possible alternatives.
- Assess both new lands and lands already being used for their suitability for different uses and the likely hazards of degradation. Provide decision-makers with alternative land uses which both satisfy communities aspiration and use of the land according to its capabilities.
- Implement education, training, and extension programs at all levels in soil management and conservation.
- Disseminate, as widely as possible, information and knowledge about soil erosion and methods of controlling it both at the farm level and at the scale of entire watersheds, stressing the importance of soil resources for the benefit of people and development.
- Establish links between local government administrations and land users for the implementation of the soils policy. Emphasize the need to put proven soil conservation techniques into practice, and to integrate appropriate measures in forestry and agriculture for the protection of the environment.

- Strive to create socio-economic and institutional conditions favorable to rational land resource management and conservation. These conditions will include providing security of land tenure and adequate financial incentives (e.g., subsidies, taxation relief, credit) to the land user. Give encouragement, particularly to groups willing to work in cooperation with each other and with their government, to achieve appropriate land use, soil conservation, and improvement.
- Conduct research programs which will provide sound scientific backing to practical soil improvements and soil conservation work in the field, and which give due consideration to prevailing socio-economic conditions.

By International Organizations

- Continue and intensify efforts to create awareness and encourage cooperation among all sectors of the international community by assisting where required to mount publicity campaigns, conduct seminars and conferences, and to provide suitable technical publications.
- Assist governments, especially of developing countries, on request, to establish appropriate legislation, institutions, and procedures to enable them to mount, implement, and monitor appropriate land-use and soil conservation programs.
- Promote cooperation between governments in adopting sound land-use practices, particularly in the large international watersheds.
- Pay particular attention to the needs of agricultural development projects which include the conservation and improvement of soil resources, the provision of inputs and incentives at the level of the farm and of the watershed, and the establishment of the necessary institutional structures as major components.
- Support research programs relevant to soil conservation, not only of a technical nature, but also research into social and economic issues that are linked to the whole question of soil conservation and land resource management.
- Ensure the storage, compilation and dissemination of experience and information related to conservation programs and of the results obtained in different agro-ecological regions of the world.

3. INDIA

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INTRODUCTION

The population in Asia has grown rapidly in the last two decades and the consequent need to increase food production led to over exploitation and improper utilization of vegetated land, resulting in its degradation. The soil degradation as percent of vegetated land in Asia is around 12 percent while it is around 1 percent and 4 percent in Oceania and North America, respectively (Figure 1).

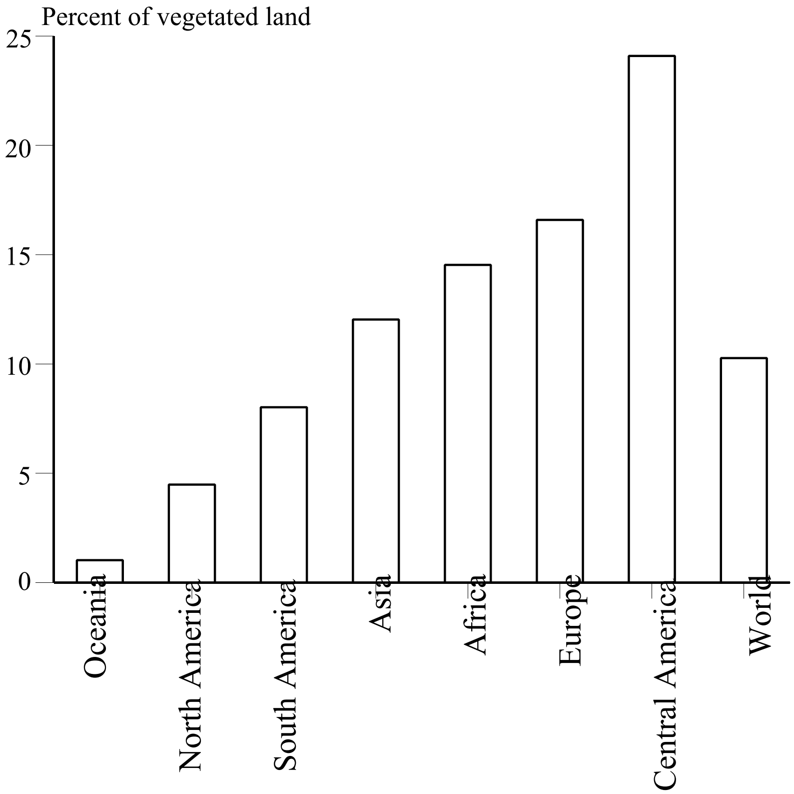

Figure 1. Soil Degradation as Percent of Vegetated Land 1945-90

The land degradation in Asia (Figure 2) is mainly due to uncontrolled deforestation followed by agricultural activities (Petry, 1995). Hence, planning for productive land use is necessary to meet the growing challenges of food security since the land resource is not expandable physically.

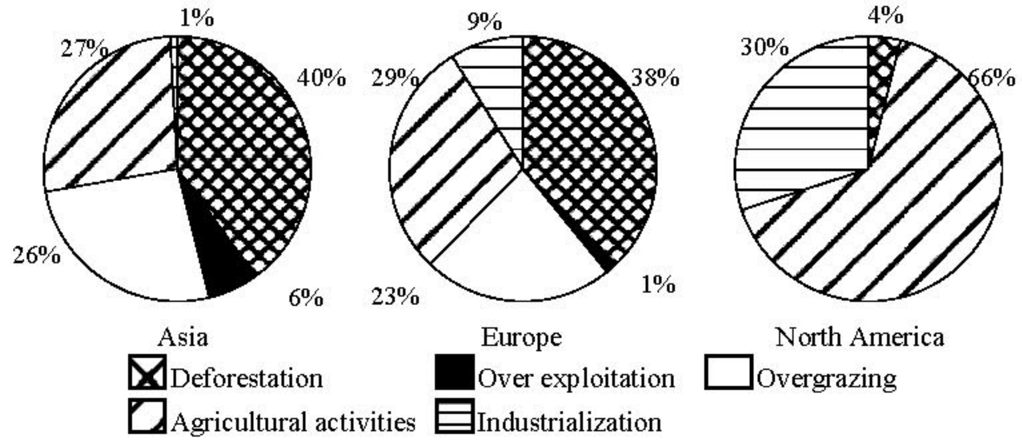

Figure 2. Causes of Soil Degradation in Asia

Country Background

India is one of the oldest civilizations and has a rich cultural heritage. It has achieved multifaceted socio-economic progress in the last 53 years of its independence besides being multilinguistic in nature, with different religions, castes and creed. India is the biggest democratic country in the world. It stretches from the Himalayas in the north to Cape Comorin in the south covering an area of 328.73 million ha. The mean annual rainfall ranges from 4 inches in the N.W. desert to 400 inches in parts of Assam. The snowy mountain peaks of the Himalayas and the graceful coconut palms growing along the coast of Kerala are the characteristics of the diversity of Indian landforms. India is one of the major mega-diversity countries and is the seventh largest in the world. The geographical matrix of India, based on reported area for land utilization statistics, of 305 million ha is broadly grouped into three sectors: (a) ecological sector (33.7 percent); (b) agriculture sector (59.2 percent); and (c) non-agriculture sector (7.1 percent) (Table 1). India is predominantly agrarian in nature with about 66 percent of its population depending on agriculture.

Agricultural Situation

The Bengal famine of 1942-43 provided the backdrop of our independence. This led Jawaharlal Nehru to pronounce that "**everything else can wait, but not agriculture**". From 1950-51 onward, when the First Five-Year Plan was developed, policies for land reform, such as ceilings on landholdings and security of tenure, were introduced and the agriculture sector received greater attention. The Green Revolution in the mid-1960s led to quantum jump in food grain production from 51 million mt in 1950-51 to a record figure of 203 million mt in 1998-99. This impressive achievement has pulled the country out of the 'ship to mouth stage' food trap in the early 1950s to a 'farm to ship' reality. With the adoption of intensive agriculture, the natural resources are, however, put under intense strain, resulting in fast degradation and lowering the production efficiency. The mounting demographic pressure, in addition to increasing industrialization and urbanization, is putting tremendous strain on the shrinking resources.

Table 1. The Geographical Matrix of India

Resources	Area (million ha)	
I. Geographical area	328.73	
II Reporting area for land utilization statistics	304.88	
a. Ecological sector:		
1. Forests	68.75	(22.5)
2. Barren and uncultivable land	19.09	(6.3)
3. Other uncultivated land including pastures, tree crops and groves	14.61	(4.8)
b. Agriculture sector		
1. Net area cultivated	142.82	(46.8)
2. Fallow land	23.22	(7.6)
3. Cultivable waste land	13.94	(4.6)
c. Non-agriculture sector		
1. Area under non-agricultural use	22.45	(7.3)

Source: Government of India, *Agricultural Statistics at A Glance – 2000*.
Note: Figures in parentheses are percent.

Cultivated Area and Food Grain Production

The present population of 995 million, which accounts for about 18 percent of the world's population supported only on 2.4 percent of the land area, is estimated to become 1.4 billion by 2025. The per capita availability of land decreased from 0.5 ha in 1950-51 to 0.15 ha in 1999-2000 owing to population escalation. The net area sown has increased from 118.75 million ha in 1950-51 to 143.0 million ha in 1998-99. There is good scope for an increase in gross area sown with improvement in the irrigation potential. The per capita availability of food grains marginally increased from 144.1 kg/year to 164.5 kg/year despite the population explosion (Table 2). This was possible due to increase in gross cultivated area, high-yielding varieties and improved production technologies. The irrigated ecosystem, while sharing 36 percent of net sown area, contributed 44 percent of total food grain production (Table 3). Fish production has gone from 750,000 mt in 1950-51 to 5,260,000 mt in 1998-99. The fertilizer consumption has gone up from 0.07 million mt in 1950-51 to 16.8 million mt in 1998-99. Yet, the per hectare consumption of fertilizers (N, P, and K) of India was low (95 kg in 1997-98) when compared to Republic of Korea (4,712 kg), Japan (352 kg), China (262 kg), Bangladesh (130 kg), Pakistan (123 kg), and Sri Lanka (112 kg) (Fertilizer Statistics 1998-99).

Landholdings

There are 93.5 million rural operational holdings in the country. The percentage of landholdings in the marginal groups increased while semi medium to large size group holdings decreased (Table 4) indicating more fragmentation due to mounting demographic pressure.

The growing population and the inability of the non-agriculture sector to absorb additional work force have led to unabated sub-division of operational holdings. As a result, the number of operational holdings has grown by 80 percent within a span of three decades and average area per holding has nearly halved from 2.63 ha in 1960-61 to 1.34 ha in 1991-92 (Table 4).

Table 2. Cultivated Area, Production of Food Grains and Other Commodities

Item	1950-51	1990-91	1998-99	2001-02*
Population (million)	326.00	846	995	-
Per capita availability of land (ha)	0.50	-	0.15	-
Food grain production (million mt)	50.82	176.39	203.04	234.00
Per capita availability of food grain (kg/year)	144.10	186.02	164.50	-
Net area sown (million ha)	118.75	143.00	143.00	142.00
Gross area sown (million ha)	131.90	185.74	189.54	203.00
Net irrigated area (million ha)	20.85	47.78	55.14	-
Gross irrigated area (million ha)	22.56	62.47	73.28	91.50
Fertilizer consumption (million mt)	0.07	12.55	16.80	20.00
Milk, eggs, wool (000 mt)	-	41.20	45.50	-
Fish production (million mt)	0.75	3.84	5.26	-

Source: Government of India, *Agricultural Statistics at A Glance – 2000*.
Note: * Projected.

Table 3. Relative Contribution of Irrigated Agriculture in Food Grain Production
(Unit: Percent)

Item	Irrigated Area[1]	Production[2]	Rainfed Area[1]	Production[2]
Food grains	36	44	64	56
Cereals	43	72	43	28
Pulses	11	21	89	79

Notes: [1] Percent of net sown area.
[2] Percent of total production.

Table 4. Size Distribution of Operational Holdings
(Unit: Percent)

Category of Holding	1960-61	1980-81	1991-92
Marginal (less than 1 ha)	39.1	56.0	62.8
Small (1.0-2.0 ha)	22.6	19.3	17.8
Semi-medium (2.0-4.0 ha)	19.8	14.2	12.0
Medium (4.0-10.0 ha)	14.0	8.6	6.1
Large (more than 10 ha)	4.5	1.9	1.3
Number of rural operational holdings (million)	50.77	71.04	93.45
Area operated per holding (ha)	2.63	1.67	1.34

Source: Government of India, *Agricultural Statistics at A Glance – 2000*.

There is a significant decline in the share of area operated in large holdings from 29 percent in 1960-61 to 15 percent in 1991-92, while the operated area has increased from 7 percent to 16 percent in the marginal holdings category in the same period (Table 5). This has its own implications on land utilization, agricultural productivity and land degradation.

Table 5. Percentage Distribution of Operational Holdings by Category of Operational Holdings

Category of Holding	1960-61	1980-81	1991-92
Marginal	6.9	11.5	15.6
Small	12.3	16.6	18.7
Semi-medium	20.6	23.6	24.1
Medium	31.2	30.1	26.4
Large	29.0	18.2	15.2

Source: Government of India, *Agricultural Statistics at A Glance – 2000.*

Soil Resources

On account of the diversity of landforms, geology, climate, and vegetation in India, a great variety of soils occur with different morphological and physico-chemical properties.

Traditionally, Indian soils are divided into four major groups viz., (1) red, (2) black, (3) alluvial, and (4) laterite. The land surface in the country of 329 million ha is predominantly covered with red soils (105.5 million ha), black soils (73.5 million ha), alluvial soils (58.4 million ha), laterite soils (11.7 million ha), desert soils (30 million ha) and hills and terai soils (26.8 million ha).

As per the soil taxonomic orders (Soil Survey Staff, 1999), Alfisols form the major soil group (40 percent) followed by Aridisols (28 percent) (Figure 3).

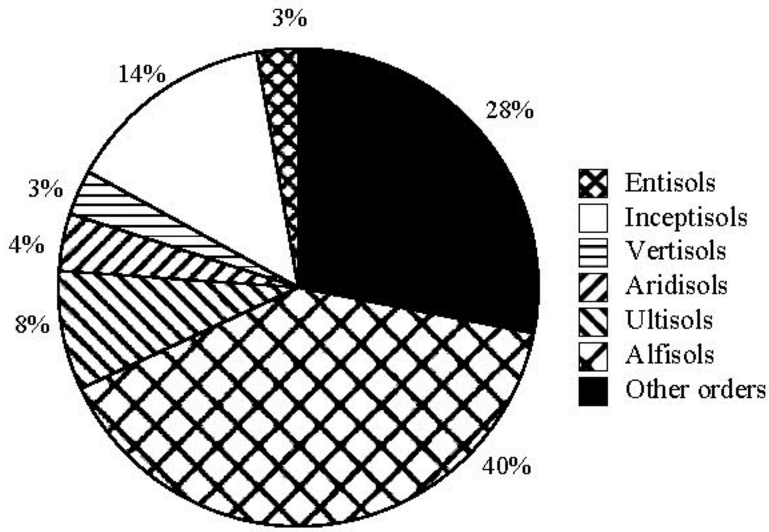

Figure 3. Share of Different Soil Orders in India

The Indo-Gangetic plains of North India are the most fertile lands and are largely irrigated, contributing to 65 percent of the total food basket. The content of organic matter in Indian soils is generally low because of the high rate of decomposition under tropical and subtropical climate. The organic matter in most of the Indian soils rarely exceeds 1 percent except in a few hilly soils.

Soil Degradation

The soil degradation studies in India (Table 6) show that an area of 187.8 million ha (57 percent of total geographical area) of the country has been affected by various land degradation problems induced largely by human intervention (Sehgal and Abrol, 1994).

Table 6. Extent of Soil Degradation in India

Degradation Type	Area Affected (million ha)	Percent of Geographical Area
Water erosion	148.9	45.2
Wind erosion	13.5	4.1
Chemical deterioration	13.8	4.2
Physical deterioration	11.6	3.5
Total affected area	187.8	57.0
Soils with no degradation problem	90.2	27.5
Land not fit for agriculture	18.2	5.5
Stable terrain	32.2	9.7

Source: Sehgal and Abrol, 1994.

Soil erosion by water is the most serious degradation problem in the Indian context. Over 5.3 billion mt of top soil alone is lost every year through water erosion resulting in a loss of 8 million mt of plant nutrients and 3 million mt of food grains annually. Nearly 29 percent of the eroded soil was permanently lost to the sea, nearly 10 percent was deposited in reservoirs, and remaining 61 percent of eroded soil was transferred from one place to another. Wind erosion is a serious problem in arid and semi arid regions including the states of Rajasthan, Haryana, Gujarat, and Punjab. It is also prevalent in coastal areas where sandy soils are predominant.

Out of the 187.7 million ha of total degraded area, 4.6 million ha are extremely affected, 8.5 million ha are strongly affected, 137.9 million ha are moderately affected, and 36.8 million ha are slightly affected.

Agro-climatic Zones/Agro-ecological Zones

It is an established fact that agriculture is highly dependent on soil and climate along with various other factors, which together form the agro-ecological setting. Cropping pattern and allocation of inputs are very much dependent on the agro-ecological condition of the site. Several attempts have been made to divide India into different regions and zones considering climate, soils, and crops such that homogeneity of these zones is greater. The Planning Commission divided the country into 15 broad agro-climatic zones based on physiography, soil type, rainfall, cropping pattern, etc. However, in view of wide soil and bio-climatic variability this effort was considered to be inadequate for the purpose of planning. The National Bureau of Soil Survey and Land-use Planning prepared an agro-ecological region map consisting 20 regions and 60 sub-regions using some scientific principles, physiography, soils, bio-climatic, natural vegetation, and length of growing period (Sehgal, *et al*., 1993).

The National Agricultural Research Project (NARP) of the Indian Council of Agricultural Research (ICAR) identified 120 agro-climatic zones after taking into account, rainfall pattern, temperature, soil types, and cropping pattern of each state as a unit (Saxena, 1989). However, as the classification fails to reflect socio-economic endowments and because of spatial diversity in farming systems, the ICAR has focused research programs under the National Agricultural Technology Project (NATP) on Production System Research (PSR) which integrates all the system components. The research and technology dissemination would be supported in the five agro-ecosystems namely: irrigated, coastal, arid, rainfed, and hill and mountain ecosystems.

	Agro-ecosystem	Associated Soil/Constraint
1.	Arid agro-ecosystem	Referred as desert soils, thirsty and hungry with generally higher pH and salt content in the lower horizon and degradation is mainly due to biotic pressure.
2.	Hill and mountain ecosystem	Soils are acidic, rich in organic carbon.
3.	Coastal ecosystem	Diversified soils mostly sandy, sandy loam and clay loam, saline.
4.	Irrigated ecosystem	Salinity and sodicity.
5.	Rainfed ecosystem	Low soil fertility, shallow, sloping, and undulated lands.

Conceptually, agro-climatic zones differ from agro-ecological zones. The agro-ecological zone is the geographical area similar in comparable climatic conditions and length of growing period suitable for particular group of crops.

Land Classification

In recent years, land use has become highly competitive as a result of tremendous population stress and the narrowing man land ratio. The multi-sectoral conflicting demands led to abuses, giving rise to serious problems of land degradation and causing diminishing production potential. Control of land degradation, restoration of degraded and waste lands to their production potential, intensifying production by adopting suitable cropping pattern, and agronomic practices (Integrated Nutrient Management and Integrated Pest Management) in areas already under cultivation are the important aspects to be taken up to ease the pressure on land use. This requires a good land resource database and suitable land capability classification (LCC) to specify with what procession or intensity a particular land area should be used.

In the history of soil surveys of India, land classification for estimating revenue is the earliest and dates back to the 16th century. This classification was done based on external features namely soil texture, color of soil, slope of land, availability of water, and yield.

Later, lands were also classified into three zones based on the distance from settlement areas. Lands on the vicinity of a settlement area were classified as good, adjacent to this zone were medium quality lands, and the third zone situated at the periphery of settlement area was classified as poor lands.

In the beginning of the 20th century, attention was focused on the productivity of agricultural lands based on fertility classification of soils that depended upon the content of available nutrients N, P, and K.

In recent years, the problem of land classification has been tackled by many researchers. The pioneer work in Uttar Pradesh was done by Shafi in 1960. He classified the lands according to fertility and productivity into the following categories:

Category	Quality	Associated Features
Land A	Good	Highly fertile, two crops a year.
Land B	Medium	Further sub-divided into BI and BII based on productivity.
Land C	Poor	Left unutilized due to salts or other limitations.

Sharma (1975) has attempted a land classification based on physical and chemical characteristics of land and socio-economic considerations with four major categories – good, medium, poor, and very poor lands.

In recent years, combined soil and land classifications have been attempted. The USDA LCC is being followed in India, as it is very broad and comprehensive. The basic USDA LCC allocates land suited to cultivation as classes I to IV followed by land suited for grazing in classes V to VI and forestry in class VII, leaving class VIII for wild life and recreation. These classes are then sub-divided into sub-classes based on several limitations including erosion risk (r), wetness (w), rooting zone limitation (s), and climatic limitation (c). The emphasis of the USDA system is on environmental factors that can not be modified practically. Thus, physical soil features such as texture are accorded greater significance. Poor soil drainage would lower the land class. Similarly, soils with a drought hazard need not be down graded if supplementary irrigation becomes economically feasible. Economic factors are thus recognized implicitly rather than explicitly (Bookes Soil Manual, 1984).

Information on lands of different fertility status helps in planning suitable cropping and agronomic practices. Land is to be divided into land capability units from the viewpoint of the treatment; the land should receive after considering the characteristics of the soil and other features. This type of classification is useful in developing projects for irrigation, drainage, forest clearing, and some other amelioration. Economic land-use classification determines and maps the local variation in the capacity of land to produce income against productive expenditure. In this context, the following bases of land classification would be useful:

– Soil fertility based land classification;
– Land capability based classification;
– Soil irrigability based land classification; and
– Economic land-use based classification.

Land-use Planning for Better Land Utilization

Proper and wise land-use planning is necessary to meet the challenges of the 21st century in providing food security and to make other commodities available to the growing population as the per capita land availability is shrinking. The modern concept of land-use planning calls for balanced and harmonious management of natural resources for making sustainable land-use decisions. The general purpose of land-use planning is to evaluate a land area in question, to study the existing land use, to suggest alternate solutions, to predict their possible impacts, and to arrive at sound decisions. A systematic resource assessment/ appraisal is a must for land-use planning. For this purpose, National Land Resource Conservation and Land-use Boards at central and state levels were established. The potentiality and problems of different soils, their extent, and distribution are mapped for developing rational land use. A huge database has developed as reports and maps have been created by many organizations. The two major approaches followed in the land-use planning are the 'top-down' and 'bottom-up' approaches. The agro-climatic zonal planning system initiated under the Planning Commission, Government of India exemplifies the 'top-down' approach. The watershed approach followed in the centrally-sponsored scheme of soil and water conservation under the Department of Agriculture, Government of India is illustrative of a combined approach.

Primarily, optimum land use is determined for each of the mapped land systems in the area. Several such location specific models have been suggested. The broad conceptual schematic methodological approach is illustrated in Figure 4 (Karale, 1992).

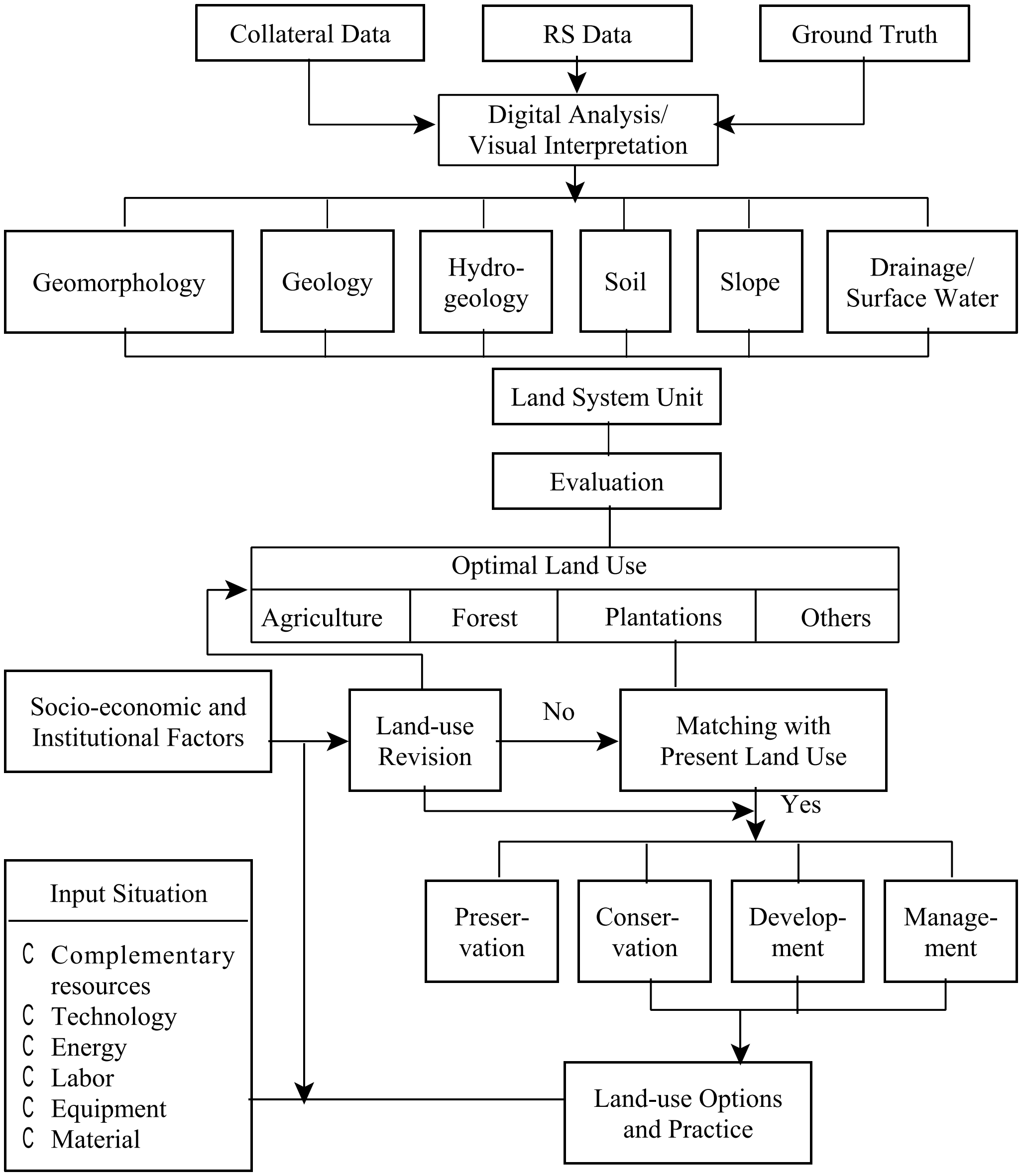

Figure 4. Land-use Planning Schematic

Alternate Land Use

Systematic studies were initiated in the recent past on alternate land use. Katyal, *et al.* (1993) reported that alternate land-use systems viz., agro-forestry, agri-horticulture, silvi-pastoral, and dryland horticulture under a rainfed agro-ecosystem generates continuous and stable income, and meets food, fodder, fuel and fruit requirements. Limited efforts have so far been made to compare the program of different land-use options on a given LCC. The results of one such study at CRIDA, Hyderabad on class IV red soils revealed that the agri-horticulture system is more remunerative and sustainable as compared with other farming systems (Pareek, 1999). Results of an experiment conducted on degraded soil at Rajkot revealed that an alley cropping system of *Leucaena* + groundnut could provide insurance against drought, besides higher monetary returns (S. K. Das and C. J. Itnal).

Sharma (1998) suggested different agro-forestry systems including agri-horticultural, agri-horti-silvi-pastoral systems depending on soil depth, slope and extent of land degradation for the North-Eastern Hill region under a hill and mountain agro-ecosystem. In coastal agro-ecosystems, fish farming is a good option on degraded lands along the coast.

In order to make land more productive, remunerative and sustainable, suitable land management practices based on resource availability and capability in a given situation are to be followed. This needs the concerted and coordinated efforts of different departments and land users. Following are the some of the aspects to be looked into for better land utilization:

– Development of an exhaustive database required for planning at a Major Land Resource Unit (MLRU) level as well as at the farm level.
– Consolidation of landholdings for effective implementation and adoption of improved technology as practiced in Punjab.
– Implementation of watershed programs and wasteland development programs on a massive scale.
– Formulating guidelines and policies for efficient water use.
– More thrust for identifying alternate land-use systems and suitable technology for improving the productivity over present land use.
– Identifying and management of constraints in present land-use systems for which frequent dialogue/interaction among scientists, planners and administrators is necessary.
– Development of suitable cropping pattern/farming systems.
– Intensification of research on alternate land use in different agro-ecosystems.
– Arranging awareness programs for landholders on best options of land utilization.
– Optimization of input use for improved efficiency, particularly water and nutrients.
– Assess both the new lands and lands already being used for their suitability for different uses and provide decision-makers with alternate land-use plans which satisfy communities aspirations.
– Encouragement of community farming.

Yadav and Singh (2000) developed the following classification system for identifying agro-ecological zones and the capabilities for sustained agricultural usage.

Table 7. Agro-ecological Zones and Land Use

Agro-ecosystem	Areas	Characteristic Features	Prevailing Land Use	Suggested Land Use and Technologies for Sustainable Production System
1. Hill and Mountain agro-ecosystem	Spread over 26.8 million ha, vastly distributed all over the country with a large area located in Himalayas.	Cultivation in terraced fields, diversified soils, fragmented and scattered holdings, undulating topography, and lack of irrigation facilities.	Jhum cultivation, silvi-agri-livestock-fisheries, rice-based production system, agro-forestry-based, vegetable-based and livestock-based production system.	Agro-forestry/agro-pastoral farming, adopting soil and water conservation methods on water-shed basis.
2. Coastal agro-ecosystem	Spread over 10.78 million ha along the coastline of 8,129 km along with a marine jurisdiction in the seas over 2.02 million km^2.	Clay loams. Rainfall more than 100 cm excluding north Gujarat coast, salinization, poor quality groundwater, impeded drainage, high water table.	Rice, wheat, oilseeds, coconut, casuarina, cashew, mango, arecanut, tapioca, millets, sugarcane, cotton, pulses, vegetables, fish farming.	Rice-based multiple cropping system, mixed farming, plantation crops including medicinal and aromatic plants, conservating mangrove promoting ecosystem, forestry, aquaculture, constructing drainage embankments along the tidal channels and rivers, conjunctive use of poor quality water.
3. Irrigated agro-ecosystem	Spread over 55 million ha mostly in Punjab, Haryana, Utter Pradesh, Bihar, West Bengal, Andhra Pradesh and Tamil Nadu States.	Alluvial soils, salinity, alkalinity problems, frequent floods and water-logging.	Rice-wheat, rice-rice, rice-groundnut/mustard, cotton-wheat, sugarcane-wheat, maize-wheat, maize-potato, pigeon pea-groundnut/wheat.	Optimum seed bed preparation, INM, IPM, scientific on-farm water management, including drainage.

... To be continued

Continuation

Agro-ecosystem	Areas	Characteristic Features	Prevailing Land Use	Suggested Land Use and Technologies for Sustainable Production System
4. Rainfed agro-ecosystem	Spread over 102 million ha distributed through the length and breadth of the country.	Erratic rainfall ranging from 500 mm to 1,500 mm, frequent occurrence of droughts, short cropping season, majority soils fall under vertisols (35%), alfisols (30%) and entisols (10%), low organic matter, micronutrient deficiencies, erosion, compaction and surface hardening of soils.	Rainfed rice, sorghum-based cropping, pearl millet-based cropping, soybean-based cropping, groundnut-based cropping, pulse-based cropping.	Different soil and water conservation practices viz., sowing across the slope, contour farming, inter plot water harvesting, conservation furrows, graded bunds, intercropping, double cropping wherever possible, adopting contingent crop plans for delayed onset of monsoon, water harvest and recycling on water-shed basis, alternate land use (tree farming, horti-pastoral system, ley farming, agri-horti system).
5. Arid agro-ecosystem	Spread over 39.7 million ha mostly on north-western India and the small packets in South India.	Rainfall less than 10 cm to more than 40 cm, high evapo-transpiration, high temperatures, large herd of livestock, wind erosion, salinity and sodicity.	Pearl millet-based cropping, pulses, sesame, groundnut, castor, arid fruit crops viz., aonla, date palm, livestock.	Mulch farming, strip cropping, sand dune stabilization, shelter belts, water harvesting, drip irriga-tion, adopting improved agro-forestry system grassland develop-ment.

Source: Yadav and Singh, 2000.

Role of Modern Technologies in Land-use Planning

Information required for comprehensive land-use planning varies with planning goals, strategies, programs, and land-use problems. Generally, information is required on the land system (landform, slope, land cover, groundwater etc.), climate and hydrology, socio-economic aspects, and agro-economic aspects (common crops, agronomic practices, diseases, pests etc.) Information required could be collected through *taluk* (sub-district), and district level records, field surveys, etc. Usually, the conventional approaches are slow, cumbersome, and sometimes inaccessible.

Role of Remote Sensing

Satellite-based remote sensing technology is a powerful tool for scientists, planners and technologists. The availability of multi-spectral satellite data coupled with the advent of high performance computers has opened new vistas in resource inventory. India launched its first operational Indian Remote Sensing Satellite (IRS), IRS-1A in March 1988 and followed it up with IRS-1B, IRS-1C in 1991 and 1995, respectively with very high spatial resolution sensors.

With the availability of high-resolution satellite data, it has become very easy and fast to gather the highly reliable data required for land-use planning. Several remote sensing application studies in the country on mapping of soils, land degradation, land use and land cover, forests, water resources have been demonstrated and published. These include soils mapping by NBSSLUP, Nagpur, waste land mapping, Wasteland Development Board, crop area estimation, yield forecasting under Agriculture Mission of Department of Space and district-wise land-use mapping in the country for agro-climatic zonal planning under the Planning Commission.

Application of GIS

Land-use planning calls for a holistic view of land systems, socio-economic conditions, regional priorities and governmental policies and integration. This is achieved with Geographical Information System (GIS). Attributing data on soil profile morphology, physical and chemical properties of soils, meteorological data, socio-economic indicators, demographic data, management practices, yield data etc., can be useful. Land evaluation for specific objectives can be achieved by integrating resource data sets and employing weighted combinations of variables or set decision rules.

Prescriptions for land-use optimization and management were given for Chandrapur district after synthesizing a composite mapping unit (CMU) by using IRS data of LISS-II Sensor and Geospace GIS S/W package (Karale, 1992).

The All India Soil and Land-use Survey (AISLUS) developed an integrated soil and land-use information system (ISLUIS) towards management of the database and its updating using remote sensing and GIS. It has also developed a soil information system and a soil health card (SISSHC). It has been suggested that a soil health card (Figure 5) should be introduced in all the watershed management programs for better use of soil and land resources (S. N. Das, 1999).

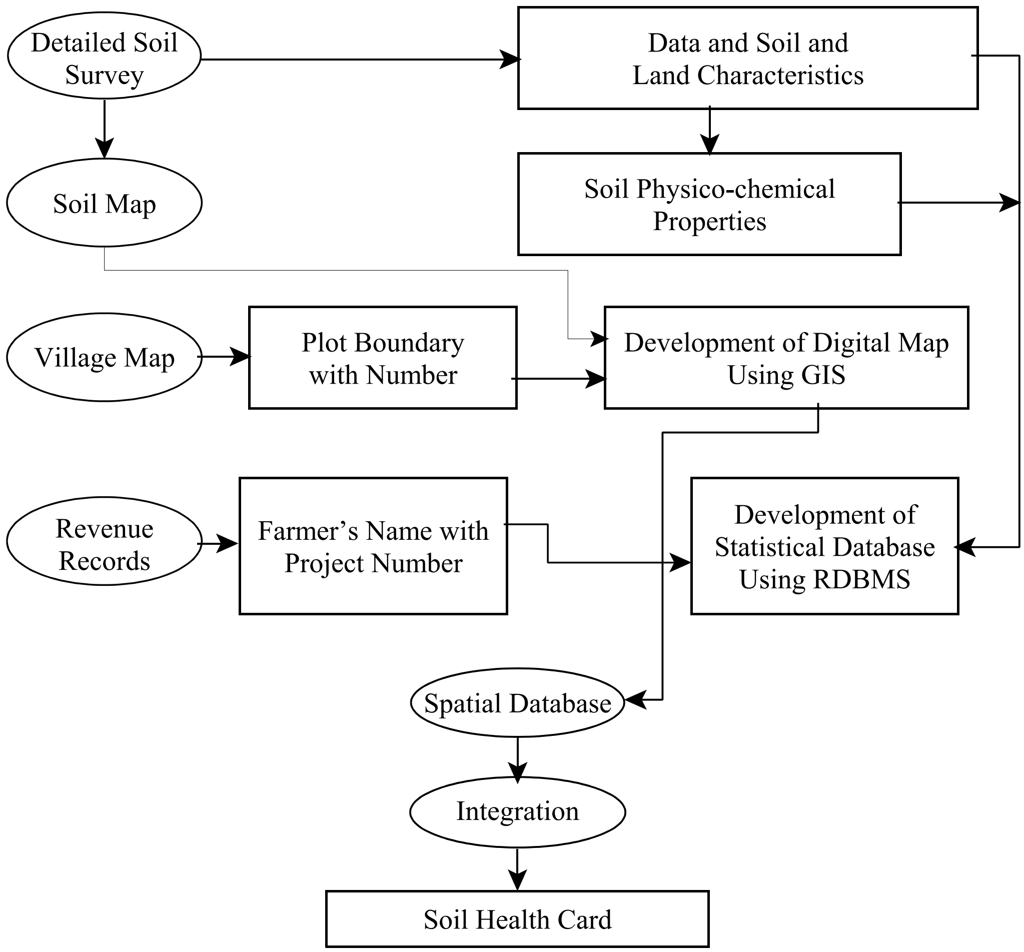

Figure 5. SIS for Soil Health Card

Source: S. N. Das, 1999 (AISLUS).

Land-use Policy – Constraints and Strategies

Over the years, there has been an increasing intensity of various soil degradation processes due to abuse and misuse of soil and land resources. This necessitates a sound National Land-use Policy (NLUP). The land, being a state subject, vitally needs uniform guidelines and their implementation by all states and Union Territories. The National Commission on Agriculture recommended that land-use policy should ensure intensive utilization of land, and reduce national and sectoral disparities. The basic objectives of NLUP are:

– To increasing the productivity of land resource;
– To prevent deterioration of the land resource;
– To restore the productivity of degraded lands;
– To allocate lands for different uses based on land capability;

- To regularize land use by all concerned including government departments and to revitalize the land-use boards;
- To prevent degradation of grasslands by restructuring the live stock production programs limited to economically productive stock;
- To provide optimum use of land by promoting the concept of mixed farming systems;
- To complete the inventory of soil and land resource surveys;
- To coordinate the water resource management policies, forest management policies and urban planning; and
- To examine legal support for enforcement of land-use policy.

Constraints

- Any single department cannot implement land-use policies;
- The use of land is being dictated by the priorities of the sector within the government;
- Large number of marginal and small operational holdings is a constraint;
- Diversified interests of people; and
- Broad national policies will have little meaning in specific local situations.

Strategies

- Joint and coordinated effort by various departments dealing with agriculture, forests, soil conservation, irrigation, extension services, financing, research institutes, etc., is required;
- Add teeth to the NLUP by providing legislative support; and
- Conducting awareness programs to landholders and land users and show that the policies are for their advantage, keeping in view of the national interest.

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4. INDONESIA

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INTRODUCTION

Indonesia is the world's largest archipelago, consisting of 17,000 islands, in which there are five big islands – Java, Sumatra, Kalimantan, Sulawesi, and Irian Jaya. Some 70 percent is sea, while its land area is about 192 million ha. The island of Java, which is rich in volcanic soils and has high potential for agricultural productivity, is one of the most populous regions with a population density of 768 people/km^2. The islands of Kalimantan and Irian Jaya, which comprise approximately 50 percent of the country's land area, have population densities of 14 people/km^2 and 3 people/km^2, respectively. Urban populations are also higher in Java and Bali. Thirty percent of the population in Java is concentrated in cities compared to 20 percent on the other islands.

The population of Indonesia increases year by year. For example, between 1980 and 1990 the number of people increased from 147.5 million to 179.4 million or at the average annual rate of 1.98 percent. Recent data shows a declining growth rate with a population of 206.5 million in 1998 (Central Bureau of Statistics [CBS], 1999).

Consequently, this tremendous increase of population encourages the Government of Indonesia to try to fulfil food supply and other population needs. Therefore, efforts should be given to increase and improve agricultural production through agricultural development in Indonesia.

Agricultural development is now faced with several challenges, such as increasing food demand, decreasing of fertile and productive agricultural land, narrowing of land ownership, lack of capital, low educational level of citizens, and slow application of science and technology. In the last two decades, agriculture has been regarded as the supporting sector to the nation's economy and industry has become the leading sector. The agriculture sector has been functioning as the supplier of raw materials for industries, food at low prices for stabilizing the prices of food as a strategic commodity, to absorb unskilled labor, and to supply cheap labor to other sectors, especially during the off-season.

CURRENT AGRICULTURAL SITUATION

Soils

Soils of Indonesia are formed from a wide range of parent materials under a range of climate and topographic conditions. There are 12 great groups of soils (Table 1), in which red yellow podsolic (ultisols and oxisols) is the dominant soil, and covers about 47.5 million ha or 24.9 percent of the total land area of Indonesia. Other dominant soils are organosols (histosols), alluvial (entisols and inceptisols), and latosols (inceptisols and oxisols) which cover an area of 24.2 million ha, 19.2 million ha and 18.4 million ha, respectively.

Table 1. Great Group of Indonesian Soil and Their Distribution[1]

CSAR	USDA Taxonomy	Area (000 ha)	
Organosol	Histosols	24,150	(12.65)
Alluvial	Entisols Inceptisols	19,170	(10.04)
Regosol	Entisols	3,907	(2.05)
Renzina	Mollisols	1,671	(0.87)
Grumusol	Vertisols	1,800	(0.94)
Andosol	Inceptisols	5,056	(2.65)
Mediteran	Alfisols	7,843	(4.11)
Latosol	Inceptisols Oxisols	18,382	(9.63)
Red yellow podsolic	Ultisols Oxisols	47,526	(24.89)
Podsol	Spodosols	5,012	(2.62)
Complex/miscellaneous	Complex	56,430	(29.55)
Total		190,947	(100.00)

Source: Center for Soil and Agroclimate Research (CSAR), 1997.
Note: * East Timor is not included.
Figures in parentheses are percent.

Red yellow podsolic (ultisols and oxisols) is considered as marginal soils, and the soil suitability class is marginally suitable for annual food crops. These soils are moderately suitable for perennial crops such as rubber, oil palm, cacao, pasture, etc. Mixed farming (tree crop, food crop, pasture) systems are possible alternative technologies for management of the upland areas. Organosol (histosols) are always saturated with water and are considered fragile soils due to its inherent soil characteristics. Limited crops can grow well on it, such as rice, several annual food crops, horticulture, and oil palm. Alluvial soil is mostly suitable for wetland rice and produces a high yield of rice.

The acidity of western Indonesian soils is mostly high to moderate with soil pH ranging from 4.5 to 5.5, while the soil acidity of the eastern parts of Indonesia is moderate to neutral with a soil pH more than 5.5. In connection with soil acidity, the soils are known to be deficient in P, K, Ca, and Mg. The organic C content and cation exchange capacity (CEC) are generally low, but Al, Fe, and Mn content are often high. The main physical constrains to production are low available water holding capacity and the soils are susceptible to erosion and degradation.

Land Resources Potential

Based on different physiographic and major constraints, the lands of Indonesia are divided into 12 groups or land types. Each group appears with potential area of land, indicating their major constraints, and showing the proposed allocation of each group (Table 2).

Table 2. Total Land Area, Major Constraints and Proposed Utilization in Indonesia, 1999

No.	Land Type with Major Constraints	Total Area (000 ha)	Proposed Utilization
1.	Land with cool climate	407.5	Natural preservation protection forest and conservation
2.	Land with steep slope:		
	– Hilly areas, dissected	21,785.8	Conservation forest, estate crops
	– Mountain areas, slightly dissected	30,240.7	Conservation forest, estate crops
	– Mountain areas, dissected	36,147.4	Protection forest
3.	Land with shallow soil	2,834.4	Estate crops, savanna
4.	Land with poor drainage	22,037.3	Wetland farming, swamp forest, natural preservation, fisheries
5.	Land with coarse texture	1,837.9	Conservation forest
6.	Land with shrinking clay	814.6	Wetland farming, dryland on flat area
7.	Land with low fertile soil	42,646.8	Dryland farming, estate crops, mixed farming
8.	Land with salinity problem	2,173.0	Farmers forest, brackish water fisheries
9.	Land with acid sulphate potential	4,109.5	Wetland farming area
10.	Peat land	16,082.6	Conservation forest, wetland farming, estate crops, horticulture
11.	Land with or without light limitation	9,394.7	Various farming
12.	Lake, river and others	1,405.1	Fisheries, recreation areas, energy
	Total	191,917.3	

Source: Hidayat *et. al.*, 1997.

Data in Table 2 shows that 97.9 million ha (51.0 percent) of the land has low to moderate potential for agricultural development due to major constrains or limitations present in the land, such as sulfuric material, drainage, peat material, and low soil fertility status. Those major constraints of the land could limit productivity of the land. Therefore, efforts should be given on the development of those lands for agriculture.

It can be seen from Table 2 that 88.6 million ha or about 46.2 percent of the land consists of land with a cool climate and with steep slopes. Those two kinds of land types have no or low potential for agricultural development due to cool climate, hilly to mountainous areas with steep to very steep slopes, severely dissected, and very susceptible to erosion. Hilly areas are often farmed using upland or dryland agricultural practices without soil conservation measures or environmental protection, and the land are only suitable for natural preservation, conservation forest, hydrology, and estate crops, especially for areas with less steep slope. The rest of the land areas is about 5.4 million ha or 2.8 percent and should be left as conservation forest, farmers forest, fisheries, recreation, and energy.

Land Utilization Type

Indonesia has 11 land utilization types covering an area of 64.1 million ha or 34 percent of the total Indonesia land area (Table 3). Most of the land is suitable for some kind of agriculture (CBS, 1999).

Table 3. Land Utilization Area in Indonesia, 1996-97

Land Type	Area (000 ha)		Growth Rate (percent)
	1996	1997	
Wetland rice	8,519	8,490	-0.34
House compound and surrounding	5,291	5,331	0.76
Dryland/garden	8,384	8,382	-0.01
Shifting cultivation	3,179	3,226	1.47
Meadows	1,953	2,056	5.29
Swamp	4,173	4,271	2.34
Dyke	439	467	6.56
Water pond	184	169	-8.24
Temporary fallow land	7,336	7,578	3.30
Woodland	9,446	9,134	-3.31
Agricultural estate	14,488	15,016	3.64
Total	63,392	64,120	1.15

Source: CBS, 1999.

Indonesian farming is carried out on wetland rice, upland and swampland. Wetland rice areas are found at elevations of 0-1,000 meter above sea level, covering an area of around 8.5 million ha, 40 percent of which exist in Java island, and which contribute to 58 percent of the national rice production (CBS, 1997). According to CBS data (CBS, 1999), average wetland rice yield in Java is about 4.94 mt/ha, while the outer island yield is about 3.94 mt/ha. These differences are due to better infrastructure in Java, especially irrigation, higher fertilizer use, and Java has more fertile soils. In Java, most of the farmers use fertilizers on their wetland rice at higher than required rate.

Upland agriculture mostly exists on acidic infertile ultisols, oxisols, and inceptisols. The western part of Indonesia is characterized by high amounts of rainfall that varies from 1,700 mm to more than 3,000 mm per year, and has undulating to mountainous topography. Therefore, these upland soils mostly receive excessive rain and are prone to erosion during the rainy season. Annual crops suffer more from low soil fertility and excessive water. Perennial crops grow and produce sustainable production, such as rubber, oil palm, and cacao.

The eastern part of Indonesia, especially East Nusa Tenggara, has a lower amount of rainfall that varies from 700 mm to 1,300 mm per year and has a long dry period. The soils are entisols, inceptisols, vertisols, and alfisols with shallow to moderately deep topsoil. The soils mostly have high cation exchange capacity, are moderately acidic, and are considered as having a better soil fertility status compared to the soils in the western part of Indonesia. However, the main problems of agriculture in the eastern part of Indonesia are water shortage and poor soil physical properties. Based on these conditions, annual food crops are planted only one time a year and various perennial crops such as cashew nuts, mango, etc. are common. On shallow soils, such as entisols, local grasses are found and animal husbandry is an important farming activity.

Another potential land resource for agriculture is swampland. However, swampland agriculture has more constraints and difficulties than upland agriculture and wetland rice. Therefore, only 4.2 million ha of swampland is used for agriculture (Table 3). Actually, Indonesia has 39 million ha of swampland and 23 million ha of it is tidal swamp. Around 5.6-9.9 million ha is considered to be suitable for agriculture without considering the degree of difficulty in management and accessibility (Subagyo and Widjaja-Adhi, 1998). The crops which are found in a swampland area are usually rice and others seasonal food crops, oil palm, and pineapple.

Shifting cultivation is still common in low population density areas, especially outside Java. Traditional farmers plant hill paddy based on shifting cultivated areas where jungles are cut down and burned. The farmers use the land for only one to three years before soil fertility decreases and the soil surface is exposed to rainfall, which causes accelerated erosion. Afterward, the farmers move and farm on newly cleared forest. The crops planted are rice and other seasonal food crops. Nowadays, traditional shifting cultivation practices have almost disappeared and changed into more exploitative ways, such as cleared forest for estate crops or industrial forest crops (HTI).

As stated before, red yellow podsolic (ultisols and oxisols) are the dominant soils in Indonesia and are mostly planted with estate crops such as rubber, oil palm, cacao, etc. These trees are known to be tolerant to acid infertile soil, and have a high priority to be developed. Recent data shows that more than 15 million ha of the land is used for agricultural estate crops (Table 3).

Apart from land utilization types for agriculture, there are more than 148 million ha of Indonesian land in forest, and 112 million ha of which is non-conversion forest, and 37 million ha is considered as conversion production forest (Table 4). However, the factual data show some limited production forest and non-conversion forest have been converted for development of estate crops and timber production, and even protected forest is cleared for timber production.

Table 4. Forest Area Based on Forest Land-use Agreement, 1998

(Unit: 000 ha)

Island	Protected Forest	Park and Preservation Forest	Limited Production Forest	Non-conversion Forest	Conversion Production Forest
Sumatra	5,779	3,996	6,191	6,688	8,481
Java	733	420	-	1,872	-
Bali and Nusa Tenggara	1,568	338	798	548	191
Kalimantan	6,906	4,195	11,348	14,250	11,285
Sulawesi	4,475	1,399	4,732	1,460	1,494
Maluku and Irian Jaya	10,199	8,753	6,539	8,421	15,251
Indonesia	29,660	19,101	29,608	33,239	36,702

Source: CBS, 1999.

AGRICULTURAL PRODUCTIVITY

Agricultural Development

Farming carries about 40 percent of the Indonesian work force, and the agriculture sector contributed 42 percent of the national GDP in 1969. But, afterward, the industry sector took the bigger portion. In 1997 the agriculture sector made up only 15 percent of the GDP.

During the period of 1975-85 agriculture grew at a rate of about 4.2 percent, and dropped to 3.4 percent during the period of 1986-96. In 1977 the agriculture sector was severely affected by the economic crisis and severe drought caused by El Niño. The planting time was delayed by two to three months in many locations, and caused a decrease in rice production of 3.3 percent, maize of 5.7 percent, and soybean of 10.5 percent.

The economic crisis also severely affected livestock production, because of animal feed, such as dairy cattle, broiler and egg layers was mostly imported. It was cheaper to purchase chicken feed and animal concentrates from abroad, but when the price increase drastically paralleled the value increase of the dollar, the country was not ready to produce animal feed. A large part of the meat industry, especially of poultry products, phased out and caused meat prices to escalate. In the milk processing industry, about one-third of the raw materials were imported and this is susceptible to economic instability.

Compared with other sub-sectors in agriculture, fisheries were more tolerant to economic crisis. This is because the main source of fish products is from open inland waters and marine water with little dependence on imported feed. Fish culture has some dependence on imported fish meat, but is an export-oriented industry. Several fish products, like shrimp, have high prices due to increases of foreign exchange.

Agricultural Production

Most rice, maize, soybean, peanut, and other food crops are produced by smallholders (CBS, 1999). Lowland rice fields in Java are the main rice basket. Of the 47.76 million mt of rice produced in 1999, only 5.5 percent was produced in the upland (Table 5). Other food crops, such as maize, soybean, and peanut are planted mainly on the upland, although maize and soybean are also planted in many lowland rice fields during the dry period.

Table 5. Harvested Area, Total Production and Average Yields of Several Food Crops in Indonesia, 1999

Crop	Harvested Area (million ha)	Total Production (million mt)	Average Yield (mt/ha)
Lowland rice	10.69	47.76	4.47
Upland rice	1.17	2.65	2.26
Maize	3.44	9.17	2.67
Soybean	1.14	1.37	1.20
Peanut	0.61	0.65	1.07
Cassava	1.34	16.35	12.20
Sweet potato	0.17	1.63	9.59

Source: CBS, 1999.

In 1999, total lowland rice area was nine times larger than the upland rice area and its production was 18 times larger than the upland area (Table 5). However, Indonesia imported 1-2.5 million mt of rice, and nearly four million mt in 1997. Recent data indicate that in 1998 Indonesia imported up to 5.8 million mt of rice (Karama, 1999). Other major food items imported are maize, soybean, and wheat.

Estate crops are grown by smallholders, in a partnership between smallholders and large estates, the so-called nucleus estates. Most of estate crops are rubber, tea, and oil palm. Coffee, cashew nut, and tobacco are usually produced by smallholders (Table 6).

Table 6. Area and Total Production of Estate Crops in Estate and Smallholder Plantation, 1999

Crop	Estate		Smallholder	
	Area (000 ha)	Production (000 mt)	Area (000 ha)	Production (000 mt)
Rubber	542.8	305.9	2,888.1	1,182.4
Coconut	120.1	85.1	3,558.8	2,632.5
Oil palm	1,993.2	4,010.9	972.7	1,326.6
Coffee	63.2	28.3	1,110.4	372.8
Cocoa	154.6	69.7	383.6	274.7
Tea	88.2	133.8	85.0	34.1
Sugarcane	402.2	2,140.1	-	-
Tobacco	5.2	5.8	219.6	135.0
Cashew nut	-	-	490.8	76.0
Pepper	-	-	120.6	52.1
Ginger	-	-	14.4	77.5

Source: CBS, 1999.

A large livestock population consists of dairy cattle, beef cattle, buffalo, horse, goat, sheep, and pigs raised in 1999 (Table 7) with the total population of around 334; 11,920; 2,775; 544; 13,881; 7,468; and 8,848 thousand heads, respectively. Most of the livestock were located in Java. Increasing population also occurred in poultry. Poultry composed of local chicken, egg layer, broiler, and duck with population of around 265; 41;418; and 26 million heads, respectively in 1999 (CBS, 1999).

Table 7. Livestock and Poultry Population in Indonesia

(Unit: 000)

Items		1997	1998	1999
Livestock	Dairy cattle	334.4	322.0	334.0
	Beef cattle	11,938.8	11,633.9	11,920.4
	Buffalo	3,064.5	2,829.3	2,775.1
	Horse	582.3	566.5	544.2
	Goat	14,162.6	13,560.0	13,881.4
	Sheep	7,697.7	7,144.0	7,467.9
	Pig	8,232.8	7,797.6	8,848.3
Poultry	Local chicken	260,834.7	253,133.4	265,346.5
	Egg layer	70,622.8	38,861.3	41,926.6
	Broiler	641,373.9	354,003.5	418,395.5
	Duck	30,320.0	25,950.0	26,254.4

Source: CBS, 1999.

Total fisheries production in 1998 was around 4.47 million mt (Table 8), which consisted of 3.49 million mt of marine fish and 0.98 million mt of inland fish (CBS, 1999). Compared to fish production in 1997, the marine fish portion decreased 3.4 percent and inland fish increased 0.98 percent.

Table 8. Fish Production in Indonesia, 1998

(Unit: 000 mt)

Islands	Marine Fisheries	Inland Fisheries	Total
Sumatra	1,049	215	1,264
Java	834	456	1,290
Bali and Nusa Tenggara	284	14	298
Kalimantan	288	154	442
Sulawesi	690	135	825
Maluku and Irian Jaya	344	3	347
Total	3,489	977	4,466

Source: CBS, 1999.

CONSTRAINTS ON LAND UTILIZATION

Agriculture has been considered as the supporting sector of the nation's economy, especially since two decades ago. Afterwards, industry has become the leading sector, and the agriculture sector has been functioning as the supplier of raw materials for industries. However, since the economic crisis happened in 1998, under an unstable monetary and political situation, agriculture leads.

There are many constraints encountered in attempts to ensure sustainable development in Indonesia, and they can be grouped into biophysical constraints and socio-economic constraints.

Biophysical Constraints

The biophysical constraints that happen in utilizing the land generally occur due to inappropriate land management and the inherent characteristics of the soil and its environment. Traditional agriculture techniques are usually inappropriate and have no specific soil and water conservation practices, resulting in the deterioration of soil productivity. Under high amounts of rainfall (1,500-3,000 mm per year), the soils tend to erode, especially on sloping land, causing sedimentation and lower soil fertility status.

As can be seen from Table 2, major biophysical constraints vary from one agro-ecosystem to another. The major biophysical constraints consist of soil conditions (soil fertility, drainage, morphology) and physical environment conditions (climate, topography, water management). To overcome these problems, a specific approach for each agro-ecosystem is needed. In this relation, characterization of each agro-ecosystem, including its constraints, is the main priority to be done before developing the farming system.

Socio-economic Constraints

The fundamental socio-economic constraints on the sustainable utilization of the land or development of agriculture are capital scarcity and the availability of an agricultural work force. The capital scarcity is one of the reasons why agricultural production is inefficient. Data from 1994 shows that the agriculture sector received only 8 percent of farm credit within a 10-year period, while industry reached 32 percent of the credit, and the service sector receive almost 60 percent of the credit. Total amount of farm credit is Rp.13,415 billion; industry, Rp.53,575 billion; and service, Rp.100,719 billion.

Transformation of the country's economic structure from agriculture into industry and service sector stimulated a shift of the work force. With the economic growth, the work opportunities in the industrial and service sectors were higher than in agriculture. Then, the significant impact on agriculture was the decrease in their number of agricultural workers (Table 9). The non-agriculture sector (industry and service) absorbed most of the work force.

Table 9. Distribution of Work Force in Agriculture, Industry, and Service Sector

(Unit: 000)

Sector		1980	1985	1990	1995
Agriculture	(people)	28,843	34,141	35,747	35,233
	(percent)	55.9	54.7	49.9	43.9
Industry	(people)	5,133	6,281	9,030	10,986
	(percent)	9.9	10.1	12.6	13.7
Service	(people)	17,251	21,613	26,113	33,809
	(percent)	33.5	35.2	36.5	42.3

Land conversion from agriculture into non-agriculture is happening in Indonesia. For the last 10 years, agricultural land conversion at the national level reached 1.28 million ha, in which 79 percent of those hectares were found in Java, and 68 percent were previously highly productive wetland (CBS, 1996). Land conversion has directly increased the number of subsistence farmers, therefore the average of their agricultural landholdings is less than before (0.25 ha).

Other socio-economic constraints to agricultural development are limited skill and capability of the farmers, and marketing and institutional factors.

IMPROVEMENT ON LAND UTILIZATION

Several studies, made by many researchers from universities and research institutions, show that most of the biophysical constraints to land utilization could be overcome relatively easily. Appropriate technologies are available for improvements to sustain agricultural productivity. However, the transferability and development of those technologies have faced many problems due to the socio-economic constraints, including culture and institutional factors. Therefore, the evaluation of socio-economic components should be developed along with the other research technologies. The transferability of technology packages is considered very important, since it will determine the impact of the generated technology on agricultural development.

Some of the technologies that could be generated in improving land utilization, especially on upland farming systems, are as follows:

1. ***Soil Fertility Management***

As most of the Indonesian soils are low in fertility status, the management of soil fertility should include phosphorus and potassium management, liming and organic matter management.

2. ***Soil Conservation and Erosion Control***

The main soil physical constraints of most soils in Indonesia are low available water holding capacity and susceptibility to erosion. Soil compaction due to improper land clearing, low in organic matter content, and the loss of topsoil due to erosion and runoff are the main causes of the degradation of soil productivity on sloping lands. The technologies generated for soil conservation and erosion control, are contour grass strips or legume strips, mulching, and conservation farming (management of crop residues and organic matter).

3. ***Improvement of Cropping Pattern***

As the degradation of soil is mainly affected by an erosion process, the principle concept related to the application of different cropping patterns is that the soil surface should not exposed to raindrop impact. Therefore, the arrangement of crops in cropping pattern should cover the surface of soil as much as possible to protect from raindrop impact, runoff and soil loss. The crops should be able to produce high yields and biomass, and have a positive conservation value.

4. ***Integrated Conservation Farming***

Experiences indicate that food crops-based farming systems, especially on sloping lands, are facing many constraints and risks. Food crops need high inputs to overcome soil physical and chemical constraints. However, the yields remain low and unstable. For subsistence farmers it is nearly impossible to overcome these constraints without assistance in the form of subsidies from the government.

In order to solve the problems raised that are related to upland agriculture, an integrated conservation farming system for the various agro-ecological zones should be developed to satisfy the needs of the farmer's family, with perennial crops as the main commodity and the food crops as supporting income. The appropriate farming system should be adjusted to the local physical conditions. Pedo agro-ecological zone characterization of the areas is urgently required.

The concept of an integrated conservation farming system is based on the maximum utilization of land resources and solar radiation. The concept should consist of tree crops, food, and animal feed crops, as well as livestock and fish.

5. ***Rehabilitation of Alang-alang***

Alang-alang (*Imperata cylindrica*) land is considered another resource for agricultural development in Indonesia. Alang-alang grows very well on abandoned land that is a result of shifting cultivation or resettlement areas that are left by the people and because of improved land management.

On alang-alang land some infrastructure is already there, therefore it need only minor land-clearing costs compared to virgin forest clearing. This is quite reasonable, because the rehabilitation of alang-alang land should be far more economical than clearing virgin forest.

AGRICULTURAL DEVELOPMENT POLICY

The 1997/98 crises have shown that under unstable monetary and political situations, agriculture leads in economic importance. This is indicated by commodities such as cacao, pepper, oil palm, and shrimps that have good prices due to high foreign currency exchange.

Therefore, in the years to come, agriculture should be repositioned as the leading economic sector. The development of the agriculture sector should be more integrated, extensive, and deepened. The operational policy for agricultural development is divided into a short-term agenda, and a long-term agenda.

The immediate attention of the government is addressed to the designing and implementing of the short-term agenda. To ensure food security, the availability of foods should be above the minimum level of the country's need. To address the food security issue, the Ministry of Agriculture launched a project called Improvement of National Food Security, through the empowerment of farmers. The basic intervention is to improve the ongoing cultivation intensification program and to expand the planted area to newly opened dryland and to increase cropping intensity of lowland rice fields to 200 percent and 300 percent as irrigation water availability permits.

The vision of agricultural development in the year 2020 is to realize a resilient, modern, and efficient agricultural through:

A. Optimal and sustainable utilization of agricultural resources including land, water, manpower (work force), capital and technology;
B. Agricultural diversification;
C. Application and improvement of local specific technologies; and
D. Improvement of efficiency in agribusiness by producing competitive agricultural commodities.

The operational policies that has been laid out in line with agricultural vision are: (1) Improvement of infrastructure for agricultural development; (2) regaining of rice self-sufficiency and improvement of food security; (3) developing human resources and agricultural institutions; and (4) developing agribusinesses.

CONCLUSIONS

1. There are about 47.5 million ha of land resources that are suitable for upland agriculture in Indonesia. Most of the land is red yellow podsolic soil (ultisols and oxisols), and is classified as marginal soil, acid, deficient in nutrients, low water holding capacity, and susceptible to erosion and degradation.
2. Wetland rice which dominates the alluvial soil, covers an area of around 8.5 million ha, 40 percent of which exists in Java Island and contributes 58 percent of the national rice production. The average yield of rice varies between 3.9-4.9 mt/ha.
3. Upland agriculture in the western part of Indonesia mostly exists on acid and infertile soils with high amounts of rainfall, while the eastern part of Indonesia has better soil fertility, but lower amounts of rainfall and has a long dry period that could limit soil water availability.
4. Most of the rice, maize, soybean, peanut and other food crops are produced by smallholders, and are expected to fulfill the food needs of the Indonesian people. However, between 1995 and 1999 Indonesia imported rice in the amount of 1-5.8 million mt. At the same time, maize, soybean, and wheat were also imported.
5. Agriculture is an important supporting sector of the nation's economy since two decades ago. Afterwards, industry has become the leading sector, and agriculture

has been functioning as the supplier of raw materials for industries. However, since the economic crisis in 1998, agriculture leads.

5. A food crops-based farming system faces many problems and risks. Integrated conservation farming systems consisting of perennial crops as a major commodity, food, livestock, fish, forage crops, and organic matter management seems to be better approach to improve and sustain soil productivity as well as farmers incomes. Estate crops seem to be more resistant than food crops, although the development of estate crops still has biophysical and socio-economic constraints.
6. To achieve sustainable agricultural development, some subsidy is needed, as well as credit for the strengthening of production factors such as improved seeds, tree seedlings, cattle breeds, and fertilizer, etc.
7. Some of the technologies that could be adopted in improving land utilization in Indonesia, are: (a) soil fertility management; (b) soil conservation and erosion control; (c) improvement of cropping patterns; (d) integrated conservation farming; and (e) rehabilitation of alang-alang and/or degraded land.
8. The government policy on the development of agriculture is for increasing national food security and the development of agribusiness.

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5. ISLAMIC REPUBLIC OF IRAN

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INTRODUCTION

Iran covers an area of 1,648,000 km^2 with a wide range of topographic features and climatic conditions in southwestern Asia. The elevations range from below sea level to more than 5,000 m above sea level. The temperatures fluctuate between -30ºC to 50ºC and annual precipitation varies from about 25 mm in the Central Plateau to over 2,000 mm in the Caspian Coastal Plain with an average of 250 mm. Approximately 90 percent of the country is arid and semi-arid. Central Iran is a steppe-like plateau with a hostile climate, surrounded by desert and mountains; the Zagros Mountains on the western border and Alborz Mountains to the north. Underground water irrigates the oases where a wide variety of grain and fruit trees are cultivated. The shores of Caspian Sea have a humid climate and are suited to tropical and subtropical crops (cotton, rice, and tea). The annual evaporation loss is high, ranging from about 700 mm along the Caspian Sea shores to over 4,000 mm in the Central Plateau and the southern part of the Khuzestan and Southern Coastal Plains in southwest, amounting to 16 times the average annual rainfall (250 mm).

Economic development calls for accurate, reliable and updated productivity information. In Iran, the agriculture sector suffers from lack of reliable statistics on the inputs that control the agricultural systems and the quality and quantity of the outputs from these systems. In this respect, the soil and water resources, as the basic elements of any agricultural system, are the main concern of many modern farming enterprises. Lack of accurate information about these resources demolishes any good estimation of their production capacity, of their degradation status and of the amount of time and money that is needed to monitor and remedy the problems, which may arise from changes in the their quality under new management practices. Lack of consistent statistics also prevents planned production to ensure food security, thus, making it difficult to establish, on a sustainable basis, a balance between the production capacity of the land resources and needs of the ever-increasing population. Adequate information about production capacity of available land resources and the trend of activities related to production systems have an important role in policy-making, planning, implementing, monitoring, and judging the performance of the agriculture sector of the national economy.

In Iran, soil survey and land evaluation studies were initiated in 1953 in conformity with an agreement between the Food and Agriculture Organization of the United Nations and the Government of Iran (Dewan, 1967). The Soil and Water Research Institute (SWRI) has been involved in mapping the soils of Iran for about 50 years. Up till now, about 20 million ha of the land area of the country have been surveyed at three levels of detail – reconnaissance, semi-detailed, and detailed. The data gathered through long-term soil survey and land evaluation studies provide valuable information about soils, their geographical distribution, their properties, and their potential uses.

As this discussion implies, the main concern in this country paper is to elaborate the situations of the soil and water resources as the main inputs to the management of the agricultural systems of Iran for evaluating their capacity to produce outputs. Attempts are made to give a logical picture of the capabilities and limitations of soil and water resources of the country for crop production. Sustainability of the current crop production systems is also discussed and the status of land degradation under ongoing management activities is assessed based on the results obtained from studies at a regional level.

LAND USE AND LANDHOLDING PATTERNS

Land Use

The distribution of agricultural activity in Iran reflects the availability of natural resources. Among the most important is the length of the growing season for a particular crop, good soils, flat land, and, above all, water. Only rarely do these four factors combine naturally to produce optimum conditions for agricultural production. In most parts of the country, one or more of these environmental parameters falls well below the optimum. As a result, farming activity shows a very patchy distribution within the framework of the country as a whole. Only in one part of the country, the Caspian lowlands, does agricultural land use provide an almost unbroken production mosaic over a very large area (Figure 1).

Currently, the total area of cultivated lands in the country is about 15.5 million ha (Statistical Center of Iran, 1998b), of which 7 million ha (45 percent) are in irrigated agriculture (including fallow) with an average holding size of 2.9 ha. There are 8.5 million ha (55 percent) under dry farming with an average holding size of 6.4 ha (Figure 2). About 90 percent of the irrigated lands are under annual crops (including fallow) and the remaining 10 percent are used for production of perennial crops (mostly orchards). In rainfed areas, the annual crops constitute about 98 percent of the total production.

In 1997, the total wheat production of the country (grain) was 10,045,000 mt, harvested from 2,230,000 ha of irrigated land and 4,030,000 ha rainfed area with an average yield of 1,600 kg/ha. The averages under irrigated and rainfed agriculture were, 150 kg/ha and 730 kg/ha, respectively (Ministry of Agriculture, 1998a).

Landholding Patterns

1. ***Historical Background***

Prior to the 1961 land reform, half the cultivable land of the country was in the hands of great land proprietors (*khans*) and was held as strictly private property (*melk*). The domain of these landowners could be vast, extending to include 20, 30 or 40 villages. Many villagers, especially those who cultivated the land, were serfs (*raaya*). Besides the vast holdings of the great landowners, some 20 percent of the cultivable land was owned by people of more modest life (the *khordehmalekin*), who nonetheless would have cultivators working on their smallholdings. The remainder of the cultivable land was held in a kind of fiduciary ownership, either in ways that resembled a private trust (*vaghf-e khass*) or for religious and public purposes (*vaghf-e amm*). The cultivators of arable land (*nasagh*) lived in rural settlements, together with landless folk (*khoshneshin*), who would be artisans, traders, workers of various kinds and unemployed or unemployable people (Lenczowski, 1978). The patterns of land ownership in Iran, and its associated social problems, necessitated a nationwide land reform effort to liberate the farmers from the bondage of serfdom.

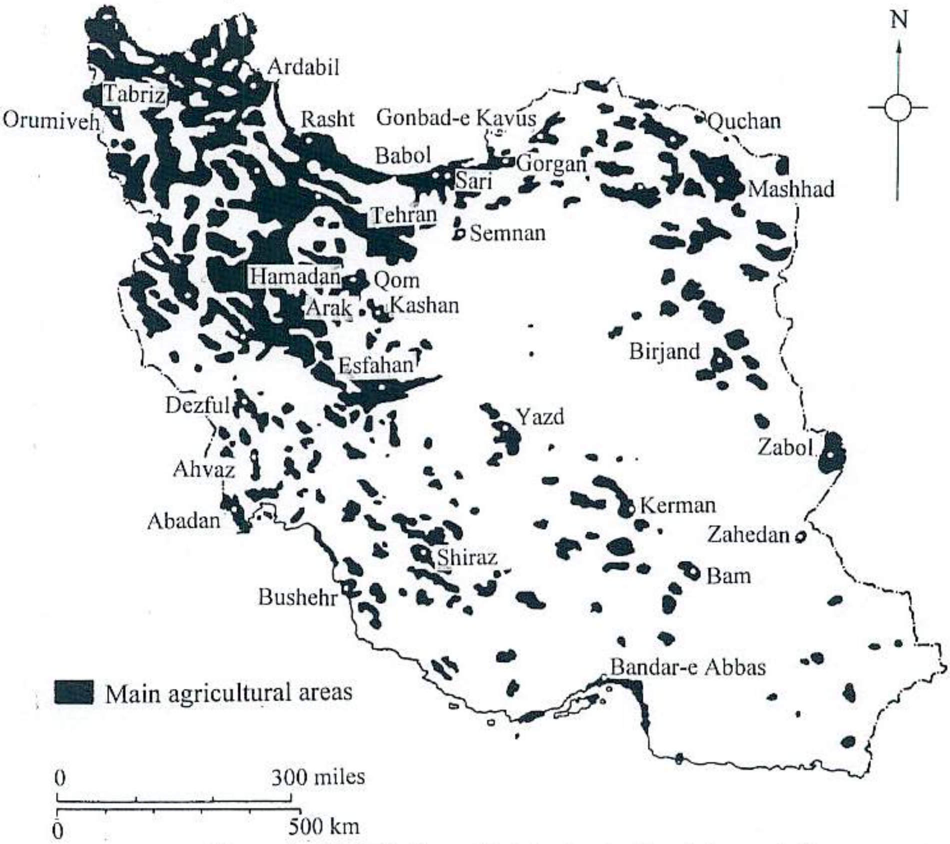

Figure 1. Distribution of Main Agricultural Areas in Iran

Source: Beaumont, *et al.*, 1976.

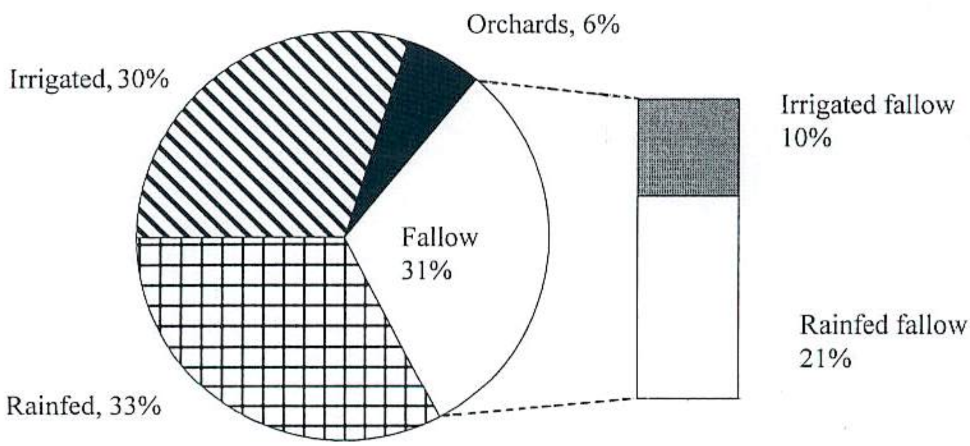

Figure 2. Distribution of Major Kinds of Agricultural Land Use in Iran

Source: Statistical Center of Iran, 1998b.

2. ***The 1962 Agrarian Reform***

The most important feature of land ownership in Iran before the 1962 Land Reform was the large-scale proprietorship of whole villages that varied considerably in area and population. The common unit of ownership was the village (*deh* in Persian). In fact, the general pattern of land ownership in Iran prior to the land reform was a combination of large-scale feudal land ownership with small-scale absentee and peasant proprietorship (Lahsaeizadeh, 1993).

An important change in the agricultural structure of Iran occurred after the passing of a land reform law in 1962. This limited the size of private holdings to 20 ha of irrigated land. As a result, large areas were distributed to landless laborers (Beaumont, *et al*., 1976). In 1976, the bulk of the rural population, more than 60 percent, dwelt on smallholdings of less than 10 ha, but their contribution was no more than 20 percent of the marketed output of the agriculture sector of the economy (Lenczowski, 1978). In tens of thousands of rural villages, cultivators and wage earners were freed from exploitation by landlords or their middlemen, but they continued to be confined in other ways. Many small landowners even experienced a decline in real income as their holdings diminished in size. Administrative and political difficulties, particularly the lack of managerial experience, limited the overall success of the land reform scheme in terms of agricultural production.

3. ***The 1979 Islamic Revolution and Land Distribution***

The smallholdings are an outcome of the 1962 Land Reform, when the first phase of the nationwide land reform was directed toward breaking up the large estates and distributing the village lands to the cultivators. In the current prevailing land tenure system, the size of individual holdings is small, with 60 percent being less than 20 ha (Figure 3).

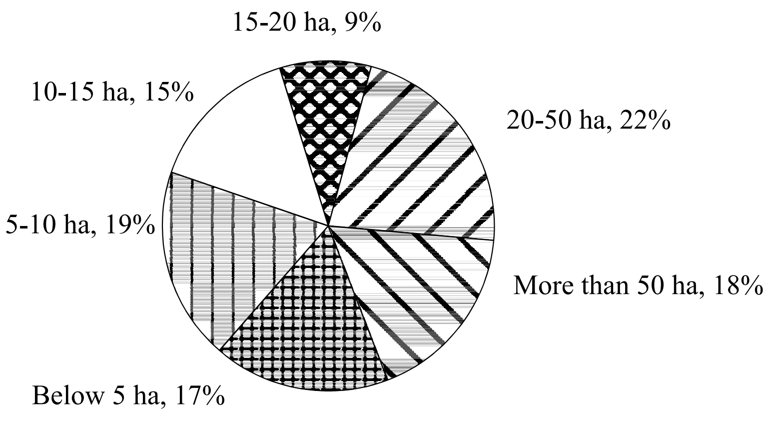

Figure 3. Size and Proportion of Land Holdings in Iran in 1993

Source: Statistical Center of Iran, 1998b.

The 1979 Islamic Revolution brought with it new social and structural forces that further transformed the agrarian structure. The most spectacular change in the modes of agricultural production after the 1972 Revolution was the establishment of *mosha* (collective ownership) cooperatives, a mode of production established after the 1979 Iranian Revolution (Lahsaeizadeh, 1993). In the private sector, on the other hand, the fall of many big agricultural bourgeoisie coincided with the maintenance of the middle sector, the preservation of large state-owned farms, the incorporation of large private farms into the public sector, the establishment of semi-public farm corporations, and the dissolution of production cooperatives. In addition, a piecemeal distribution of land instead of a genuine comprehensive land reform was conducted, which, in turn, created a new forms of relations to production. Most of the small-scale production units belong to independent peasants. Independent peasant production units are the basis for agricultural production in most parts of Iran.

4. ***Smallholdings and Their Associated Problems in Iran***

Since the country has a long history of agriculture, its habitants have already occupied almost all the fertile lands. In the more recent past, however, there had been a slight increase in the total area under cultivation, achieved through bringing under cultivation the barren lands and national resources lands with marginal agricultural potentials (gravelly lands, salt-affected lands, rangelands). By comparing the 1973 and 1998 agricultural censuses, it became clear that in a quarter of a century only 483,000 ha (2.8 percent) of new land areas were brought under cultivation (Ministry of Agriculture, 1992). In contrast, the population had increased about 85 percent within the same time period. Over the past 40 years, the population of Iran has been increasing at a high rate (Table 1). The current population of the Iran is about 60 million people, and these individuals are inflicting tremendous strains on land resources and the environment.

Table 1. Total Population at Successive Censuses

(Unit: 000)

Year	Urban Areas	Rural Areas	Total
1966	9,790	16,000	25,790
1976	15,850	17,850	33,700
1986*	26,840	22,350	49,190
1991*	31,840	23,640	55,480
1996*	36,820	23,030	59,850

Source: Statistical Center of Iran, 1998a.
Note: *Discrepancies in totals are due to inclusion of non-settled population in the county figures.

Because population increases rapidly and the area of cultivated lands remains almost unchanged, the per capita availability of agricultural land decreases over time (Table 2). During the past three decades, the per capita of availability of agricultural land has declined from 0.54 ha to 0.29 ha, a decrease of about 55 percent.

Table 2. Changes in Per Capita Agricultural Land in Iran Over Time

Year	1960	1974	1988-91
Per capita land (ha)	0.54	0.52	0.29

Source: Ministry of Agriculture, 1992.

The contemporary population trends in Iran indicate that the urban population is constantly increasing (currently, about 61 percent of the total population live in urban areas). In contrast, the rural population has remained almost stable during the last decade (Table 1).

The average population growth rate in rural areas of Iran is about 2 percent; therefore, the stability of the rural population suggests a high rate of out migration.

The rural population is also basically young with the recent high rate of out migration. The 1976 and 1986 census reports indicate that three million individuals have migrated from rural to urban areas. This migration is 13 percent of recent rural population of Iran. The age distribution of the rural migration shows that migrants usually belong to young age groups. On the other hand, the high rate of migration among children and teenage indicates an increase of family migration. With regard to the age distribution of migration, it seems that young people are seeking work outside of the agriculture sector, which will be approximately enough to pay for their way of life. The participation rate of the rural people is going to increase more rapidly in the future, for in the rural areas more than a third of active labor force is made up of young people between the age of 10 to 24 (Lahsaeizadeh, 1993).

The data given in Table 3 demonstrates that the land is not capable of supporting more people under current management levels, and indirectly shows that the share of the newly cultivated marginal lands in the economic development of the rural Iran has not been sufficient to encourage farmers to remain on land. Most of these lands possess various degrees of hazards and limitations for cultivation of most crops. Apparently, the benefits obtained from cultivation of these lands do not compensate for the costs of land reclamation and hence young people do not have incentives to remain on the land. According to the Ministry of Agriculture (1992) a total of 12,326 *mosha* (collective ownership) cooperatives, with 96,550 households as members were established after the Revolution. These cooperatives hold 586,670 ha of agricultural land (4 percent of the total cultivated land of the country), including 535,480 ha (91 percent) of barren, state-owned and national resources lands, and 51,190 ha (9 percent) of confiscated lands. On the average, each *mosha* covers seven households with 48 ha of land. This size means that each member works on 7 ha (the average holding size at national level). Since most distributed lands are either barren or uncultivated, cooperatives have to invest in heavy capital in order to prepare the lands for cultivation. In addition, the smallness of holding size does not allow economic food production at a level sufficient to meet the needs of the whole family.

SOIL RESOURCES

The Approach Adopted for Soil Characterization and Mapping in Iran

In Iran, in 1953, soil survey and land evaluation studies were initiated upon the establishment of the Soil Department of the Government of Iran (now Soil and Water Research Institute, associated with the Agricultural Research, Education and Extension Organization of the Ministry of Agriculture), attached to the Independent Irrigation Corporation (Bongah) of the Ministry of Agriculture (Dewan, 1967). SWRI has been involved in mapping the soils of Iran for about 50 years and up to now, about 20 million ha of land areas of the country have been surveyed at three levels of detail (reconnaissance, semi-detailed, and detailed). The results of the soil survey studies are published in the form of reports and maps. These include about 500 reports with accompanying maps. SWRI is the official body responsible for collecting information about soils, their geographical distribution, properties, behavior and use. It has been responsible for producing the National Soil Maps at 1: 2,500,000 scale (Dewan and Famouri, 1964), and at 1:1,000,000 scale in digital format (Banaei, *et al*., under the press), and over a thousand soil maps with different resolutions. The data gathered through long-term soil surveys provide valuable information about the capabilities and limitations of the soil resources for crop production.

Table 3. Distribution of Rural Population and Migration by Age Group in 1986

Age Group	Number	Percent	Rural Migration between 1976-86
Below 15 years	10,977,287	48.60	-1,343,529
15-19	2,399,995	10.62	-539,298
20-24	1,721,394	7.62	-420,546
25-29	1,411,615	6.25	-160,136
30-34	1,129,794	5.00	-28,908
35-39	846,540	3.75	-64,295
40-44	692,716	3.06	-66,522
45-49	711,145	3.15	-41,319
50-54	758,732	3.36	-37,435
55-59	640,919	2.84	-1,567
60-64	589,722	2.61	-3,679
65-69	272,634	1.21	6,324
70-74	160,636	0.71	-51,139
75-79	97,290	0.43	5,945
80 and above	177,707	0.79	-21,049
Total	22,588,126	100.00	-2,767,153

Source: Lahsaeizadeh, 1993.

Soil characterization and mapping were conducted, adopting the standards given in *Guide for Soil Survey and Land Classification for Irrigation*, prepared by the Soil Department of the Government of Iran, attached to the Independent Irrigation Corporation (Bongah) of the Ministry of Agriculture with the help of FAO experts (Mahler, 1970).

Following the standards given in the above-mentioned guide, lands were grouped into six classes depending on the capabilities and limitations of the soils for cultivation of annual crops under gravity irrigation, assuming that no land improvement works are made which would change the present limitations and qualities of the lands. Depending on the type of limitation, land classes lower than class I land were subdivided into subclasses by appending to the class number a letter showing the type of limitation (Table 4).

Table 4. Definitions of the Main Land Classes and the Basic Subclass

Land Classes		Basic Subclasses	
Class I:	Arable	**S** =	Soil limitation (texture, dept, soil permeability, infiltration rate, etc.)
Class II:	Arable	**A** =	Salinity or alkalinity limitation.
Class III:	Marginal arable	**T** =	Topography/erosion limitation.
Class IV:	Restricted arable	**W** =	Drainage limitation (flooding, ponding, presence of groundwater, pseudo gley, etc.)
Class V:	Undetermined arable		
Class VI:	Non-arable		

Agricultural Potential of the Soil Resources

Soil survey and land classification studies during the past 50 years, reveal that the majority of land resources possess various degrees of limitations (either individually or in combination) related to soil properties, salinity and alkalinity, topography/erosion and drainage, which limit economic and sustainable crop production. The results of soil survey and land classification activities in Iran (reconnaissance, semi-detailed and detailed), obtained from 1953 to 2000) are shown in Table 5.

Table 5. Area Covered by Land Classes in Iran

Land Classes	Area (000 ha)	Percent
Class I	1,300	6.5
Class II	4,290	21.45
Class III	5,340	26.7
Class IV	3,120	15.6
Class V	2,700	13.5
Class VI	2,250	11.25
Complexes*	1,000	5.0
Total	20,000	100.0

Note: * Any cross-bred of above land classes.

Of a total of 20 million ha land areas surveyed from 1953 to 2000 (including almost all irrigated lands plus the majority of dry-farmed areas), good-quality lands (class I lands) cover only 1.3 million ha (6.5 percent). The remaining lands have various degrees of limitation and/or hazards for irrigation farming. Class I lands do not possess hazards or limitations of soil, salinity, topography or drainage for irrigation farming under present conditions and are capable of producing sustained high yields of a wide variety of climatically adapted crops at reasonable costs under good management. Owing to the absence of apparent hazards of limitations at present, these lands are considered highly sustainable for irrigation farming and have a high income potential under normal conditions of soil and water management. However, in the semi-arid conditions of the country, their productive capacities are threatened by mismanagement. If sustainable crop production is to be practiced, changes in their quality under irrigation farming must be monitored through long-term studies.

Lands having slight to moderate hazards and/or limitations of soil, salinity, topography or drainage, for irrigation farming (class II + class III lands) cover about 9.6 million ha (about 48 percent of the total land areas surveyed). Moderately sustainable lands for irrigation (class II lands) are either adapted to a somewhat narrower range of crops than for class I land or they are more costly to prepare for irrigation (drainage, leveling, etc.) Under present conditions, these lands are expected to give lower yields, compared with class I land. Marginally sustainable lands for irrigation (class III lands) either have a restricted crop adaptability or are expected to give higher yields than those of class II lands, or will demand more costly land improvement and land preparation works or more costly management practices. The problematic lands (class IV + class V + class VI lands) cover about 8 million ha (40.4 percent of the surveyed area) and undifferentiated lands (complexes), 1.0 million ha (5 percent). A brief description of these land classes follows:

- Owing to their severe limitations of soil and/or topography for irrigation farming, class IV lands are considered non-suitable for irrigation under normal conditions of irrigation management. Under present conditions they must be used for cultivation of special crops or with special conditions of management that can cope with their limitations. Although under normal conditions of management most of the common tilled crops cannot be profitably grown on these lands, under special conditions (operation in units of abnormal size such as very intensive, or extensive cropping, irrigation from cheap sources of water, including flood waters, irrigation on steep slopes either after terracing, or by sprinkler, special crops such as vegetables, fruit trees, rice, pasture) irrigation farming can be profitable. This category of lands also includes those areas in which crops such as date palms, rice, etc. can grow under severe limitations of salinity and/or drainage.
- Class V lands are considered temporarily to have undetermined suitability for irrigation because of their severe hazards and/or limitations of soil, salinity, topography or drainage for any type of irrigation farming. If set free from limitations (such as salinity and excess water), these lands can play an important role in increased crop production and hence economic development of the country. In most cases, however, they require important land improvement works. It must be proven through investigations and trials that crop production on these lands is possible and feasible economically.
- Class VI lands possess hazards and limitations for any type of irrigation farming under present conditions. Because their reclamation is not technically and/or economically feasible at present, they are considered as non-arable lands.

WATER RESOURCES

According to Mannion (1995), in 1989 there were about 236 million ha of irrigated land worldwide, of which 73 percent was located in the developing world (Figure 4). In Iran, irrigation serves some six million ha of land, corresponding to about one half of the total cultivated area in the country (Table 6). In Iran, vast cultivable areas suffer from absence or shortage of irrigation water, thus availability of agricultural land is less of a constraint for the development of the land than the availability of water. Water supply has been a constant preoccupation since the beginning of the country’s history, thousands of years ago. The innovative *ghanat* irrigation, developed thousands years ago by Persian, represents the harshness of agriculture in the hostile climatic conditions of the country. The patterns of ownership and distribution of water for irrigation are crucial, especially if summer cropping is practiced.

Costs of Development

The establishment, extension and improvement of irrigation systems are key factors in increasing the country’s food supply from the available agricultural lands. This requires the optimum use of limited water resources and bears high costs. According to FAO (1997), the cost of surface irrigation development in Iran is US$2,300/ha for large schemes, US$2,500/ha for medium schemes, and US$2,600/ha for small schemes. Average operational and maintenance costs are estimated at US$130, US$175 and US$60/ha/year for the three scheme sizes, respectively. The costs of micro-irrigation and sprinkler irrigation development are US$2,200 and US$1,200/ha, respectively. The average price of water delivered to farmers by the government varies from US$0.2 to US$0.8/1,000 m^3, while the cost of withdrawal of groundwater by the farmer is US$5 to US$9/1,000 m^3 and the cost for regulating surface water in existing projects is US$3 to US$5/1,000 m^3. This indicates that the government heavily subsidizes delivered water.

(Unit: Million ha)

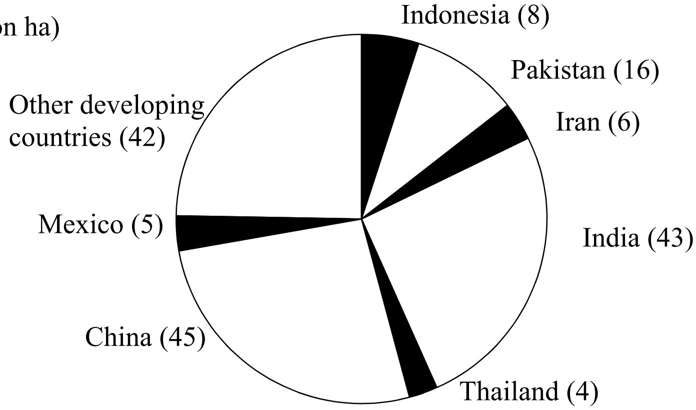

Figure 4. Distribution of Irrigated Land in Developing Countries

Source: Mannion, 1995.

Table 6. Basic Statistics on Agriculture of Iran

Physical Areas	Year	Area (million ha)	Percent of Total
Area of the country	1995	164.8	100.0
Cultivable area	1993	51.0	31.9
Cultivated area	1993	14.4	8.7
Annual crops	1993	12.7	7.7
Permanent crops	1993	1.7	1.0

Source: FAO, 1997.

Water Balance

Water supply in Iran consists of both surface and groundwater resources, totally amounting to 142 billion m^3 per year. In 1993, the surface water supply was 93 billion m^3 and the groundwater supply provided 49 billion m^3, of which the share of wells was 62 percent; *ghanats*, 21 percent; and springs, 17 percent. Of the total water consumption in Iran the share of agriculture sector was 60 billion m^3 (Jamab Consulting Engineers, 1990).

The intensity of groundwater resources (springs, *ghanats* and wells) in land areas is rather low, being one per 7 km^2 over the entire country's surface and one per 3 km^2 in the plains where agriculture is most concentrated. In spite of low amounts of annual rainfall and hence insufficient recharge of the aquifer in the arid and semi-arid conditions of the country, the proportion of annual discharge of groundwater to land area is high; 35,000 m^3/km^2 at the national level (based on the total area of the country) and 70,000 m^3/km^2 in the plains. The sparse distribution of water sources means that water confines agricultural development only in certain regions of the country. Water is the main factor governing crop production and is the main cause of the patchy nature of agriculture in Iran.

According to Jamab Consulting Engineers (1990) over a period of 25 years (1965-89) the amount of annual discharge from aquifers changed from 14 billion m^3 to more than 49 billion m^3, an increase of about 350 percent. Figure 5 shows an estimate of the water balance of Iran. In the climatic conditions of the country, the estimated total rainfall recharge reaching the aquifers is 46.6 billion m^3. On the other hand, the annual discharge from the groundwater is 49.7 billion m^3, demonstrating a negative water balance of 3 billion m^3 each year. Under the current management levels, this amount of groundwater together with surface water supplies is just adequate to irrigate the land areas, which are already under irrigation farming (7 million ha).

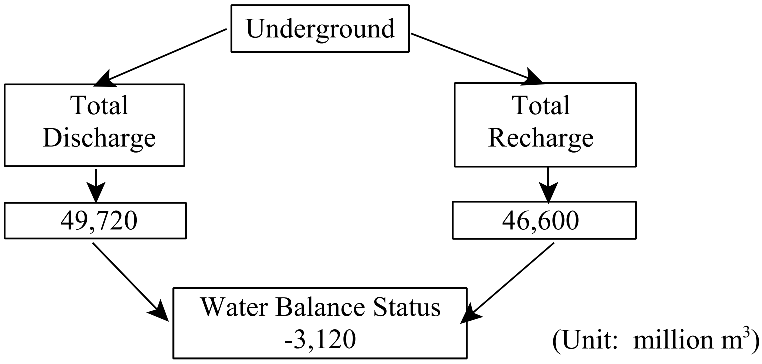

Figure 5. Estimated Water Balance of Iran

Source: Data from Jamab Consulting Engineers, 1990.

The negative water balance implies that: (1) no more new land can be brought under cultivation; and (2) the country is already facing a critical situation regarding the management of water resources and sustainable food production in existing cultivated lands. Excluding some striking regional variations, the negative water balance has to be regarded as an indication of a looming water crisis at the national level.

Water has been and is the ultimate factor controlling agricultural production in Iran. It is suggested that due to rapid rate of population growth, the water need of the agriculture sector will have to be increased by 20 billion m^3 (Ministry of Agriculture, 1996). If the requirements are to be met, groundwater resources will have to provide a greater proportion of the total supply. With current utilization efficiency rates, pumping additional water from aquifers will aggravate the situation. Supplying sufficient water to ensure food security for 100 million people will remain a real challenge in the next 20 years.

Water Management

In most parts of Iran, agriculture is still benefiting from the old irrigation canals. Water loss from old irrigation canals, is the major cause of low efficiency in water utilization (Justin-Courtney and Taleghani-Daftary, 1970). Development of the old irrigation canals was based on the experience accumulated by many generations and on excellent technical skills. Normally, large hand-dug canals, about two to five miles in width, generally unlined and thus allowing percolation losses through the bed and banks, make up to one half or more of the total intake volume. Canals usually commence at a point where the river leaves its upland course or from dam sites along the river courses, and radiates like the veins of a leaf to the cultivated area. Along the individual fields, breaches are made in the canal banks to permit basin or furrow irrigation. According to Ghassemi, *et al*. (1995), in the Marvdasht Plain (South-Central Iran) for example, water losses from old irrigation canals were about 40 percent. These losses, estimated at 12 m^3/s (422 million m^3/year), plus the losses in the irrigated fields were the major contributors to the rise in the water table to less than 2 m in a large part of the plain.

On-farm application rates in the country are rather high and in general irrigation has a low efficiency, 32 percent on average at national level. This means that only about one-third of the water delivered from the reservoir or pumped from the aquifers is actually used for crop production. At the world level, efficiency in water use is 40 percent and above (Ministry of Agriculture, 1996).

Improved efficiency in utilization was a high priority in the Second National Plan and it was expected to improve efficiency rates to 45 percent through land leveling, which, due to the relative evenness of the land, allows more uniform water distribution, better preservation techniques, such as lining of the irrigation canals, and improved irrigation methods. So far, hardly any good results have been achieved in this effort and hence the problem has remained unsolved. Increasing the efficiency in water utilization is also a priority in the Third National Plan. Although some actions have been taken to use water more efficiently, factors such as careless operation, poor on-farm management, and low water prices make it likely that irrigation efficiency will remain close to the present level.

The environmental costs of irrigation water are also high and depend on the efficiency and management of the irrigation system. Low irrigation efficiency may trigger soil salinity and water-logging, which are two major problems for crop production in the arid and semi-arid conditions of the country. While the water itself may become saline as well as contaminated with silt, pesticides and fertilizers, it may also give rise to aquifer contamination, which in turn creates problems for the domestic water supply. The most critical situation arises in the salt-affected areas. Irrigation water in these areas either comes from saline groundwater or is pumped from the drainage canals.

LAND DEGRADATION

In earlier times, the people of Iran found these solutions that enabled them to maintain soil productivity: (1) the management system was based on long fallow periods; (2) the land tenure system was governed by tenants who inherited expertise from their experienced ancestors, within the socio-cultural structure of the area; (3) cultivation was of low intensity; and (4) population growth was modest, with no demand for labor from other sectors.

At present, landowners, land tenants, program planners, and local authorities prefer short-term benefits rather than placing preservation above production. This is in contrast to sustainable land use, which optimizes current production within the framework of maintaining land productivity for the long term. Overexploitation of the soil resources threatens soil productivity and may lead to land degradation.

The information obtained from soil surveys and land classification studies in Iran reveals that large tracts of productive agricultural land had gone out of cultivation, because of the arid and semi-arid climatic conditions of the country, the inherent characteristics of soils that reflect their geological composition, mismanagement of the soil and water resources, and intensification of crop production on old arable lands with a long history of wheat cultivation. Of these, the last two factors are the most effective ones aggravating the situation.

Modern farming practices owe much to the legacy of the previous generations. Past activities have molded not only farming principles and experiences but also much of the environment in which modern agriculture takes place (Briggs and Courtney, 1994). In Iran, wheat cultivation is extensive in such a way that almost all agricultural lands have been the scenes of wheat cultivation for centuries. The area under wheat together with barley, which requires similar management, constitutes half of all cultivated lands. Although recently cultivation of a second crop after wheat has become customary, the long-term wheat cultivation and its management have to be seen as the main factors responsible for changes in land quality over time.

Of the soil degradation types recognized in the *Guidelines for General Assessment of the Status of Human-induced Soil Degradation* (Oldeman, 1988), chemical and physical soil deterioration are the types that are active in Iran. Among the most common types of chemical deterioration are soil nutrient loss and salinization. Soil physical deterioration occurs mainly through compaction by agricultural machinery and transportation vehicles and through the sealing and crusting of the topsoil, resulting partly from mismanagement and partly from natural processes. Water-logging is also an important soil degradation factor that has a close relationship with potential salinity hazards that may occur through mismanagement.

In Iran, land degradation has not been a matter of concern at the national level. Recently, however, some studies have documented the extent of this problem at a regional level. Reports from the field and research findings are confirming the compaction damage from increased field traffic. A study conducted by Moameni and Zinck (1999) in the Marvdasht Plain, an inter-mountain basin in the Zagros Mountains (South-Central Iran), exemplify the situations of land degradation in intensively cultivated areas of Iran. The authors used an integrated approach, using geo-statistical tools, remote sensing, and geographic information systems (GIS) to assess agricultural land degradation. Attention was focused to quantify changes in soil quality under long-term wheat cultivation, provoked by lack of a fallow period in the new intensive cropping systems of the area. The results obtained, demonstrated that the new agricultural land-use systems have led not only to soil chemical degradation, including nutrient depletion and salinity, but also to soil physical deterioration, such as soil compaction by agricultural machinery and crusting. A brief summary of the research procedures and the result obtained follows.

Soil Nutrient Losses

The contour maps depicting the spatial variability of soil fertility properties, obtained through geo-statistical analysis, were spatially referenced to the digital soil map of the area. This allowed the degree of soil nutrient loss within soil map units to be aggregated and the regional extent of soil nutrient loss to be mapped. The soil nutrient variability features, which were mapped with geo-statistical techniques, were related to geo-referenced units in the UTM projection system (WGS-84 ellipsoid), using the ILWIS software package.

A decision tree (Figure 6) was applied to generate information about the degree and extent of soil nutrient losses in each map unit. Four levels of soil degradation were considered, following Oldeman, *et al*. (1991). A query syntax in the form of 'IF, THEN and ELSE' statements was used to aggregate the degree of occurrence and the extent of nutrient loss within each soil map unit.

Soil Degradation Type	Soil Degradation Subtype		Rating	Degree of Soil Degradation
Chemical	Nutrient loss	N (percent)	>0.300	Light
			0.225-0.300	Moderate
			0.125-0.225	Strong
			<0.125	Extreme
		OC (percent)	>2.0	Light
			0.8-2.0	Moderate
			<0.8	Strong
		P (ppm)	>20	Negligible
			15-20	Light
			10-15	Moderate
			<10	Strong
	Salinization (mS/cm)		<4	Light
			4-8	Moderate
			8-16	Strong
			>16	Extreme
Physical	Compaction	CBR value	<3	Light
			3-6	Moderate
			>6	Strong
		Bulk density (g/cm)	<1.3	Light
			1.3-1.5	Moderate
			>1.5	Strong
	Depth to the groundwater table (cm)		150-300	Light
			100-150	Moderate
			50-100	Strong
			<50	Extreme

Figure 6. Decision Trees for Aggregating the Degradation Types Within Soil Map Units and Mapping the Extent of Soil Degradation at Regional Level Plain

Table 7 shows the statistics for soil nutrient losses in the Marvdasht Plain. Loss of total N is the most severe subtype of chemical soil degradation, strongly affecting 53,000 ha, corresponding to about 88 percent of the cultivated land (63 percent of the total area studied).

Table 7. Loss of Nutrients in the Topsoil (0-25 cm) as a Result of Crop Intensification in the Marvdasht Plain

Degree of Nutrient Loss	Soil Nutrients/Nutrient Sources								
	N (percent)			OC (percent)			P (ppm)		
	Area (ha)	Area (percent)		Area (ha)	Area (percent)		Area (ha)	Area (percent)	
		Percent Cul[1]	Percent Tot[2]		Percent Cul[1]	Percent Tot[2]		Percent Cul[1]	Percent Tot[2]
Cultivated:									
Negligible	-	-		-	-		36,000	60.0	43.0
Light	500	0.8	0.5	-	-		8,000	13.3	9.5
Moderate	6,500	11.0	8.0	21,500	35.8	25.5	11,000	18.3	13.0
Strong	53,000	88.2	63.0	38,500	64.2	46.0	5,000	8.4	6.0
Sub-total	60,000	100.0		60,000	100.0		60,000	100.0	
Non-cultivated:									
Mountain	24,000		28.5	24,000		28.5	24,000		28.5
Total	84,000		100.0	84,000		100.0	84,000		100.0

Source: Moameni and Zinck, 1999.
Note: [1] Percentage of the cultivated area covered by the contour maps of soil nutrient variable obtained through kriging techniques (i.e., 60,000 ha).
[2] Total area studied.

Strong variations in nutrient deficiency levels over the major part of the cultivated area indicate a large fertility imbalance between soil nutrients, which results from the overutilization of the soil resources and can seriously constrain future economic crop production in the Marvdasht Plain. The need to improve the management of soil fertility in a way that balances the productive capacity of the soils is an important challenge for sustainable crop production in the area.

Soil Compaction

In recent years, increased mechanization has increased the risk of soil compaction in areas, which were under wheat for centuries. For mapping the degree and extent of soil compaction at a regional level, the digital soil map of the Marvdasht Plain was rasterized in a GIS environment and used as a base map. The decision tree applied was constructed from soil bulk density values measured at representative sites, supplemented by CBR values measured in soil map units (Figure 6).

Soil compaction caused by agricultural machinery and transport vehicles is a serious problem in the Marvdasht Plain. Soils over the entire cultivated area are affected by compaction at various degrees of severity (Table 8). Strongly affected soils account for about 31,000 ha of land, corresponding to 24 percent of the total cultivated areas.

Table 8. Soil Compaction Status in the Marvdasht Plain

Degree of Compaction	Extent of Areas Affected by Compaction		
	Area (ha)	Percent of Cultivated Areas	Percent of Total
Cultivated areas:			
Light	55,155	43.4	30.2
Moderate	40,515	31.9	22.2
Strong	31,398	24.7	17.2
Non-cultivated areas:			
Mountain regions and rangelands	52,790	-	28.9
Dam reservoir	2,748	-	1.5
Total	182,606		100.0

The results obtained in Marvdasht Plain imply that land degradation is a widespread problem in Iran, but its geographical distribution and the total area affected are not known. Reviewing the extent of soil degradation at the national level can help raise public awareness about the loss of soil productivity and prioritize actions to be taken by decision-makers and policy-makers. Monitoring the results of current management practices and creating public awareness are crucial for maximizing societal benefits and sustaining the long-term productivity of the soil resources within practical economic limits and according to the capability of these vital resources.

CAUSATIVE FACTORS OF SOIL DEGRADATION

Iran has a high potential for producing wheat, which is the staple food of the country. During the past three decades, attempts have been made to ease the problem of feeding the increasing population by intensifying agriculture and bringing marginal lands under cultivation without adequately considering soil conservation measures. The result of such practices has been to lower soil productive capacity.

Some of the important factors involved in soil degradation in Iran are given in Figure 7. The immediate cause of soil degradation is mismanagement. Besides improper tillage, the discontinuation of animal husbandry, the lack of fallow periods and the burning of crop residues are the main factors responsible for the deterioration of soil physical conditions and for the fertility decline. In general, overexploitation and mismanagement lead to declining soil productivity. The overexploitation is partly because of accelerated investment that seeks profit maximization with little or no effort at maintaining soil productivity.

Public awareness is a key factor in relation to soil quality resilience and the renewal of soil fertility. This can be achieved by raising farmer's knowledge about the magnitude of the damage. In recent years, much has been said about the potential for increasing crop yields and reusing degraded soils, but little has been done to assess and monitor soil quality deterioration. Food increases through the intensification of agriculture without considering soil conservation measures has been bought at the price of potentially less food production in the future.

YIELD GAP ANALYSIS

Taking into account the suitability of the environmental conditions and the good adaptability of wheat to these conditions, two important questions arise: (1) how far is wheat productivity in Iran from potential yield (about 14.7 mt/ha); and (2) how stable is crop production in the country?

The concept of the four A's of wheat productivity (absolute, attainable, affordable, and actual yields) provides a good basis for evaluating the economic stability of commercial wheat production, the main cultivating enterprise in Iran (Figure 8). The four A's of wheat productivity are defined as follows.

The **absolute yield** is the yield possible with no limiting factors, on the basis of the genetic potential of the crop in a certain area. It is the theoretical maximum yield of wheat, which at least matches the world record yield (now about 14.7 mt/ha). The crop is amply supplied with water and nutrients and is free from weeds, pests and diseases. Its growth period length depends only on the physiological characteristics of the crop and the current radiation and temperature conditions.

The **attainable yield** is the yield possible in a given environment, year, and area. It is limited by climate, soil depth, and other given factors, such as water shortage for at least part of the growing season, which cannot be changed. The attainable yield of wheat is limited by rainfall, growing degree-days, temperature extremes, intensity of sunshine, and day length. It is at least as high as the best yield obtained in any given area, season, and management system on a given soil.

The **actual yield** is the yield harvested in any given field and is the outcome of the crop response to growing conditions, counterbalanced by weeds, insects, diseases, nematodes, salinity, fertilizers, compacted soil, frost, or other production hazards. The actual yield might be more appropriately called the allowed yield – allowed by the competitors and other specific but manageable problems or limitations in the field.

The **affordable yield** is limited by economics and is determined by the potential value of the actual yield offset by the price that is paid to achieve that yield. The price includes the short-term direct costs to the farmer and the long-term costs to the industry and eventually to society.

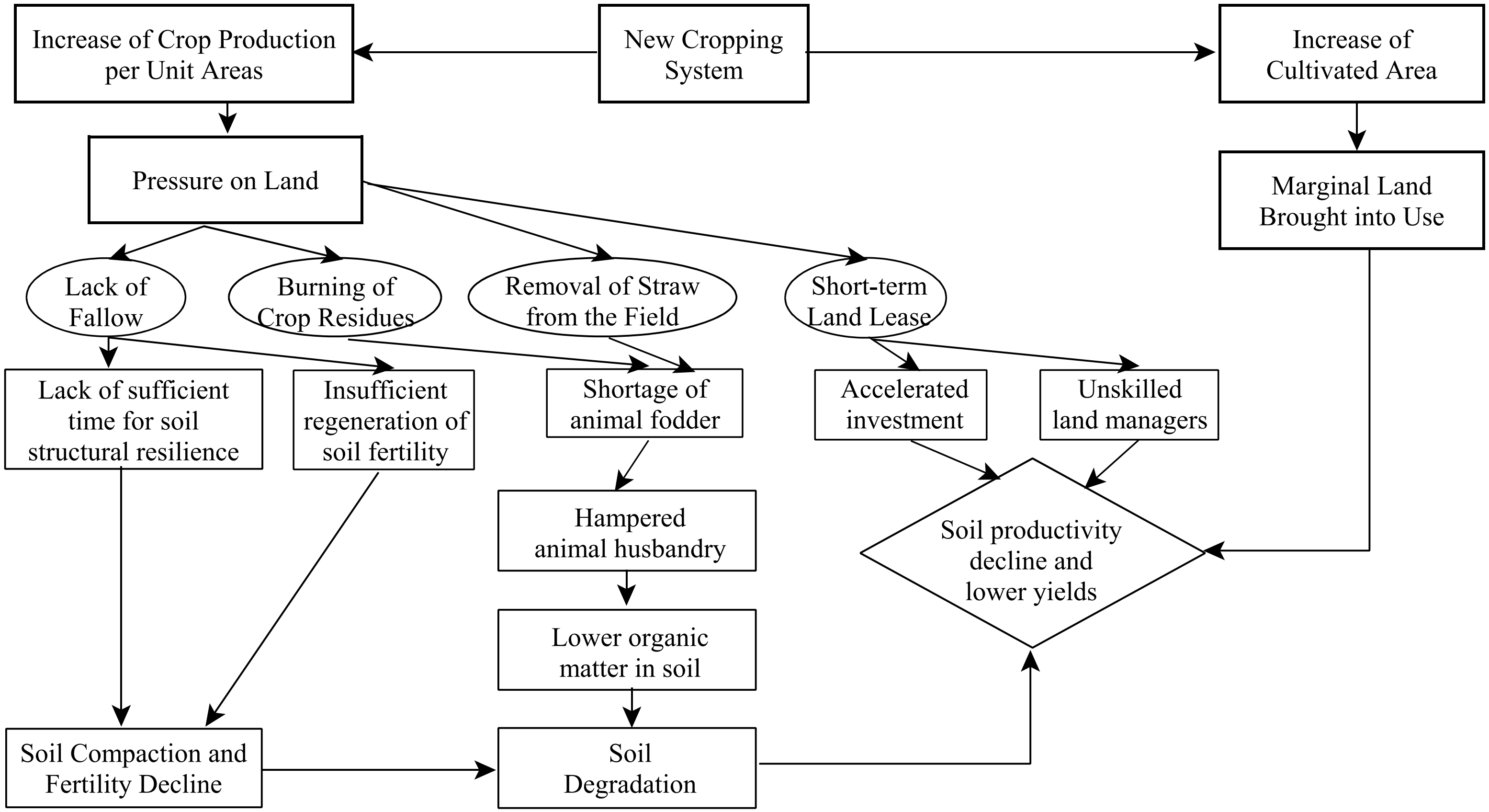

Figure 7. The Causative Factors of Soil Degradation under the New Cropping Systems in the Marvdasht Plain

Source: Moameni and Zinck, 1999.

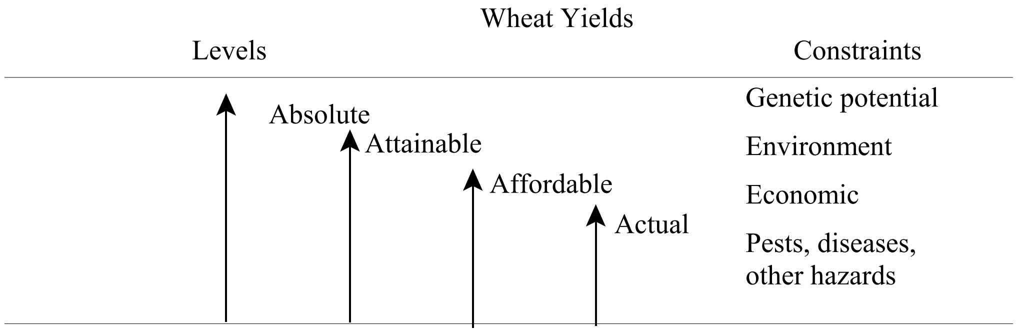

Figure 8. The Four A's of Wheat Productivity: Absolute, Attainable, Affordable and Actual Yields

Source: Redrawn after Cook and Veseth, 1991.

In the semi-arid conditions of the country, the absolute yield may not be achievable. The attainable yield may also be constrained by the environmental conditions. Therefore, the economic stability of the crop production must be judged on the basis of the actual yields obtained under current management levels. The data given in Table 9 show that during the past two decades, there has been a real increase in wheat yield under irrigation farming, achieved through better managing of manageable problems. In 1997, the average yield of wheat in Iran was 1,600 kg/ha (irrigated and rainfed). This amount is far below the records obtained in leading countries (7,590 kg/ha in Germany) and is 40 percent below the world average (2,634 kg/ha) (Ministry of Agriculture, 1998a). Under irrigation farming, the actual average yield of wheat was 3,150 kg/ha, which is about one-fifth of the wheat potential yield (about 14,700 kg/ha). Wheat yield in rainfed areas is also very low, on average 730 kg/ha at the national level. Since Iran is a drought-prone country, yields fluctuate widely in rainfed areas having varied climatic conditions. However, the average of long-term yield averages (730 kg/ha) signifies the status of agricultural productivity under rainfed conditions.

Table 9. Average Yield of Wheat in Iran Over Time

Year	Wheat Yield (kg/ha)		Year	Wheat Yield (kg/ha)	
	Irrigated	Rainfed		Irrigated	Rainfed
1981	1,695	588	1990	2,264	766
1982	1,843	671	1991	2,561	781
1983	1,710	597	1992	2,901	799
1984	1,735	639	1993	2,777	947
1985	1,852	643	1994	3,050	856
1986	2,031	771	1995	3,096	967
1987	1,964	710	1996	3,037	772
1988	2,097	763	1997	3,146	720
1989	2,033	442	Average (1981-97)	2,341	731

Source: Ministry of Agriculture (1998b).

In Iran, the cost of inputs to wheat production, such as mechanized row cropping, use of fertilizers, improved seeds, pesticides and harvesting are high. Therefore, the crop yield may not be directly related to the input level but rather reflects the effect of land management practices on the production capacity of the soils. The gap between actual yield and absolute yield can be regarded as inefficient use of soil and water resources. It can also be indicative of degradation of the soil resources by mismanagement, which has lowered their inherent production potential. Accordingly, the actual yields reflect the current production capacity of soils deteriorated through mismanagement during years of wheat cultivation. There is a trade-off between production capacity of the soil resources and land management activities. Within the agriculture sector, strengthening farmers' capacity to better learn and use the new technology of crop production is the most salient strategy for development of agriculture.

FOOD SECURITY

Estimates suggest the population growth in Iran will stabilize around the year 2025 at approximately 100 million people. Feeding 100 million individuals is the big challenge ahead. Under the most optimistic conditions additional food and fiber have to be produced each year for more than one million additional people from land already in use. It can be understood from trends of past and present food imports that the existing land resources have not been used optimally to fulfill the nutritional needs of the population (Table 10).

Table 10. Basic Food Commodity Import

(Unit: 000 mt)

Commodity / Year	1987 (A)[1]	1997 (B)[2]	Percent (B/A)
Wheat	4,960	5,942	120
Rice	787	673	86
Vegetable oils	448	610	136
Sugar	434	1,189	274
Total	6,629	8,414	127

Notes:
[1] Ministry of Agriculture, 1996.
[2] Ministry of Agriculture, 1997.

The data given in Table 10 connote a never-ending competition between food and population in Iran. The race between food and population has been one of the deciding factors in food security and national development. During the past decade, this competition has been in favor of population and will probably remain so at least for the next 25 years. Low productivity rate, aggravated by mismanagement has led to insufficient food production from the land resource. According to Plan and Budget Organization (1999), currently, about 20 percent of the total population of Iran suffers from food insecurity. If the needed actions are not taken, the future generation will probably suffer more from underfeeding.

The excessive subsidies paid by the government in recent years (Table 11), imply low economic returns that should be thought of in the context of declining soil productivity. In other words, without government subsidies and/or yield improvement, the production of crops (especially wheat) will not be profitable. Low farm income may also stimulate the migration of rural population to urban centers, although research conducted in Iran showed that families stayed and produced so long as the profit from the farm as a whole equaled or exceeded the family labor costs (Soltani, 1982).

Table 11. Food Subsidies Paid by the Government

(Unit: Rl. billion)

Commodity / Year	1987 (A)	1992 (B)	1994 (C)	Percent (C/A)
Wheat	45.2	1,154	2,528	5,593
Sugar	29.8	205	288	966
Meat and dairy	-	-	140	-
Rice	21.0	103	169	805
Vegetable oils	-	-	501	-
Tea	-	100	-	-
Total	96	1,562	3,626	3,777

Source: Statistical Center of Iran (1998a).

CONCLUDING REMARKS

In addition to smallness of landholding sizes, fragmentation of land ownership and the distances between farms are determinant factors for the sustainability of crop production in Iran. The fragmented land ownership and the distances between farms pose new problems, which can eventually lead to uneconomic holdings in the new cropping systems and will be an obstacle to agricultural development. This is because mechanized crop production on small farms may not be economically justified (Soltani, 1978). Hence, the mechanization process now favors land consolidation. Some of the main reasons for this are the following:

1. Some farms are too small to economically support individual families;
2. Every farm needs separate equipment for land preparation, sowing, harvesting and irrigation;
3. When farms are below a certain size, the use of new technologies is not feasible for the farmers;
4. The use of machinery on small scattered holdings in irregular plots distributed over village territories is often inefficient;
5. Because land is worked individually, mobilization between the mosaics of tiny fields requires long journeys; and
6. Because of fragmented land ownership and the distances between farms, it is difficult to introduce consolidation and mechanization efficiently.

These problems affect most farmers. On the other hand, experiences in Iran have shown that with no comprehensive consolidation plan, land worked collectively is often poorly maintained. During the 1960s, several farm corporations were founded, in which individual farmers in a village transferred their holdings to the corporations in return for shares in highly capitalized agribusinesses. The purpose was to establish rural cooperatives as institutions through which communal production programs could be engineered and promoted in a manner that, by substituting shares in a corporation for land itself would not take away the land ownership. In 1971, one of these corporations was established in the Marvdasht Plain by integrating a number of farms (Moameni, 1999). After the failure of the farm corporation, the consolidated lands were again divided into private holdings. The main reasons for the failure of the farm corporations were lack of sufficient information on the socio-economic norms of the rural societies involved and lack of a logical basis for land consolidation. Farm corporations were established on lands with heterogeneous soils having varied capabilities and limitations for crop production. These lands were managed similarly, in spite of the fact that each land area may need specific treatment. Variations in production capacities of the soils, as reflected by yields obtained, became a basis for conflict. Without a coordinated and comprehensive national plan for land consolidation, crop production through collective work can lead to land degradation.

Although individual owners pay more attention to their land, at present both the land and the farm family are under pressure. The intensification of agriculture leaves no room for fallow or the resilience of declining soil production capacity. On the other hand, the farm family suffers from undesirable economic conditions, brought about partly by population pressure and partly by land partitioning. This means that farmers put more pressure on the land in order to obtain more income and improve their welfare.

A study conducted by Karami (1983) showed that farmers with smallholdings were unable to take advantage of the new technology and were thus less productive. The low productivity of small farms constrains sustainable crop production at regional and national levels.

Small landholdings were well-adapted to traditional agriculture. With increasing population pressure and more efficient technology, they are coming under increasing strain. In the long run, they may be not adaptive at all. Therefore, for an economic crop production it is necessary to determine a minimum farm size that can provide appropriate living standards for farmers. According to Soltani (1978), who evaluated the productivity of small versus large farms in Iran, the optimum farm size for economic crop production should be at least 12 ha. Accordingly, the extensive arrays of smallholdings need to be restructured and consolidated. The policy-makers must attempt to marry independence with production incentive and encourage farmers to voluntarily restructure the land ownership pattern of the village and increase the proportion of medium-sized holdings, without the compulsory dislodgment of rural families. Delimitating of lands having comparable production capacities as a prerequisite for land consolidation, seems promising for resolving many problems, which hinder planned production through collective work.

The agriculture sector should not only provide food, fiber and employment for the rapidly growing population, but should also preserve and even nurture its resource base for future generations. There is much land left uncultivated in Iran, but availability of irrigation water hinders further agricultural expansion. Irrigation water is the major limiting factor for agricultural development and areas where the combination of land and fresh-water resources is well-suited to agriculture are, for the most part, already in use. To keep pace with the growing population, agriculture should become more intensive. The productive capacity of the soil resources must be improved if the well-being of the habitants is to be sustained.

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6. REPUBLIC OF KOREA

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INTRODUCTION

Geographysical Situation of Korea

Korea, situated longitudinally between 124°11'E-131°52'E and latitudinally between 33°06'N-43°N in the northern temperate zone of the Eastern Hemisphere, is a mountainous peninsula in the far east extending southeast from Manchuria . The overall area of the Republic of Korea is 99,022 km^2.

Philosophy of Land in Korea

In Korea, land has important meanings going beyond being a resource for agricultural production. Landholding is an integral part of the Korean mentality. Thus, any attempt to change the existing land ownership system receives a cool reaction. Farmers, as well as urban dwellers, regard land as an asset. They want to keep their landholding in preparation for their retirement and for the purpose of increasing their property.

Koreans have a special interest in land system and place a very high value on land. This attitude has become a major restraint hindering the flexible use of land. In fact, several policy change attempts for the more versatile use of land have failed due to serious opposition from landowners during the last decades.

General Characteristics of Agriculture in Korea

Korean agriculture is characterized by small subsistence farms. Average farm size remains at around one ha in the form of small plots scattered in the mountainous areas of the country. Rice is the dominant crop, accounting for about 31 percent of the total agricultural production value, and approximately 60 percent of the total area cultivated in 1999. Despite the dominance of rice, rising income and population growth have created increased demands for livestock products, vegetables, and fruits.

Agriculture has become very intensive with respect to its use of input such as fertilizers, pesticides, and machinery. As a result of government attention and investments focused on the industries sector, the gap between the rural and urban sectors has widened at a steady pace and infrastructure, educational facilities, and medical services in rural areas are far inferior to those in urban areas.

A series of agricultural policy reforms is aimed at preparing the sector to compete in world markets and to proceed to a more advanced sector. This and other changes mean that the Korean agriculture sector is in transition and it is becoming more market-oriented, although the pace is gradual.

The Current Land Utilization Systems in Korea

In Korea, the Rural Development Administration (RDA) finished a detailed soil survey for cultivated land throughout the country and part of reclaimable hillside areas by 1976 and completed the detailed soil survey of the whole country including mountainous areas in 1987 for the following purposes: improved fertilizer application; collective farming for particular crops; improving soil utilization; and planning for best management of farmland. The results of the soil survey include 9,750 reconnaissance soil maps (1:50,000) and 76,000 detailed soil maps (1:25,000) for eight provinces and 137 cities and counties, respectively. Other results are soil series descriptions, soils of Korea, paddy soil in Korea (with soil profiles in color), upland management, paddy soil management, suitability class for land use, and interpretative soil maps.

The survey results show that the distribution and areas of soil in Korea decrease in the order of forest lithosol, alluvial soil, lateral moraine, and calcareous soil. The calcareous soil is found in the northeast but the lateral moraine is found west along the coastal line.

Status and Changes of Farmland in Korea

At the end of 1999, the total land area of the Rep. of Korea was 99,600 km^2, and per capita land area is 0.0023 km^2. Of the total land area, there are 1,899,000 ha (19.1 percent), 6,430,000 ha (64.8 percent), and 1,614,000 ha (16.1 percent) for farmland, forestry land, and others, respectively (Figure 1). The remainder is the area that is used as residential, industries, roads, rivers, and small watersheds, etc. Thus, nearly 20 percent of the total land area of 9.9 million ha is cultivated while the remaining 80 percent of the land is mountainous and not suitable for agricultural use.

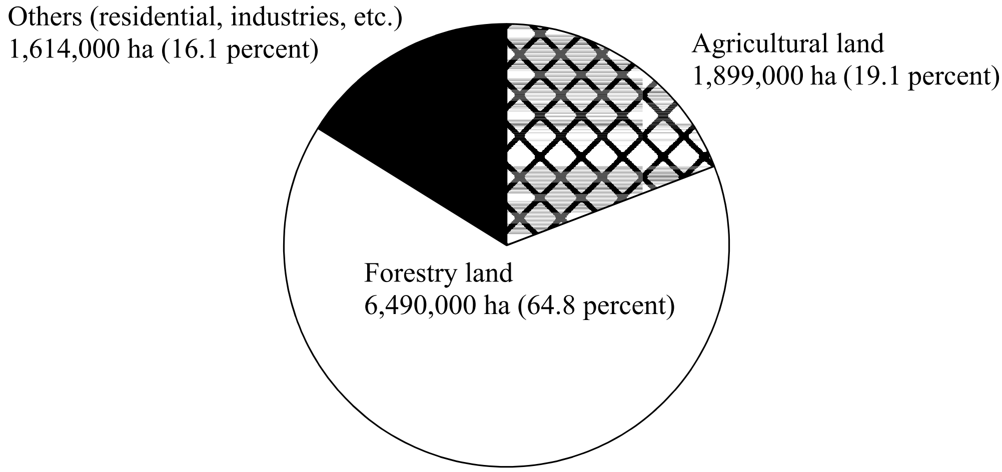

Figure 1. Status of Land Uses in Korea, 1995

During the last three decades, land encroachment from urban and industrial sectors and conversion of farmland to other uses have increased due to continued industrialization, whereas the total land area increased from 9,848,000 ha to 9,943,000 ha during the same period (Table 1). The reason of the increased total land area was mostly contributed by reclamation in the southwestern coastal area. The area of targeted reclamation in the southwestern coastal area will be 157,000ha (government fund: 117,000 ha; and civil fund: 40,000 ha) by the end of 2005. As of now, 76,000 ha had already been developed while 60,000 ha are currently still being developed.

Table 1. Trend in Land Use

(Unit: 000 ha)

Year	Farmland	Forestry	Others*	Total
1965	2,256 (22.9)	6,614 (67.2)	973 (9.9)	9,843 (100.0)
1970	2,298 (23.3)	6,611 (67.1)	939 (9.6)	9,848 (100.0)
1980	2,196 (22.2)	6,568 (66.3)	1,135 (11.5)	9,899 (100.0)
1990	2,109 (21.3)	6,476 (65.3)	1,341 (13.5)	9,926 (100.0)
1995	1,985 (20.0)	6,452 (65.0)	1,490 (15.0)	9,927 (100.0)
1999	1,899 (19.1)	6,449 (64.8)	1,601 (16.1)	9,949 (100.0)

Source: Ministry of Agriculture and Forestry, MAI, 1999.
Note: * Includes residential, industrial, and recreational uses.
Figures in parentheses are percent.

In 1999, the total farmland area was around 19.1 percent of the total land area, while it stood at 22.9 percent in 1965. The land utilization ratio in 1999 fell down to 107.8 percent, from 113.1 percent in 1990. Reasons for the decline include labor shortage in rural areas and lower profitability in farming.

Other uses of farmland, both of the arable land and other areas of land use, gradually decreased since 1970 from 3,500,000 ha and 2,300,000 ha to 2,130,000 ha and 1,899,000 ha for land uses and arable land area between 1970 and 1999, respectively. This was mainly caused by rapid decrease in the number of farmers and sudden changes of crop rotation in paddy land such as rice-barley or wheat, and the changes of food consumption patterns and importation of cereal crops.

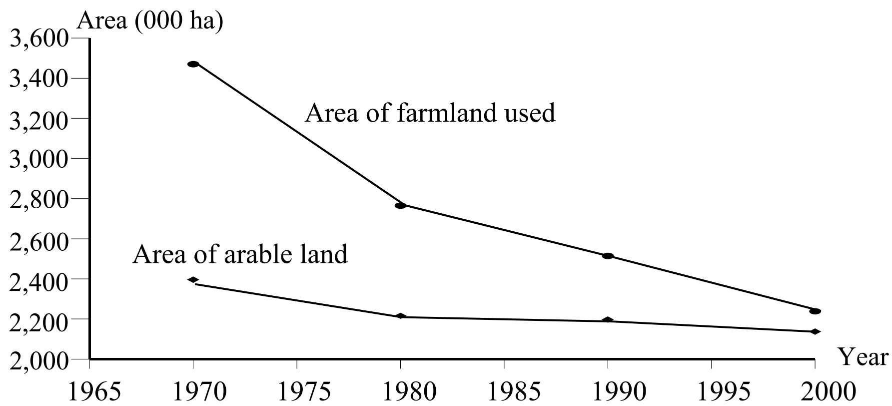

Figure 2. Trend of Arable Land Area and its Usage in Korea Since 1970

Table 2 shows the changes of farmland areas for the last 30 years since 1970. The reduction of total agricultural land area between 1970 and 1999 was 398,600 ha, and the maximum reduction occurred between 1990 and 1999, almost equal to twice those of the

1970s and 1980s. For changes in farmland, the largest reduction was paddy land, which was much as 192,700 ha due to mostly by conversion into upland crops.

Table 2. The Changes of Farmland Areas in Korea Since 1970

(Unit: 000 ha)

Year	Paddy	Upland	Total Farmland	Area Per Capita
1970	1,272.9 (0)	1,024.6 (0)	2,297.5 (0)	0.93 (0)
1980	1,306.8 (+33.9)	889.0 (-135.6)	2,195.8 (-101.7)	1.02 (0.09)
1990	1,345.3 (+38.5)	763.5 (-125.5)	2,108.8 (-87.0)	1.19 (0.17)
1999	1,152.6 (-192.7)	746.3 (-17.2)	1,898.9 (-209.9)	1.37 (0.18)

Note: * Inside the parenthesis indicates the decreasing/increasing land area.

However, the upland area was also reduced by 17,200 ha, even though the large area of paddy land was converted into upland. This was caused by rapid expansion of urban areas and residential complexes between 1985 to 1999.

1. ***Paddy Fields Covering Over 60 percent of the Cultivated Land***

About 60.4 percent (1.2 × 106 ha) of the 1.9 million ha under cultivation in 1999, was paddy fields for production of the staple crop, rice. The remaining 39.6 percent was upland. These proportions have remained largely unchanged since 1960, although the ratio of paddy field area to upland area varies from region to region. In addition, most farms in Korea have several parcels of land, which leads to a fragmented farm structure. The possibility of expanding crop land is limited, judging from the past trends and an increasing demand for non-agricultural land uses.

2. ***Land for Non-agricultural Use***

Land demand for non-agricultural uses such as residential, industrial and recreational purposes has been increased in recent years due to increased industrialization and urbanization. The proportion of agricultural land diverted to other uses increased from 9.9 percent in 1965 to 14.9 percent in 1999, and the trend is likely to continue. Since the 1980s, there has been a specific effort to reverse this trend. To increase the total agricultural land area, large-scale land development projects were undertaken at a considerable cost to the national budget. These large-scale projects have been undertaken not only for the purpose of increasing the food production base, but also for expanding land area available for industrial, housing, highways and other uses. The distribution and areas as of 1999 was shown in Table 3. However, the areas for upland and live stock have been gradually increasing since 1990.

Table 3. Types and Distribution of Farmland in 1999

(Unit: ha)

Paddy	Upland			Livestock	Others	Total
	Orchard	Special Crop	Vegetable Crop			
1,379,637	150,554	39,052	253,421	74,605	2,540	1,899,809

CONSTRAINTS TO IMPROVING LAND UTILIZATION SYSTEMS

Forest Area

In Korea, as of 1999, forestland is about 6.5 million ha, representing 65 percent of the total land area. Forest lands are classified into national, public and private forests by ownership and are classified into reserve and semi-reserve forests according to utilization. Approximately 22 percent of the forestland is national forests, most of which are permanent forests and the remaining national forests are disposable forests which may be converted to other uses. On the other hand, the private forests, owned by private individuals, and organizations such as people's parties, families, and cooperative groups, constitute 71 percent of the total forestlands, turned over to private forest owners and to date, the response has been good. However, utilization of these forestlands are restricted by slope gradients, ownership, regulations, and others. The slope distribution, which is the important constraint in using forestland as farmland, is as follows in Table 4.

Table 4. Slope Distribution of Forest land in Korea, 1999

(Unit: Percent)

Less than 15°	16-20°	21-25°	26-30°	Greater than 31°
2.8	8.4	11.0	15.3	62.5

As shown above, only 2.8 percent of the forestland can be converted into arable farmland in Korea. During the period of 1991-99, 19.9 percent of the forestland located at less than 200 m in elevation was converted as a farmland, industries, and other uses. The forestland converted as farmland can also be used for livestock or grassland due to management problems including cultivation and climatic conditions. Thus, the limitations placed on forestland are the most critical obstacle in improving the land utilization system in Korea.

Deterioration of Soil Quality by Erosion and Salinization

Soil in Korea is highly erodible because the land is steep and fragile because of frequent tillage. Erosion remains the most serious threat to the health of our soil and which is vulnerable to water erosion rates above the soil loss tolerance level during the heavy rainy season between June and August in Korea, which is when the maximum rate of soil erosion can occur and still permit profitable crop production to continue indefinitely.

Salinization also threatens crop land productivity and the long-term health of the land. Approximately 80 percent of the greenhouse farmland are affected by a build-up of salts in the soil, caused mainly by irrigation of poorly drained soil and soil compaction due to frequent traffic. These factors affect the farmland utilization ratio, resulting in longer fallow period and high input of farmland management.

Prevalence of Small-sized Farms

The rapidly aging agrarian workforce hinders efficient utilization of farmland. Since 1970s, the rural population over the age of 65 has ballooned from approximately 50 percent to over 80 percent. The trend is exacerbated by an exodus of youth that leave their parents' farms for better wages in the city. Farming incomes have grown, but they have not kept pace with gains in other sectors.

In 1999, about 59 percent of total farms had less than one ha, 27 percent had between one ha and two ha, and 13 percent had more than two ha (Table 5). Few farms have more than three ha compared to the 1970 farm distribution by size. The proportion of farms with less than one ha has declined by 6 percent. Over the same period, the proportion of farms with three ha or more increased from 1.5 percent to 4.9 percent.

Table 5. Number of Farm Households by Arable Land Size

(Unit: 000 farms)

Year	Less than 1 ha	1.0-2.0 ha	2.0-3.0 ha	More than 3 ha	Total
1970	1,611	639	124	37	2,411
1980	1,360	629	108	31	2,128
1990	1,027	543	129	44	1,743
1999	861	383	115	70	1,429

Sources: MAF, *Statistical Yearbook of Agriculture and Forestry*, 1998; and MAI, 1998.

On the other hand, the small-sized farm structure has remained virtually unchanged since the 1960s, although the ratio of paddy field area to upland area varies from region to region. In 1970, farm size was 0.9 ha on average. There was a marginal increase in average farm size to 1.0 ha in 1980. The average farm size increased to 1.34 ha in 1999 mainly due to increased rural-urban migration and is expected to remain unchanged in the near future.

Given the limited arable land and the number of farm households, it is not surprising that most Korean farms are very small. The average farm size of Korea contrasts sharply with that of other countries. The prevalence of small-sized farms has been a major contributor to some of the current problems facing Korean agriculture.

MEASURES TO RESOLVE CONSTRAINTS OF LAND UTILIZATION

Improvement of Forestland Utilization System

For efficient utilization of forests, the government established the “forestland utilization plan” by a Presidential Decree. The purpose is to meet the various demands on forestland and to harmonize conservation and development goals, the forestland-use system was revised to reclassify all forestland into three categories: productive, protective and convertible (multipurpose) forests. All types of forest will be intensively managed to accomplish their functional purposes. However, the details are still under development.

Improvement and Preservation of Soil

The provinces and local governments shall devise policies concerning the improvement and preservation of the soil, and policies related to the experiment, research, survey, etc., so as to help farmers and agricultural corporate bodies continue their agricultural management in a pro-environmental manner.

In order to achieve the purposes mentioned above, the province may provide support through local government; such agricultural producers’ associations as prescribed by the Ordinance of the MAF. Farmers, or agricultural corporate bodies that can implement such projects for the improvement and preservation of the soil, etc. with a part of the fund required for the implementation of the said projects, within the limit of the relevant budget. The projects that can be executed follow.

1. ***Farmland and Drainage Improvement Project***

The farmland development project includes 690,000 ha out of the total 1.157 million ha of paddy field area. The remaining 467,000 ha are being developed by the general farmland and simple farming-base improvement project.

The 200,000 ha of excellent farmland of the improved farmland is plotted in one ha farms or farm of larger size suited to large mechanized farming, and have paved agricultural roadways so it comes under the large-plot farmland improvement project for the enhancement of agricultural productivity.

In the development of agricultural water, improvement of drainage and preparation for cultural villages especially, there is a simultaneous development. The Korea Agricultural and Rural Infrastructure Cooperation (KARICO) is responsible for investigating, designing and supervising development as necessary in coordinating all of the interrelated projects.

Moreover, the drainage improvement project that targets the repeatedly flooded farmlands is a totally public-funded project. The pertinent area involves a total of 235,000 ha, of which 92,000 ha were completed in 1999. The remaining 143,000 ha area will be finished by 2014.

2. ***Enforcement of Farming-scale Improvement Project***

The farming-scale improvement project is to enlarge farming scale through transaction, long-term lease and by promoting the consolidation of farmlands to heighten rural productivity and revenue by exchanging and re-plotting the farmland.

Some 71,000 professional rice farmers had been selected by 1999 and some ₩1,573 billion was allocated for their support so that the average farming-scale per supported house could be increased from 2.11 ha to 3.47 ha after support. According to farming-scale enlargement, the ₩10-million of revenue increased per house was the result of the cost reduction from larger-scale farming. Some 82 percent of the farmers in scale farming are less than 50 years old, which has lowered the average age of farmers, and has set the foundation for a key agricultural operational entity. The 80-percent of supported farmland is adjacent to the existing land within 500 m so that the efficiency of agricultural management has greatly increased.

3. ***Farmland Transaction Project***

This project requires KARICO to purchase the farmlands belonging to non-cultivating landowners, retired farmers and occupation-changing farmers, and to sell the land to professional farmers to increase farming scale and to actualize the principle that the cultivator must own the farmland.

4. ***Long-term Farmland Lease Project***

This project is to enlarge farming scale to guarantee stable farming by leasing land to professional farmers that leased farmlands on a long-term basis from the farming house of a non-cultivating landowner, retired farmer or occupation-changing farmer.

5. ***Farmland Exchange and Plotting Project***

This project aims at achieving efficient farming and productivity enhancement by collectivizing farmlands, with the support of the difference in amount after a farmland exchange and plotting and supporting the adjusted amount of land after collective re-plotting.

6. ***Direct Purchasing Project***

This project is for government to provide subsidiary money for direct purchasing of farmland, when the aged farmer wants to stop rice farming, and is an epoch-making revenue-supported project to provide for stable revenue for the farmer that was introduced by the government to the WTO system.

7. ***Land Re-plotting Project***

As irrigation canals, drainage ways and farm roads are developed anew and farmlands change in the shape, size, and other factors, the existing paddies and fields are improved by the agricultural infrastructure improvement project, the location and size of newly developed land is designated to its original owner by replacing the existing land.

Ownership and other rights to the existing land are transferred to the re-plotted land and the unbalance of interests between existing farmland and the new land are adjusted. Moreover, the re-plotting project is driving farming-scale improvement and collectivization for the rationalization of agricultural management, driving the increase in competitiveness and is contributing to the acquisition of facility sites for the processing and distribution of farm products and the enhancement of rural welfare (Table 6).

Table 6. Recent Status of Farmland Re-plotting in Korea, 1999

(Unit: 000 ha)

Normal Land Rearrangement Area			Typical Land Rearrangement		
Plan (A)	Completion (B)	Ratio (B/A) (percent)	Plan (A)	Completion (B)	Ratio (B/A) (percent)
800	688	86	182	61.4	33.7

8. ***Maintenance and Expansion of Farmland Area under Rice Cultivation***

In recent years, the MAF has been making positive efforts in conformity with the policy principle that fertile farmland should be preserved to the maximum extent possible for agricultural use, regardless of whether or not the farmland in question belongs to an Agricultural Promotion Zone. As a result of the policy efforts, it was estimated that farmland area converted into non-agricultural use decreased by 39 percent from 4,902 ha in the first half of 1997 to 2,983 ha in the same period of 1998, except public utility areas including roads.

Although part of existing farmland area under rice cultivation was withdrawn from the Agricultural Promotion Zone, farmland areas under the Zone expanded by 400 ha in 1998 from the end of 1997, owing to the MAF's active operation of an alternative system of putting other eligible farmlands under the Zone.

Meanwhile, strict control over illegal conversion of farmland to other use was enforced at the province and city levels in mid-1998. Furthermore, the MAF took active measures to enhance farmland-use, including placing the landowners under a farmland disposal obligation, who have not cultivated their farmland after buying it for cultivation purposes.

Under the medium-term objective that the projects of rearranging paddy land area of 800,000 ha are to be completed by 2004, the MAF, in cooperation with related government agencies, finished the rearrangement of paddy land covering 20,000 ha by spring 1998. In addition, the MAF and related agencies are also focusing on water resource development projects, which are essential for paddy farming.

In addition to these measures, the MAF established transitional measures related to Farmland Diversion Permission, etc. Korean Government is enforcing the transitional measures to prevent the reduction of available farmland as of January 1998. The contents are as follows:

1. The person who has obtained the farmland diversion permission or who has reported on the diversion of the use of farmland under the previous Farmland Preservation and Utilization Act, the previous Farmland Expansion and Development Promotion Act, or the Act on the Special Measures for Development of Agricultural and Fishing Villages, at the time of enforcement of this Act, shall be regarded as having obtained the farmland diversion permission or the permission on the temporary use of farmland for other purposes or as having reported on the diversion of the use of farmland under the conditions as prescribed by this Act.
2. The farmland which has passed through the consultation about the diversion of the use of farmland or which has obtained the approval or authorization under the previous Farmland Preservation and Utilization Act at the time of the enforcement of this Act, shall be regarded as having passed through the consultation about the diversion of the use of farmland under the conditions as prescribed by this Act.
3. As for the farmland which is located within such an area as the residence area, the business area, the industrial area designated as of the Urban Planning Act, or the farmland designated as the building site of the urban planning facilities as set forth in the said provisions; if it has not passed through the consultation about the diversion of the use of farmland under the previous Farmland Preservation and Utilization Act at the time of the enforcement of this Act, it shall be regarded as having passed through the consultation about the diversion of the use of farmland in accordance with Farmland Protection Act.

The Salient Improvement in the Land Utilization Systems

Up to now, restrictive land-use regulations have remained the most significant constraints to the development of the agriculture sector. In accordance with the agricultural structural adjustment policy established in 1992, the government designated “Agricultural Promotion Zones” which replaced the “absolute and relative” land system. Some of the regulations and restrictions were mitigated under the new system stipulated in the Farmland Act. Farmers were allowed to own land without any limitation within the Agricultural Promotion Zones. Further modifications to this Agricultural Promotion Zone are being considered which would ease regulations on the use of farmland.

The purpose of this Act is to contribute to stabilizing farmers’ agricultural management, to strengthening the competitive power of the agriculture industry through the improvement of productivity, resulting from the efficient utilization and management of farmland by means of stipulating necessary matters concerning the ownership, utilization and preservation, etc. of farmland; and thereby, to contribute to the balanced development of the economy and to the preservation of the national environment.

ESTABLISHMENT OF AGRICULTURAL PROMOTION ZONE

Designation of Agricultural Development Regions

The mayor/governor shall designate agricultural development regions for the efficient utilization and preservation of farmland. The agricultural development regions are set forth in distinction of the areas of the following uses.

1. ***Agricultural Development Area***

The area which is currently being used for agricultural purposes or whose farmlands to be used for agricultural purposes and has been collectivized from among the area where a farmland creation project or an agricultural infrastructure creation project has been implemented or is currently being implemented.

2. ***Agricultural Protection Area***

Referring to the area necessary for the protection of such agricultural environment as securing the irrigation water source for the agricultural development area and preserving the quality of water therefore.

In Table 7, the ratio of total designated area vs. total farmland is approximately 55.3 percent. However, the ratio is less than the ratio of 65 percent for absolute farmland set forth before. One of the reasons for this trend is that the objection for designating the promotion was harsh due to the land price differences between inside and outside of the farmland promotion zone, as well as the automacy board of city and town planners consider this type of farmland designation can play as an obstacle to raise and collect taxes from land properties.

Table 7. Status on Designation of Agricultural Promotion Zone

(Unit: ha)

Designated Area			Total Farmland (B)	Ratio (A/B) (percent)
Development Zone	Protection Zone	Sub-total (A)		
893,617	187,192	1,080,809	1,898,925	56.9

For an agricultural development zone designated by the act, the allocation for paddy land is prominent compared to other farmlands because rice is a major food crop in Korea (Table 8).

Table 8. Areas of Agricultural Development Zone per Cropping System, 1999

(Unit: ha)

Farmland					Non-farmland	Total Area
Paddy	Upland	Orchard	Others	Sub-total		
753,528	138,012	9,030	107,459	1,008,029	72,780	1,080,809

LAND CLASSIFICATION SYSTEMS IN KOREA

A properly characterized land classification and rating system may serve as an indicator of the soil capacity to produce safe and nutritious food, to enhance human and animal health, and to overcome degradable processes. The land class, depending on the land valuation work often conducted by tax assessors and economists, is only focused on an assessment of its benefits and limitations for agricultural productivity and environmental safety even though land guidelines aim to provided a land-use planning framework which allowed local municipalities to identify significant agricultural lands for long-term protection.

In general, the planning to develop a land classification system involves inventorying lands with agricultural potential and environmental hazards, and identifying the highest priority lands in contiguous designations. This process should emphasize the evaluation of the land resource based on soil capability for agriculture. Notwithstanding the capability rating, lands are also subjectively reviewed against several factors which could either enhance agricultural potential (i.e. irrigation systems, capital investment in farm infrastructure, tile drainage, etc.) or diminish its long-term capability for food production (e.g. property fragmentation, intrusion of non-farm uses, etc.)

While this approach to the identification of provincially significant agricultural lands has been widely adopted across the province, the methodology has long been perceived by some as subjective and qualitative. Implementation and replication at the local municipal level has been variable.

In Korea the land classification scheme is divided into five classes from I to V as shown in Table 9.

Table 9. Land Classification Systems and its Distribution in Korea, 1999

(Unit: ha)

Classification	Class I	Class II	Class	Class	Class V	Others	Total
Paddy land	183,037	368,391	487,938	217,201	31,682	0	1,288,249
Upland	45,073	238,983	321,887	206,080	66,461	17	878,501
Orchard	23,869	39,561	28,482	21,449	5,460	190	119,011
Grassland	5,532	17,460	28,713	33,620	17,184	337	102,846
Total	257,511	664,395	867,020	478,350	120,787	544	2,388,607

Class I

Class I (*Prime Farmland*) is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. The land must also be available for these uses (crop land, pastureland, forestland, or other land, but not water or urban built-up land). Prime farmland has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods. In general, prime farmland designated in Korea has the following:

- an adequate and dependable water supply from precipitation or irrigation;
- a favorable temperature and growing season;
- acceptable acidity or alkalinity;
- few or no rocks;
- is permeable to air and water;
- is not excessively erodible;
- is not saturated with water for long periods of time; and
- does not flood frequently, or is protected from flooding.

Class II

A few restrictive factors for using as a farmland such as erodibility, soil texture, and drainage problems. The land can be available for crop land, pastureland, forestland, or other land. However, this land requires some management to produce high crop yields.

Class III

Low yield capacity due to many restrictive soil and climatic factors. Soil quality is easily degraded and the portion of Class III in Korean farmland is almost 25 percent. It needs intensive management and input.

Class IV

The lowest yielding capacity because of erodibility, salinity, water quality, acidity and alkalinity, rock fragment. Most of Class IV can not be used as farmland because it is located on mountainous sites.

Class V

Not available as farmland or grazing. This Class can be used for buildings and storage related to farming activity. Some areas can be used for mushroom cultivation.

KARICO cooperated with the RDA and has constructed the RGIS (Rural Geographical Information System), in which the materials related to the rural structural improvement projects are compiled. The use and management system for farmland enables strengthening agricultural competitiveness by quick and precise business planning and designing of the related business for agricultural comprehensive development. With the best service for farmers, the most important customer of KARICO, by the accumulated expertise and advanced information in hand, KARICO is preparing for the future information society and intelligent farming.

The ability to identify disturbed lands and to detect urbanization is a highly important component of the Farmland Mapping and Monitoring Program (FMMP)'s responsibility. Another consideration of the program is that a change in land use or land cover is of equal value to the FMMP as is a single classification. To do this, the FMMP was established in 1994 to develop and maintain data on agricultural land-use conversion in Korea and to provide these data in maps and statistical formats to decision-makers, planners, and the public. The maps depict currently urbanized lands and a qualitative sequence of agricultural designations based on irrigation status and modern soil survey data.

MAPPING AND REPORTING

Map Compilation

The FMMP integrates public review, air photo interpretation, field mapping, and computer analysis in its statewide land-use inventory. Use of a geographic information system (GIS) enables reporting by category on the amount of land converted to or from agricultural use. The GIS also aids with cartographic revision and reproduction of farmland maps. This system makes it possible for a relatively small staff to map, monitor, and report on biennial conversion statistics.

The mapping process begins by comparing the existing maps to new air photos in order to discern any land-use changes that have occurred in the two years between updates. Areas that are questionable or that lack photographic coverage are then field verified.

Aerial photos are obtained from governmental agencies or the private sector. The cost, availability of existing photo coverage, and photo format dictate which air photos are actually used in a given update. When possible, color infrared photography is used due to its superior ability to depict irrigated agriculture.

Important and interim farmland maps are incorporated into and maintained on a GIS. This system places maps in a geographic projection and links them to a database. After field mapping is complete, land-use changes are incorporated into the GIS by updating the prior version of the map. Quality control is maintained through both manual verification of the changes and computer verification of the new line work. The database is then updated to produce new acreage totals and conversion data. After the land-use conversion data is reviewed and verified, new maps are compiled. A developed FMMP can be categorized below.

(a) ***Agricultural Development Region***: Provide the basic information for the effective conservation and planning of farmland has within an agricultural development region.
(b) ***Classification of Agricultural Practice Regions***: Delineate the boundary of agricultural practice for planning of farmland use within an agricultural development region.
(c) ***Farmland-use Plan***: An effective management of farmland by providing the basic information for a farmland-use plan within an agricultural development region.
(d) ***Rearrangement Plan of Production Base***: Supports effective management of farmland by providing the basic information for rearrangement plans of Production Base inside the agricultural development region.
(e) ***Suitability of Farmland Use***: Allows effective management of farmland by providing the basic information for rearrangement plans of the Production Base outside the agricultural development region.
(f) ***Capability Classification of Farmland***: Helps effective management of farmland by providing the typically classified information of productivity and ranges of use for the farmland outside the agricultural development region.

Map Review

Public review is an important aspect of both initial map compilation and biennial map updating. When new maps are released, map reviewers provide the copies of the color maps (1:100,000 or 1:120,000). Upon request, enlargements at 1:24,000 are provided to reviewers interested in particular cities or regions. The maps are reviewed at the local level for accuracy of land-use classification and delineation. In addition, city and county planning departments have the option to provide information on land committed to non-agricultural use as additional map and statistical data. The FMMP staff use the information received from reviewers to assist in identifying areas which must be reclassified or delineated as land committed to non-agricultural use during the next mapping cycle.

The FMMP also actively seeks and welcomes public review comments since they increase the accuracy of the maps and also indicate how maps are used at the local level. And maps developed can be reviewed by the Board of Farmland Supervisors, County Planning Department, Resource Conservation Districts, Incorporated City Planning Departments, Agricultural Commissioner's Office, Farm Bureau, Public Interest Groups, Environmental Groups, Agricultural Producers/Landowners, Community Members, etc.

SUGGESTION FOR IMPROVEMENT IN THE LAND UTILIZATION IN KOREA

Expansion of Development Investment or Giving First Priority in Making Development Investment to Agricultural Development Regions

Under the conditions as prescribed by the Presidential Decree, the State and the local government shall make an investment, with the first priority given to the agricultural development region, in the projects which are for the improvement or maintenance of farmland and agricultural facilities or for the expansion of the roads for agricultural and fishing villages and the expansion of agricultural products distribution facilities, or in other projects which are for agricultural development in general.

The State and the local government shall support, prior to others, the farmers or the agricultural corporate bodies that are engaged in the cultivation of the crops or in the growth of perennial plants on the farmland within the agricultural development region with such necessary aids as financial aid, tax reduction benefits in accordance with the Regulation of Tax Reduction and Exemption Act, and so on.

The State and the local government shall render necessary guidance and mediation services required for smooth execution of the farmland utilization promotion project and, and may extend financial support, within the limit of the relevant budget, to cover a part of the fund required for the execution of the said project.

Strict Enforcement of Farmland Preservation for Conversion of Farmland

In Korea the power to plan and zone the use of land has been given to the provincial and/or local government since 1992. Similar power is given entirely to county and municipal officials in Illinois in the U.S.A. The result is a hodge-podge of land-use patterns that reflect each local government's attitudes about the type of growth they want, and how they choose to respond to increasing development pressures. The lack of a coordinated effort to control urban and suburban growth into some of the nation's best farmland continues to put farming on the edge at risk, that is, the most impact on the premature loss of farmland.

The fate of farmland in the remaining unincorporated areas is left to the consulting board in each region. It can be expected that more farmland will be converted to rural residential uses in unincorporated areas as demand for this type of housing increases, and as more farmers decide to retire or to move out of the farmland area.

As long as the land remains undeveloped, it will continue to be farmed, even if it is owned by investors or land developers. Escalating prices being paid for farmland in the country, rising property taxes and federal tax policies all push farmers to sell out. These counties have both initiated a process to determine how to implement a transfer of development rights programs.

There is no single solution to stopping the continued loss of farmland on the edge of rapidly expanding urban areas in Korea. But it is clear that what is done to control suburban sprawl, and protect farmland in the next few years will determine the fate of farmers who are farming on the edge.

Based upon these findings, there are the recommendations to help protect farmland in Korea. The Korean Central Government should recognize the important role that farming plays in the local economy and the contribution that farmland makes to local property taxes without putting demands on public services, and not view farmland as vacant property waiting to be developed. Farmland viewed as an economic asset provides decision-makers with greater justification to protect farmland and farming when faced with proposals for development.

Local governments should not rely on zoning to protect farming. More permanent solutions are needed to stop expansion of urban areas into prime farmland and rural areas. Creation of green-belts, or growth boundaries, around municipalities through the use of conservation easements, transfer of development rights, or purchase of open space lands, are viable options, but the benefits of such programs must first be explained to taxpayers.

County and township planning officials should recognize that allowing low-density residential development in rural areas displaces farming as surely as other development, and is the worst kind of sprawl. Rural residential development should not be allowed in farming areas just because the land is not used for production of row crops. Pasture and woodland contribute to viable farming operations, and help to provide other sources farm income.

Districts should be given more authority to implement farmland preservation plans and policies through the use of intergovernmental agreements, property tax incentives to discourage annexation of farmland, and limits on expansion of utilities into designated agricultural areas.

Therefore, the head of *Shi/Kun*/autonomous *Ku*, the KARICO or such other persons as prescribed by the Presidential Decree may carry out the projects of the following specifications which are for the promotion of the utilization of farmland in accordance with the farmland utilization plan (hereinafter referred to as the "farmland utilization promotion project").

1. A project for promoting transfer of the ownership of farmland by means of sales transactions, exchange, partition and merger of farmland.
2. A project for promoting the establishment of the right of lease of farmland (including, hereinafter, the right established by means of a free lease) by means of the long-term lease or the long-term free lease.
3. A project for promoting the entrusted agricultural management.
4. A project for fostering agricultural management bodies in order to improve agricultural management through the joint use or collectivized use of farmland by farmers or agricultural corporate bodies.

Development of Land Classification and Soil Productivity Rating Systems to Improve Land Utilization System

The present land classification system can only differentiate the land capabilities related to agricultural productivity. This simple classification can help to convert the farmland into land of other uses. Therefore, we need to develop the land classification system that may strictly limit the conversion of the farmland that can be used as fertile soil by minimum management and input. Land classification and soil quality rating systems suggested can be the pragmatic concept of developing reliable science-based information systems for multiple users, such as land planners and consultants.

Unlike water or air quality standards that have been established by legislation using potential human health impact as the primary criterion, soil quality depends on the primary function of the soil and its relevant environmental factors, which is much more site- and soil-specific. A properly characterized soil quality assessment system should serve as an indicator of the soil capacity to produce safe and nutritious food, to enhance human and animal health, and to overcome degenerative processes.

For example, a high quality soil with regard to maintaining an adequate soil productivity as a food production resources must include both soil and water properties, food chain, sustainability and utilization, environment, and profitability, that does the following: facilitates water transfer and absorption; sustains plant growth; resists physical degradation of soil; produces a safe food resources; and has cost-effective agricultural management. Possible soil quality indicators are identified at several levels within the framework for each of these functions. Each indicator is assigned a priority or weight that reflects its relative importance using a multi-objective approach based on principles of systems to be considered. To do this, individual scoring system is differentiated by the several levels from low to very high category or point scoring ranging from 0 to 10. And then weights are multiplied and products are summed to provide an overall soil quality rating based on several physical and chemical indicators. The framework and procedures in developing the soil quality assessment are determined by using information collected from alternative and conventional farm practices in the regions.

To develop one possible form for a soil quality index, we should permit coupling the characteristics of the soil with an assessment system based on soil properties and incoming and resident chemicals.

CONCLUSIONS

As of the end of 1999, the total land area of the Rep. of Korea was 99,600 km^2, and there are 1,899,000 ha (19.1 percent), 6,430,000 ha (64.8 percent), and 1,614,000 ha (16.1 percent) for farmland, forestry land, and other uses, respectively. Thus, nearly 20 percent out of total land area of 9.9 million ha is cultivated while the remaining 80 percent of the land is mountainous and not suitable for agricultural use.

Because of food supplies and rapid reduction and deterioration of agricultural land, we have long been concerned with the identification and protection of our agricultural land base and farming industry due to environmental hazards.

The major constraints to improving land utilization systems are:

1. Forest area representing 65 percent of the total land area.
2. Deterioration of soil quality by erosion and salinization.
3. Prevalence of small-sized farms. To resolve these restrictive matters, MAF established the following measures:
    a. Improvement of forestland utilization system;
    b. Improvement and preservation of soil;
    c. Farmland and drainage improvement project; and
    d. Enforcement of farming-scale improvement project, and so on.

For the purpose of stabilizing farmers' agricultural management, the salient improvement in the land utilization systems is to designate the “Agricultural Promotion Zones” which replaced the “absolute and relative” land system.

Land classification systems in Korea, divided into five classes, are only focused on an assessment of benefits and limitations for agricultural productivity and environmental safety even though land guidelines aim to provide a land-use planning framework which allowed local municipalities to identify significant agricultural lands for long-term protection.

Therefore, we may suggest some methods to improve the land utilization in Korea as follows:

1. Expansion of development investment or giving first priority in making development investment in agricultural development regions;
2. Strict enforcement of farmland preservation for conversion of farmland; and
3. Development of land classification and soil productivity rating systems to improve land utilization.

7. MALAYSIA

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INTRODUCTION

The utilization of land resources for agricultural development in Malaysia is phenomenal. Indeed, the favorable climatic regime of the country, which favors the cultivation of exotic crops such as rubber and oil palm, is instrumental in shaping the economy of Malaysia. Since their introduction in the 19th century, Malaysia has become the world's front runner in the export of rubber and palm oil. The post-independent era saw a rapid expansion of land for agricultural development covering not only the smallholders and plantations or estates but also new land development schemes, aimed at providing land to the poor and landless farmers.

For food crops, land utilization systems were limited to subsistence cultivation and often for internal consumption. Rice is now being cultivated in areas with irrigation facilities especially those designated as granary areas. The ubiquitous coconut is subsequently substituted by oil palm. Cocoa became the third most important economic crop, after oil palm and rubber, but its importance declines following the recent collapse of cocoa prices. Cocoa is grown as either a mono-crop or intercropped with coconuts or fruit trees.

Only recently, fruit crops such as watermelon, papaya, mango, guava, star-fruit, citrus (resistant rootstock), pineapple, and jackfruit became viable options. This is a result of emphasis given by the government to crop diversification, aimed at developing a local fruit industry and providing suitable substitution in place of foreign fruits which are imported in massive quantities.

Although the contribution of the agriculture sector to the national economy has declined in recent years, and is gradually being overtaken by the industries sector, its role is still important in terms of food security, import substitution, reduction of a massive food import bill, and as a resources supplement to industry-based development. In fact, agriculture remains the largest single user of the country's land. The accelerated development has resulted in a rapid depletion of most of the suitable agricultural land in the country. It is for this reason that efforts are continually being made to ensure that land utilization in agriculture sectors is managed wisely and sustainably.

LAND USE

Malaysia has a land area of 32.98 million ha. Approximately 15.56 million ha (47 percent) of the land is potentially arable. Peninsular Malaysia has the biggest extent of arable land (8.10 million ha), followed by Sarawak (5.31 million ha), and Sabah (2.15 million ha), most of Sabah is covered by very steep land. Land-use changes have been taking place particularly through land utilization activities through conversion of primary forest. A total of 3.4 million ha of land had been opened for utilization by 1996.

However, since 1991 there has been a growing competition for prime land among various sectors such as agriculture, urban, industry, recreation and forestry. Urban and industrial developments are quickly taking up quality agricultural land bordering on settlements. Table 1 shows the magnitude of land-use changes over the years. Most of the areas under major crops, except oil palm and paddy, have gradually declined.

Table 1. Major Agricultural Activity Changes in Peninsular Malaysia

(Unit: 000 ha)

Agricultural Activities	1966	1974	1984	1990	1995
Rubber	1,777.8	1,941.5	1,717.0	1,517.4	1,373.6
Oil palm	99.4	485.4	879.9	1,744.7	1,906.9
Cocoa	0.5	13.1	78.0	149.1	76.4
Paddy	40.0	428.7	424.2	488.4	496.4
Fish pond	0.6	0.9	-	19.3	13.9
Forest	7,870.4	7,247.3	-	6,110.6	5,991.4

Source: Ministry of Agriculture, Malaysia, 1995.

CURRENT LAND UTILIZATION SYSTEM AND THEIR CONTRIBUTION TO AGRICULTURAL PRODUCTIVITY

In Malaysia, land utilization systems for agriculture can be classified into categories of shifting cultivation systems, smallholders and the large land development scheme systems and plantation sectors and marginal land utilization systems.

Regional Land Development Schemes

Agricultural land utilization in Malaysia during the 1960s was dominated by land development and resettlement schemes and *in-situ* development. The former led to the opening of virgin forest, primarily by the Federal Land Development Authority (FELDA), and establishment of regional development authorities for the cultivation of export commodities like rubber and oil palm and the land was allocated to the landless. The latter effort was mainly concerned with the development of land already assigned to smallholders, giving rise to the creation of the Muda Agricultural Development Authority (MADA), the Kemubu Agricultural Development Authority (KADA) and Integrated Agriculture Development Project (IADPs). The goals of IADPs are to increase the productivity and income of farmers, fishermen, and livestock producers as well as to reduce the incidence of poverty.

Open Grazing System – Large Commercial Beef Project

Large commercial beef projects using the open grazing system were initiated by the Regional Development Authorities (RDAs) such as the Pahang Tenggara Development Authority (DARA) in the early 1970s. These projects were not very successful, mainly because of the non-viability and slow return on investment, long gestation period (12-15 years), and low internal rate of return for the project to break even, but also because of the high cost of initial land development from jungle to pasture land, importation of high quality grasses, legume seeds, breeding animals, machinery, and fertilizers. Farm maintenance and low calving percentages also contributed to the failure of the system.

Smallholders

Smallholders dominate land utilization systems for food production in Malaysia. Fruits, vegetables, and paddy cultivation are basically the smallholders' domain. One of the constraints faced by the smallholders is the small, uneconomic farm size, which has led to low farm productivity and income. One of the reasons why farmers' incomes are low is that most farmers practice monoculture where only single type of crop is planted.

Smallholders normally practice individual and group farming systems for agricultural production. Current efforts in commercializing smallholder agriculture being undertaken by government focuses upon establishing extensive group farming, mini-estate and nucleus farms, where landholding consolidation and centralized management are encouraged.

As a comparison, yields obtained by smallholder farmers for four major crops are lower than that achieved by estate sector. However, a higher target yield could also be achieved by centralized management systems such as mini-estates and nucleus farms.

Table 2. Average Yield for Selected Crop, 1990

Crops	Unit	Smallholder	Estate	Percent Achievement Compared to Estates
Paddy	Mt/ha	3.6	6	60
Oil palm	Mt/ha	12.0	20	60
Rubber	Kg/ha	910.0	1,330	68
Cocoa	Kg/ha	400.0	800	50

Source: Zaharuddin, 1994.

Highland and Steep-land System

The main highland areas under cultivation are the Cameron Highlands in Peninsular Malaysia, Bario in Sarawak, and various parts of Sabah, particularly Kundasang and Ranau. There are many other plans for highland agriculture, for example in the Lojing Highlands, Kinta Highland and possibly along the Titiwangsa Range. There are 2,598,000 ha of highlands compared to 10,625,700 ha of lowlands in Peninsular Malaysia (Lim, 1993). In highlands, large-scale cultivation of temperate crops, such as vegetables and flowers, is possible.

Tea is planted as a plantation crop and covers approximately 2,700 ha while approximately 2,140 ha of temperate vegetables are grown on broad bench terraces carved out on undulating land or moderately steep low hills (15-30º slopes). About 91.4 percent of the agricultural land in Cameron Highland are at an elevation of more than 1,000 m above mean sea level, consequently, 57 percent of these agricultural land are classified as having a very serious soil erosion risk (DOA, 2000).

Shifting Cultivation

Shifting cultivation is still widely practiced by the indigenous people of Sarawak and Sabah. In Sarawak, shifting cultivation of hill paddy has been a common practice, covering areas ranging from 75,000 ha to 150,000 ha. In Sabah, it has been estimated that approximately 17,300 ha are under shifting cultivation but the hectarage is declining (Sinajin, 1987).

Shifting cultivation is often practiced on steep terrain with hill paddy as the main crop grown and with maize, cassava, banana, papaya as well as sweet potato as intercrops. The shorter fallow period on steep slopes induces landslides and slumps. These phenomena contributed to the surface erosion in the forestland in western part of Sarawak (Andriese, 1972) resulting in declining soil fertility (Hatch, 1982).

Marginal Land

There are about 2.7 million ha of peat and organic soils in Malaysia. The hectarage of peat soils are 0.8 million ha in Peninsular Malaysia (Paramanthan, *et al*., 1984), 0.2 million ha in Sabah and 1.4 million ha in Sarawak. For BRIS (beach ridges interspersed with swales) soil, 155,400 ha in Peninsular Malaysia (Abd. Wahab, 1982a), 40,000 ha in Sabah (Thomas, 1966) and 90,000 ha in Sarawak. On the other hand, there are 187,000 ha of potentially acid sulfate soil in Peninsular Malaysia, 270,000 ha in Sabah and 571,000 ha in Sarawak. It was estimated that there is about 200,000 ha of tin tailing land in Peninsular Malaysia.

In terms of land utilization, about 35 percent and 5 percent of peat have been utilized for agriculture in Peninsular Malaysia and Sarawak, respectively. Only 5-10 percent of BRIS soil is being utilized for agriculture (Abdul Wahab and Othman, 1989).

1. ***Peat Land System***

Coastal peat swamps form distinct landscape units in the coastal areas and despite having a low inherent productivity potential due to poor drainage, high acidity, and low fertility, they have been reclaimed and managed successfully for annual crops and some perennial crops, such as oil palm. In order to develop peat soil, a drainage system must be efficient in order to be able to control water table. Peat soils in Malaysia are widely utilized for the planting of oil palm and pineapple for export. Pineapples are rather suitable for condition of peat land, for instance, and can tolerate low pH of 3.2-4.9 (Tay, *et al*., 1968).

2. ***BRIS and Sandy Mining Land***

The soils found on BRIS landscapes are sandy, excessively drained soils with a very low inherent fertility status. The utilization system of these soils will require a careful selection of crops to suit the soil, a high level of investment, experienced management and high input investment. The utilization system for BRIS soils and sandy tin tailings may have to be based on small scale, intensive integrated systems that incorporate livestock and high value cash crops. The major crops currently planted on BRIS soil are coconut, tobacco, watermelon, roselle and some annual and perennial crops.

On the other hand, the ex-mining lands are the large tracts of tailings laid waste by the mining operations. The major crops planted on this soil are fruit crops such as guava, star-fruit and mango. A significant proportion of ex-mining land has already been exploited for fish production. Various methods of fish production are employed in these water bodies namely; pond culture system, monoculture or polyculture, development of recreational fisheries, utilization of pool water for aquarium fish breeding and hatchery operation, and culture of aquatic weeds (Ismail and Gopinath, 1990).

3. ***Acid Sulfate and Potentially Acid Sulfate Soils***

Potentially acid sulfate soils are found in mangrove swamps and other low-lying swamps along the cost. These swamps are inundated by seawater and have major economic and social importance in supporting fisheries, coastline protection and build-up, forest products and a huge variety of domestic uses.

Although beset by problems of high acidity and imbalances in macro- and micro-nutrients, these soils have been reclaimed, used, and managed successfully for agricultural production in Malaysia. With proper management such as liming, fertilization and gradual lowering of water table over a number of years these soils can be transformed into productive soils and economic yields can be obtained for a number of crops such as coconut, oil palm, paddy and fruits. Emphasis should be given to the development of shallow rooting crops such as oil palm and annual crops. The introduction of deep rooting crops should only be made after ameliorative measures have been taken to reduce soil acidity.

ISSUES AND CONSTRAINTS IN IMPROVING LAND UTILIZATION SYSTEMS

Land Limitations and Optimization

In many ways the existing constraints to the land utilization are very much related to the country's rapid development. The present focus on industrialization has resulted in encroachment into existing agricultural land. As new fertile lands for agriculture are rather limited, future agricultural areas will need to be developed more on marginal soils.

As land becomes scarce, food imports increased. For example, the country spends about RM12 billion annually to import food and feed products. Therefore, the government has enhanced efforts to raise food production, reduce imports and increase exports.

Low Income and Low Production

There are an estimated one million smallholders who are involved in agricultural food production. One of the constraints smallholders face is the small farm size averaging about one ha. This leads to low farm productivity and low income. For instance, one ha of rice cultivation gives a monthly income of approximately RM200. Income from a traditional coconut holding of two ha is only about RM100 per month (Abdul Kadir, 1999).

Labor Shortage

Although both the industries and agriculture sectors face labor shortages, the problem in the agriculture sector is greater and will be more acute as the industries sector is able to promise better working conditions, higher income and more fringe benefits. The National Agricultural Policy (NAP) proposal for the formalization of arrangements for employing migrant labor is a temporary solution. Concurrently, plans need to be made for full mechanization at each stage of every farming activity in the land utilization system.

Idle Land

The issue of 'idle land' management is also a continuing challenge, and is a serious issue where good land is excluded from productive agriculture – especially with increasing pressures on land availability and greater land costs. It should be possible to devise a tax/levy system to deal with the 'idle land' issue that would discourage such neglect and encourage this land to be appropriately incorporated into neighboring farmland.

There are more than 630,000 ha in private agriculture plots in Peninsular Malaysia which have been neglected or are left idle and that have become unproductive, although some of the areas are composed of fertile soil types but are left idle due to either socio-economic factors or technical reasons. The development of abandoned or idle land has been the target since 1985. Until 1990, agencies such as LPP, Federal Land Consolidation and Rehabilitation Authority (FELCRA), Rubber Industry for Smallholders Development Authority (RISDA) have developed 240,000 ha of such land. Recently, by 2000, the total idle land on Peninsular Malaysia that was left idle by private owners is estimated to be about

66,356 ha. The government is continuing its effort to ensure sustainability of development so that land will be utilized and does not revert to an idle status.

Measures to Improve the Contribution of Land Utilization Systems to Productivity

In order to overcome some of the constraints and issues related to improving the contribution of the land utilization system in Malaysia, a strategy of intensification of land use and crop zoning should be followed.

1. ***Permanent Food Production Zone***

The government has identified 75,000 ha of land throughout the country to be designated as permanent food production zones for the commercial cultivation of fruits, vegetable, fish farms, poultry and livestock. Once designated, the land will not be allowed to be used for any other purpose. The federal government will provide support services and infrastructure funds when the land had been identified. The permanent food production zones would enable the ministry to be more aggressive in introducing modern large-scale farming methods backed by use of the latest clones and seedlings. Research and development funding will be provided in order to produce the highest quality crops. The whole idea is to use higher technology and more precision farming to maximize sustainable food production.

The zoning would make it easier for investors to secure land for agricultural purposes. Banks will also be more comfortable because they will know that the land will be used specifically for the production of food.

2. ***Integrated Farming for Smallholders***

For an efficient and optimal utilization of resources, including land, and to increase productivity, an integrated farming system will be introduced in order to increase smallholder's average income from RM200 per month to above RM1,000 per month. Four kinds of integrated farming systems promoted by DOA are: (1) rice cultivation integrated with vegetables, sweet corn, fruits, fish, and duck rearing as well as compost-processing; (2) coconut cultivation integrated with fruits and vegetable cultivation; (3) rubber cultivation integrated with banana, vegetable cultivation; and (4) corn cultivation integrated with cattle feed lots.

Consequently, with a strategy of mixed-cropping systems, the government hopes to bring neglected coconut land back into production by rehabilitating nearly 120,000 ha of uncared for coconut plots in Peninsular Malaysia.

3. ***Crop Integration in Rubber Plantations***

Presently, rubber is an essential smallholder crop with its land share of 82 percent and which accounts for 72 percent of production. With an average uneconomic farm size of 1.9 ha, productivity per unit land area can be considered low and inefficient. One effort to broaden smallholders' income base, is the focus on inter-row management for cash cropping and ruminant integration. The smallholders commonly grow crops like vegetables, groundnut, maize, banana and pineapple. When intercropping ceases due to shading, options are open for inter-planting of shade-tolerant crops such as rattan (*Calamus manna*), salak (*Salaca edulis*) fruit and medicinal plants.

Sheep integration under rubber trees, under the conventional planting system, has led to low animal productivity where the stocking rate has to be reduced drastically from 15 head to two head per ha. However, in terms of productivity, sheep integration has significantly contributed to additional income, organic manure and reduction in weeding costs.

In order to sustain long-term productivity and land-use efficiency, the hedgerow planting system of rubber with wide inter-rows of 18-25 m has been introduced. It provides a better long-term environment in the inter-row for further increases in crop diversity. Continuous production of short- and medium-term food and cash crops can now be extended to more than 10 years. In addition, it is also possible to sustain a higher stocking rate of sheep or cattle with the cultivation of nutritionally improved pasture. The agro-forestry approach can now be intensified with bamboo and several species for chips and wood production such as acacia hybrid, sesenduk (*Endospermum malacanes*), teak (*Tectona grandis*), sentang (*Azadirachta exelsa*) and khaya (*Khaya ivorensis*).

4. ***Integration in Oil Palm Plantation Sector and Land Development Schemes***

There are constraints faced by the plantation sector, among them is the shortage of labor and increased labor costs. Cattle, deer, and other ruminant livestock can be utilized as biological agents to reduce the requirement of labor for weeding. With livestock integration, the problem of labor scarcity faced by FELDA management is effectively reduced (M. Nasir, 1999). Labor cost was reduced to RM240 per settler or RM59 per ha per year. The cost of chemicals was reduced by RM249 per settler or RM62 per ha per year. Annual farm income increased by an average of 5.3 percent resulting from increased yield of oil palm and 8.6 percent from cattle rearing activities.

A defined system of integrating cattle into mature oil palm was introduced in 1987, and at the end of 1999, 120 estates and 300 block of FELDA settler's scheme involving 71,838 head of beef cattle had adopted the system. Output from the land is maximized through optimal use of resources and weeds are biologically controlled. The productivity of cattle integrated in the oil palm estates is comparable to those reared by open grazing on improved pasture (Rosli, 1999).

Crop integration in palm oil plantations is also beneficial. For example, integration of sugarcane in three harvests, banana in two harvests, and pineapple in one harvest in immature oil palm generated net incomes of RM11,731.00/ha, RM16,664/ha and RM3,487/ha, respectively (Suboh, *et al*., 1999).

ISSUES AND IMPROVEMENT OF LAND UTILIZATION SYSTEMS FOR CONSERVATION AND SUSTAINABLE AGRICULTURE

Soil erosion on agriculture land systems is still very much apparent and most is prominent in land utilization activities such as, large land development schemes, replanting of rubber and oil palm, shifting cultivation, and in intensive farming in the highlands. Numerous soil conservation techniques associated with sustainable agriculture have been developed. The common conservation measures are proper land use, cropping systems and rotation, cover crops, appropriate fertilizer application and tillage operations. Other specific techniques including mulching, contouring, terracing, construction of silt ponds, and diversion drains. In addition, a 22-point action plan has also been drawn up to ensure the effective utilization and conservation of soil resources of the country (DOA, 1982). The plan takes into consideration of technical, economic, social and legal factors.

Although there are adequate soil conservation measures available for implementing an efficient soil conservation program in the land utilization system, it is just a matter of selecting the right techniques and implementing them correctly. Therefore, appropriate soil conservation measures must be adopted and implemented effectively to control soil erosion.

Shifting Cultivation

In the early years, shifting cultivation was regarded as relatively sustainable, due to a long fallow period of often more than 20 years. However, recently, with increased population pressures, the shifting cycle has shortened from 20 years to 15 years to less than three years, thereby reducing a fallow time which worsens erosion and accelerates river siltation. Considering that about 80 percent of shifting cultivation is carried out in hilly and mountainous terrain, this has inevitably resulted in soil erosion. Cutting of trees followed by burning is a process that causes depletion of soil organic matter and soil fertility resulting in bare plots, besides destroying valuable timber and displacing wildlife.

In order to reduce negative impacts associated with shifting cultivation, efforts have been made to introduce a permanent agricultural system by resettling shifting cultivators to less-isolated areas and to help them grow long-term crops such as rubber, oil palm or cocoa. In this program, basic needs such as housing, schools and health clinics are provided. In addition, agro-forestry programs are introduced to encourage cultivators to plant tree crops as inter-rows in their traditional subsistence farming system, so as to reduce the rate of soil erosion.

The idle lands left by shifting cultivators are also now being used for grazing of sheep, buffalo and deer in an effort to conserve soil as well as to fully utilize the available cleared land. Pasture grass such as *Setaria kazungula* was introduced and found to have quick establishment on steep slopes.

Steep-land Agriculture

In Malaysia, land having slopes of more than 20 degrees is termed as steep-land and is not recommended for agriculture. This is in view of adverse consequences that may result when forestlands on steep slope are cleared, causing intense soil erosion with heavy siltation in the streams.

The impacts from this type of land utilization on steep highland agriculture are mostly serious soil erosion, falling soil fertility, declining yields, severe heavy siltations of dams and spoiled environments. Highland or steep-land agriculture will also likely fragment permanent forest estates, damage catchments at their steepest locations, and have serious impacts on diversity of mountain flora and fauna.

In areas where steep-land has been exploited, high levels of agricultural management is required to ensure sustainability. In other areas where no crops have been grown, they should best left for protective forest since other lands suitable for agriculture such as idle lands, are still available.

Marginal Land Utilization Systems

Marginal soils in Malaysia are soils where high yields are not possible with normal agronomic practices. These soils include acid sulfate soils, peats, BRIS soils, and ex-mining lands used for agriculture. With improvements in methods and new technology, profits could be increased while at the same time land resources and the environment are conserved.

The success achieved so far of growing crops in these problem soils, such as oil palm on peat and acid sulfate soils, vegetables on BRIS and paddy on acid soils has helped Malaysia exploit its limited resources without undue degradation of the environment. In developing these marginal lands, there is a need for substantial soil amelioration before they can be made productive and sustainable.

For sandy soil, the use of POME (Palm Oil Mill Effluent), and palm oil empty fruit bunch (EFB) and animal wastes can improve yield significantly.

As peat subsides as soon as it is reclaimed, it is anticipated that continued soil subsidence will ultimately render the soils unsuitable for agriculture, due to their susceptibility to flooding. Fire hazards in reclaimed peat are common and is another cause of soil degradation. To make peat soil sustainable for agriculture, water table control is essential. Addition of appropriate amounts of lime and fertilizer can alleviate low nutritional status of the soil.

For acid sulfate soils, agricultural utilization programs require proper management of groundwater to minimize oxidation of pyrite that is the main causes of excessive acidity. Ameliorative measures taken include water table control, liming, wood ash, crop selection, acid-tolerant crops, and building of ridges and beds. In view of the exorbitant costs of utilization of areas with marginal soils and the detrimental effects they pose to the ecosystems and the environment, it is recommended that options such as preservation and protection in their natural state as conservation areas be considered.

Sustainable Land Utilization Systems Under Oil Palm

The Malaysian oil palm industry is losing its competitive edge due to increasing production costs and severe labor constraints. The highly competitive future of the oil palm industry will necessitate that all agronomic practices be highly cost effective, sustainable and environmentally sound. In this respect, it is important to ensure that all oil palm/palm oil by-products be effectively utilized, to achieve the zero waste strategy of the palm oil industry.

Recent expansion in oil palm cultivation in Malaysia has been mainly on sloping inland soil especially in the east Malaysia State of Sabah. Measures adopted to reduce erosion and increase productivity are:

- Construction of wide planting terraces (4.2 m) with adequate back slope);
- Early cover crop establishment to maximize soil, water and nutrient conservation; and
- Large planting hole treatments with incorporation of topsoil and other byproducts (e.g. oil palm EFB, POME sludge cake, and palm trunk chips (PTC).

Sustainable Land Utilization System under Rubber Plantation

Intercropping systems under immature rubber trees were in the form of conservation of land utilization systems where several combinations of crop cover were established. The lower input systems include inter-rows under natural vegetation, legumes, crops such as peanut and corn rotation, pineapple and combination of peanut-corn and pineapple. Overall, intercropping is beneficial to the growth of hevea and is an effective erosion control measure during its immaturity phase (Zainal, *et al*., 1995).

LAND CLASSIFICATION SYSTEMS

The following are important land classification systems that have been drawn up to ensure the judicious use of land resources and proper planning and application of land utilization systems in Malaysia.

Soil Survey

In Malaysia, DOA carries out soil mapping on a routine basis for agricultural purposes. The Soil Classification System used in Malaysia is based on that of the USDA (United States

Department of Agriculture) Soil Taxonomy (Soil Survey Staff, 1975 and 1994) and the FAO/UNESCO Soil Map of the World (1974 and 1990). Both of these systems have been modified and adapted for use in Malaysia.

Soil surveys are carried out at different scales of mapping to meet specific needs and purposes. A reconnaissance soil survey is carried out in large areas to identify potential land for agricultural utilization. A semi-detailed soil survey is undertaken to collect more detailed information to assist in the planning of projects in regional development areas and for feasibility studies. A detailed soil survey is carried out for specific purposes and usually on small areas. In addition, services of land certification for crop suitability are also provided.

The reconnaissance soil map is used to identify areas in newly explored regions for their potential suitability for different types of agricultural utilization, for example, paddy on poorly drained soils, permanent tree crops on the sloped lands and various short-term food crops on the fertile alluvial soils, poor peat lands, and sandy coastal areas.

For the semi detailed and detailed survey, individual soil units called soil series were identified as single mapping units, and a suitable crop or group of crops can be recommended more accurately. The semi-detailed survey is widely used for the planning of RADs, IADPs and commercials estates.

Soil-Crop Suitability Classification

The first soil suitability classification for agricultural development was published in 1966 by Leamy and Panton. This classification, which grouped soils into five classes, was based on various factors that affect crop production. Some of these factors are drainage, topography, soil chemistry, soil texture and availability of plant nutrients.

In line with the accelerated pace of land development for agriculture, there was an urgent need to have a classification system to determine more specifically the suitability of crops for different soil types. Hence, the earlier basic land classification evaluation system was refined, improved and upgraded to its present form which is called the Soil-Crop Suitability Classification for Peninsular Malaysia in 1974 (Wong, 1986). This classification determines the classes of the soils by their qualities; Class 1 has better soils which allow a wider range of suitable crops as compared to Class 2 which is then better than Class 3. Classes 4 and 5 soils are better reserved for forest.

Agro-climatic Classification

Agro-climatic Classification is another decision-making domain used in Malaysia. Factors used to determine agro-climatic zones are rainfall, evapotranspiration, wind, and soil moisture content. In 15 years, two agro-climatic classifications have been developed in Malaysia, namely Agro-ecological Regions in Peninsular Malaysia (Nieuwolt, *et al*., 1982), and Agro-climatic and Crop Zone Classification of Malaysia (Malaysian Meteorological Services [MMS], 1993).

Crop Zonation

The production of maps for agro-ecological and agro-climatic zones map resulted in the production of various crop zone maps in the country. In the zonation concept, the factors considered are soil, terrain, climate, disease incidence, economic, socio and even political factors. Crop zone maps for Peninsular Malaysia were produced by DOA in 1983 (DOA, 1986). The maps show the regions where strategic and economic crops should be grown. The major crop zones identified are those of paddy: paddy and mango; field crops, cocoa/ coconut; and fruit areas consisting of various combinations.

Land Capability Classification (LCC) System

For the classification of land in terms of economic importance, the Economic Planning Unit (EPU) of the Prime Minister's Department, with other departments and agencies, produced the LCC (EPU, 1967) as a basis for defining optimum land use and for the allocation of land to various uses. The LCC classifies land into four major activities: mining, agriculture, forestry, and recreation. Based on this classification, the government published the Land Capability Resources Maps at a scale of 1:250,000 (EPU, 1967). These maps are useful in providing broad zoning of land for the planning of economic development in the States of Malaysia.

There are also a detailed classifications for mining and forestry namely, Mining Potential Classification (EPU, 1975) and Forestry Potential Land Classification System.

Remote Sensing for Land-use Planning

In Malaysia, there are basically three main types of land-use survey which are carried out, namely; survey based on aerial photography, updating of the existing database, as well as surveys based on an integrated approach. The integrated approach is a combination of the survey using aerial photography, and updating of the existing database (past land-use information), together with the extraction of information from satellite images. The satellite data available is used to detect and locate the changes. This can complement as well as check on the accuracy of data collected through the systematic survey.

According to classification, land uses are divided into nine groups where seven are related to crops or vegetation, and the remainder are associated with urbanization, mining and unused land. Land-use survey and mapping has been implemented since the 1960s based on aerial photography. The advancement of computer and remote sensing technologies has allowed for the continuous monitoring of the changes in land-use pattern covering a wider area. Analysis and evaluation of land-use data from satellite and radar images provides data on the most recent changes in land-use patterns. Since the mid-1980s satellite and radar images are increasingly being used for detecting and monitoring the changes in land-use patterns.

The availability of satellite imagery in different forms has attracted a flood of applications in land-use mapping, mainly because of its cost effectiveness for collecting data and the ease of updating data. Land-use maps are produced at a scale of 1:50,000. The Malaysian Land-use Classification System is a modified version of the World Land-use Classification System designed by the International Geographical Union.

GOVERNMENT POLICY

The formulation of the new NAP 1998-2010, is very timely to continue to face new challenges in agricultural development, and in order to lead the world in the plantation sector. The primary objectives of the Third NAP, launched in 1998, is to further enhance agricultural production in Malaysia in the new millennium. Building on the previous policies, it seeks to bring about a further transformation of the agriculture and forestry sectors of the economy to meet the rapidly changing domestic and global challenges. The policy retains the objective of the Second NAP to maximize income through optimal utilization of resources. This includes maximizing agriculture's contribution to national income and export earnings as well as maximizing income of producers. The utilization of limited land resources will be maximized through programs such as promoting agro-forestry enterprises, integrating livestock with plantation crops, and intensive mixed farming ventures.

In the Third NAP, more definite mechanisms will be established to encourage greater private sector participation in the development of the agriculture sector, in particular food production. Among the mechanisms introduced are the establishments of Agro-Technology Parks. These parks will be developed to promote high technology agricultural production systems in the private sector. Such production systems involve mechanized operations, precision control of inputs and the growing environment, production of quality and high value products such as fruits, vegetables, aquarium fish, flowers, fishery and livestock products. State governments will be encouraged to zone specific areas for agricultural production and make available land on a long-term lease basis.

The key issues for agricultural development in Malaysia remain the optimization of land, labor and capital. It must involve integration among crop, livestock and fisheries enterprises that can exploit the economies of scale and foster optimum utilization of resources. Currently, the land utilization systems in Malaysia are guided directly by this policy; in fact, this policy determines the overall types of land utilization system applied on various types of land and economic sectors.

CONCLUSIONS

Agricultural land utilization systems in Malaysia continue to be productive, for instance, in terms of contribution to the country's economy. In 1999, major export values for rubber and oil palm are RM2,343 million and RM19,510 million, respectively, compared to crude petroleum that was only RM9,306 million. The food sector contributed about RM4,340 million to the GDP in 1995. This is likely to jump to RM7,260 million in 2010. However, in order to remain productive and competitive, sustainable productivity has to be improved using new technologies and information.

The new approach for agriculture and food production in Malaysia through various land utilization systems should be based on intensification of production through science, engineering and technology, without any significant increase in the opening of new land. It should strive to attain efficiency and productivity for all factors and resources. In Malaysia, land availability is generally limited and there is competition for land resources, so much so that there is a need to take measures that would increase output without any significantly increase in area.

To ensure sustainable agricultural development in Malaysia, various planning tools, strategies, land utilization systems have been applied over the years to increase productivity besides minimizing negative impacts on the land resources and environment. The successful planning of agricultural development projects must be based on a comprehensive and integrated approach, which must be technically feasible, economically viable, ecologically safe, socially agreeable and politically acceptable.

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8. MONGOLIA

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COUNTRY BACKGROUND

Mongolians are a primordially nomadic people and life primarily was based upon the country's key branch of nomadic animal husbandry and mobile dwellings. Mongolians have little experience with respect to setting up densely-populated settlements, cities, and with a settled way of life generally. The historical development of the state of Mongolia was closely interrelated with its nomadic civilization going on according to its own particular traditions, which makes up its major distinguishing feature compared to the world's other countries and states predominantly based on a settled type of civilization.

Mongolia is a landlocked country with a total of 1,566 thousand km^2 located in the heart of Central Asia, between the Russian Federation to the north and the People's Republic of China to the east, west, and south. With a total population estimated just over two million, Mongolia's population density, at 1.5 persons/km^2, is one of the lowest in the world. About 58 percent of the population lives in urban areas, a quarter of those live in the capital city of Ulaanbaatar.

Mongolia has total area of 156,411.6 thousand ha, of which 402.7 thousand ha are made up by cities, settlements and villages, 130,337.7 thousand ha are in agricultural estate, 328.6 thousand ha are in roads and communications networks, 18.292 thousand ha are forest, 5,365.6 thousand ha are land reserves, and 1,665 thousand ha are water bodies and wetlands.

The country is divided into three main topographical zones: mountains, with the three largest ranges located in the north and west; the inter-mountain basins, in one of which Ulaanbaatar, the capital, is located; and the steppe, which covers three-fourths of the natural territory.

The largest part of the country is pastoral, with animal husbandry (sheep, goats, cattle, camels, and horses) as the main activity. Mongolia is land of numerous lakes, the majority of which are situated relatively high above sea level. The river system is most extensive in the northern part of the country. Because of the mountainous terrain, there is a great concentration for potential hydropower development in the north. Most rivers are unsuitable for navigation and are used only to float timber. Rivers are used as sources of water for livestock and for irrigation of fields and pastures.

Although the Mongolian economy has experienced considerable industrialization, particularly in recent decades, the agriculture sector remains the backbone of the economy with a 7-percent increase in the GDP in 1994. The agriculture sector also has important links with the rest of the economy, providing inputs into many processing industries such as leather and shoe manufacturing, wool processing, milk production and food processing. Agricultural production is subject to the vagaries of the Mongolian climate, which is characterized by extremely low winter temperatures, a short growing season and low, erratic precipitation. A privatization program for the agriculture sector, initiated in 1985, is now virtually complete, with more than 95 percent of the livestock in private hands and most state farms broken down into joint-stock companies. Eighty percent of the total land in Mongolia is suitable for agriculture, in its broadest sense. Only 1.6 percent of this is used for crops, 1.1 percent is mowed for hay, and 97.3 percent is used for pasture. Table 1 shows the magnitude of a number of Mongolian economic factors.

Table 1. Basic Indicators (1999)

Indicators	Unit	
Population, at the end of year	000 persons	2,446.4
Labor force, annual average	000 persons	869.8
Number of employees, at the and of year	000 persons	830.0
Unemployment	000 persons	39.8
GDP (at constant prices)	Billion tugrik*	873,679.2
Investments	Billion tugrik	253.8
Exports	US$ million	358.3
Imports	US$ million	512.8
Gross industrial product (at constant prices)	Billion tugrik*	491.0
Gross agricultural output (at constant prices)	Billion tugrik*	430.0
Livestock	Billion tugrik	386.0
Crops	Billion tugrik	44.0
Livestock	Million head	33.6

Note: * 1,072.7 tugrik = US$1.00.

INSTITUTIONAL SETUP FOR GOVERNMENT POLICY

Mongolian Governmental institutions have been experiencing a period of great change since 1990, with the passing of a series of laws directed at economic liberalization. The current structure is described as traditional. A further restructuring proposal aimed at bringing the Ministry within the framework outlined in the law concerning government organizational structure, and adopted by the Mongolian Parliament in June 1993 and by Government Resolution in 1997 is currently before the government.

The basic responsibility for land administration was transferred from the Ministry of Agriculture and Industry (MAI) to the Ministry of Nature and Environment (MNE) formed in August 1992. While the MAI retained responsibility for the administration of the national productive land resources and livestock, MNE resumed the responsibility for land assessment, management, and control.

Land assessment and control responsibilities were passed to the Government Regulation Agency. The Bureau of Land Management (LMA) was established in 1997 and the Land Cadastral Laboratory, a self-financing organization was established in 1998. The LMA will have a Central National Administration Department, together with staff at the aimag[1] level. Their responsibilities will include the assessment of a range of conditions and

[1] One *aimag* is 100-120 people. Mongolia has 21 *aimags*.

the protection of the ecological state of the land, under the technical support and guidance of the national administration.

THE LEGAL BASIS FOR AGRARIAN REFORM

During the command economy period, the Government of Mongolia focused its attention and efforts upon the development of the crop production and flour processing sectors. In order to satisfy demand, a number of state-managed enterprises for crop production and supply of fodder to the intensive livestock sector were established. The numbers of state farms increased, until in 1990, Mongolia had a total of 53 state farms for producing specific crops.

During the change of the country to a market-oriented economy the issue of privatization of state farms was raised. With the issue of privatization, the importance of the creation of a legal framework for land possession became evident, a method whereby land previously possessed by state enterprises could be split. According to the above need, the Land Law of Mongolia was adopted and enforced by the Parliament in 1994.

The Mongolian "Law on Land" was enacted through regulation number 143 in 1995. Further resolutions concerning land included land management, state certificates on land characteristics, quality procedures, unified land territory records and reports, the form of a state unified report, state procurement of land for special needs, and maximum allowed land area to be used by economic entities and organizations for production and service activities was established.

In 1997 the Parliament enacted the "Land Fees Law" and regulation number 152 was issued to organize related activities. These included the assessment of unified land territory, basic land assessment per ha of agricultural land, the minimum amount of annual land fees, and the minimum and maximum land basic fees per ha in cities, villages and other settlements. Figure 1 shows the governmental organizational structure for land management and agriculture.

In the Mongolian "Law on Land" the Unified Land Territory of Mongolia was classified as follows:

- Agricultural land;
- Cities, villages and other settlements land;
- Transportation and network land;
- Forest resources land;
- Water resources land; and
- Reserve lands.

Pasture, hayfields, cultivated land, planted areas, fallow land, and other land allocated for agricultural construction and production is referred to as "agricultural land". The agricultural land in Mongolia is 130,358 thousand ha, of which 296.3 thousand ha are for crop production.

The Mongolian "Law on Land" included a legal framework for crop production as follows:

- State-owned agricultural land may be possessed by a Mongolian citizen, legal entity or organization upon a contract and the condition and duration described in this Law.

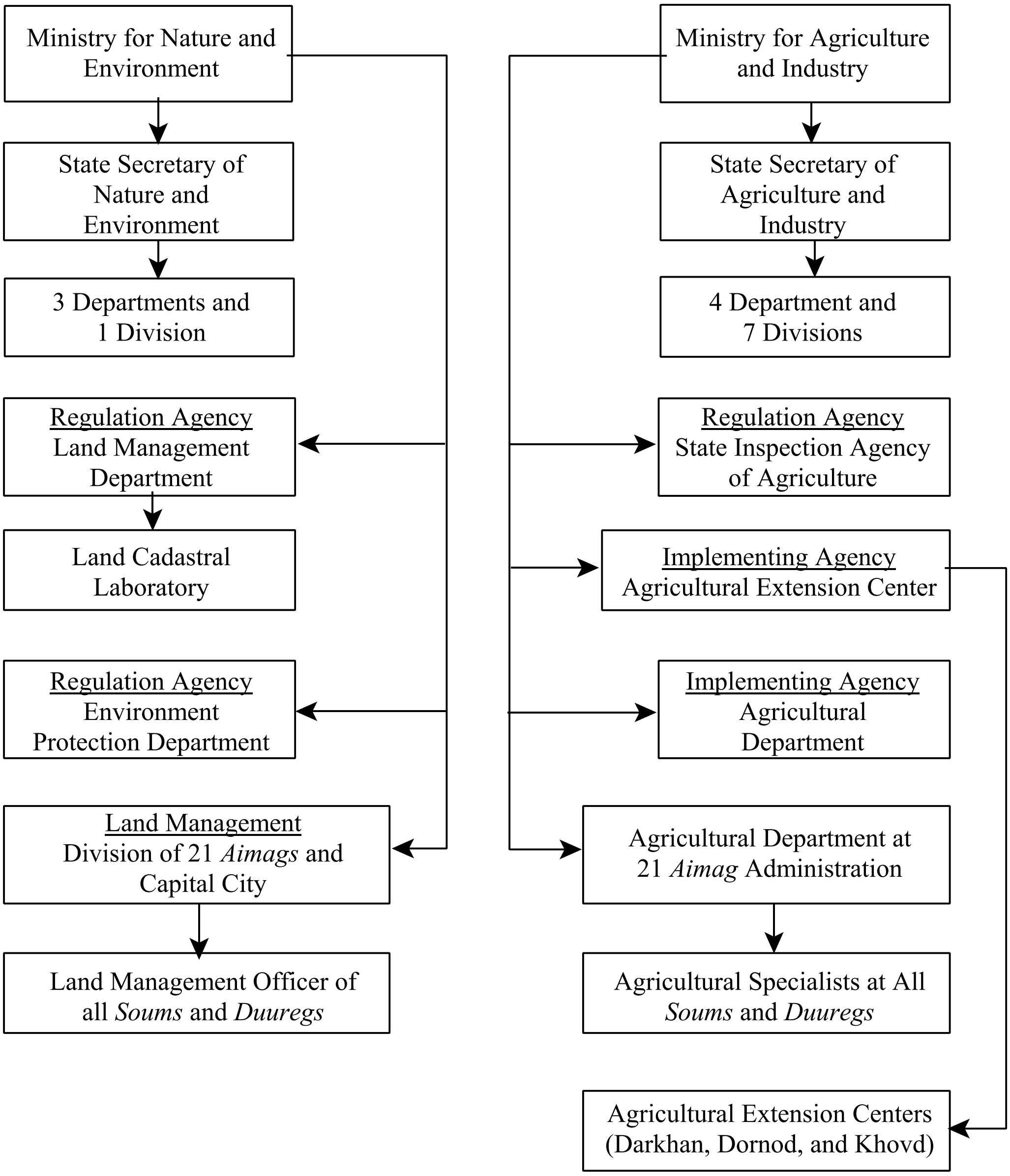

Figure 1. Governmental Organizational Structure Scheme for Land Management and Agriculture

Note: 1 *aimag* = 10-12 *soums*.

– During the contract term it will be possible to use this land partially or completely for other uses, but only with the approval of the legal body which made the original decision on the land use.

- The initial term of the crop area to be possessed or used by citizens, economic entities or organizations shall not be less than five years and shall not exceed 25 years.
- There can be a combined land use between citizens, economic entities or organizations.
- A citizen is able to transfer his/her rights to land possession on heritage.
- The government shall determine the maximum size of agricultural land to be possessed by an economic entity for production and service activities.
- A legal inheritor shall be able to transfer a land-use contract to his name and possess the land up to the term of expiration set out in the first contract.
- A citizen, economic entity or organization possessing or using land with cultivating aims must permanently carry out activities on soil conservation and not degrade the soil fertility. State certification on land status and quality will be issued.
- A citizen can cultivate vegetables and fruits on his/her winter settlement land for family needs.
- In the case of land allocated for livestock grazing, it is prohibited to graze livestock on cultivated areas from the time of planting to time of harvest.
- The government shall retain the right to terminate a contract if any of the contractual conditions are broken.

PRIVATIZATION OF THE CROP PRODUCTION SECTOR

In terms of grain production, the most far-reaching effect of the changed political and economic scene was the breaking up of the state farms. In 1991 there were 91 state farms controlling over 600,000 ha of agricultural land, for grop and fodder prodiction.

State farms were sold off with the government retaining a 51-percent share in all the newly created farms, the other 49 percent was either held by one of the farm types classified above or in some cases by an individual. The main reason for the government retaining this majority share was the recognition of the fragility of these newly privatized businesses having previously been heavily subsidised operations.

The actual privatization of farms was done in the following modes:

- ***Share Certificates*** (SH) – The Mongolian Government issued SHs to every citizen for the privatization of State properties.
- ***Leasing*** (LS) – In this case the purchaser buys the shares belonging to the government in parts or gradually in parts.
- ***By Agreement on Management*** (MC) – The Government of Mongolia has privatized the capable farming enterprises for the future based on the agreement of efficient work.
- ***By offer*** (OF) – This is the way to privatize by offering the rest of the shares to the legal entity with more shares.
- ***By open sale*** (OS) – In this case shares are auctioned openly between purchasers. Starting price on shares is equal to the financial balance of the economic entities.
- ***By closed sale*** (CS) – This approach was used in the privatization of the bigger entities. Participants in this type of sale delivered their bids in sealed envelops to the Stock Exchange (SE) including their intended share and price on unit share.
- ***Through Stock Exchange*** – Selling shares owned by the government through the SE.
- ***Proposal*** (PR) – Economic entities or individuals interested on owning state property may issue a project proposal to the government.

The process of privatization began to highlight problems that the state system had masked with high subsidies. Many of the farms were privatized with debts still outstanding. This caused a chronic shortage of working capital, which was exacerbated by the removal of fixed prices that had been an essential feature of the old communist command economy.

In 1997, the privatization of agrarian state enterprises was based on "the Concept on Privatization of State Properties in 1997/2000". This was adopted by Governmental Decree 63 and by the "Privatization Program for State Property in 1997/2000" adopted by Decree 160 of that year.

The privatization of state farms was handled by the "Committee for State Property". The MAI played a part in the privatization process by establishing a unit for the preparation and organization of state farms for crop production.

According to the "Concept on Privatization of State Properties" and "Privatization Program for State Property", the shares of smaller enterprises were sold on the stock exchange by open auction and the shares of bigger enterprises were sold by bids.

According to the Privatization Commission for the leasing of state-owned shares by management contracts, a number of state-owned shares were transferred to companies or individuals. The above farms were leased after the evaluation of contracts by the Committee on State Property before August 1996. By 1998, 314 independent farming units were involved in crop production and 270 of them were companies with limited responsibilities. Crop production in Mongolia is experiencing problems as more natural disasters occur and the low fertility of topsoil take its toll.

Small- and medium-sized farms consist of:

- Individuals, owning facilities and equipment by privatization, concentrating on vegetable production.
- Individuals and economic entities concentrating on cereal production.
- Individuals and economic entities, owning facilities and equipment by privatization, concentrating on vegetable and cereal production.
- By 1998 the total number of small family farming units was 661,000. This means that of all Mongolian families 13 percent are involved in small-scale farming, which is significant, making up 13.2 percent of the total families of Mongolia.

In the latter part of 1950 the "ploughing of the virgin lands" commenced. This policy was brought about to increase the production of cereals and to satisfy flour needs from domestic production.

The highest levels of crop production were seen in 1985, during this year 886,200 mt of grain was harvested. At that time 52 state enterprises, 20 state fodder farms, and 255 agricultural cooperatives were involved in crop production. Strong price policies were in place and the state farms received large budgets from the government. In 1990, pricing policy and subsidies were removed leaving many state enterprises without the capacity for work and agricultural production came to a halt. Over the last few years, it can be seen that cultivation has decreased except for vegetables and potatoes (Tables 2 and 3).

Cultivated land and yields per ha are decreasing. Due to this, the country is no longer satisfying its demands for vegetables and flour. Needs are now supplied by importation of products, these products are often of low quality and do not satisfy the users requirements. The government recognizes the need for an increase in domestic production and has set up programs designed to assist with this.

Table 2. Total Crop and Sown Area, 1989-99

(Unit: 000 ha)

Type of Area	1989	1990	1991	1992	1993	1997	1998	1999
Crop area	1,400	1,350	1,300	1,200	1,100	700	900	800
Sown area	800	750	700	650	550	300	300	280

Table 3. Land-use Change

Type of Land Use	1960	1970	1980	1990	1999
Arable lands	532.0	719.6	1,037.5	1,340.1	902.7
Crop land	447.0	650.0	960.0	785.8	
Of which: cereals	247.0	420.0	576.0	653.0	27.0
Of which: Wheat		348.0	424.0	532.0	27.0
Potatoes	2.0	3.0	7.0	12.0	
Vegetables	1.0	1.0	2.0	3.0	
Green fodder	15.0	37.0	104.0	117.8	
Hay making land	900.0	1,213.0	1,367.4	1,990.0	1,991.7
Pasture land	141,090.0	119,288.7	119,136.3	122,294.8	127,099.6

The “Green Revolution Program” is helping to rehabilitate vegetable and potato production. In 1998, 65,200 mt of potatoes and 45,700 mt of vegetables were produced. Compared to the previous years, grain harvest decreased by 18.9 percent, whereas potatoes increased by 19.4 percent and vegetables by 34.4 percent. The following conclusions can be made:

– From 1989 to 1997, the total cultivated area decreased by 134,600 ha to 783,000 ha.
– In 1999, there was a further decrease and the decrease in 2000 is evident.
– In 1989, cereal production was 839 thousand mt; by 1995 the figure had fallen to 261 thousand mt and has continued to fall except for 1997.
– From 1989 to 1995 total crop land, cultivated land and total volume of production has seen a dramatic decrease and the figures are still falling.

Crop production in Mongolia reached its zenith in 1989 producing 839,000 mt of crops (687,000 mt of grain, 103,000 mt of potatoes, and 59,000 mt of vegetables) from 837,000 planted ha, 169.4 thousand mt of wheat, 63.8 thousand mt of potatoes, and 39.0 thousand mt of vegetables were harvested in 1999.

The decline in crop production can be attributed to a general lack of finance, inadequate policy reform and the lack of technical innovations during the move from a command to free market economy.

Thirty years have passed since the first cultivation of virgin steppe land and a large part of the arable land has now been abandoned. Prior to 1990, the survey on the erosion of arable land was incomplete the figures used in the above table are the results of a survey done on 1,206,400 ha. The eroded arable land has increased three times since 1970, reaching 561,600 ha in 1990. This is 41 percent of the total arable land (Table 4).

A survey has been carried out over the last three years on the erosion of arable land. It covers 1,206.4 thousand ha on 145 farms in 12 *aimags*. This represents 89.6 percent of all arable land in Mongolia. It shows that 46.6 percent has been eroded by wind of which 12.9 percent is severe erosion and 28.2 percent is moderate.

Table 4. Increase in Arable Land and Erosion

(Unit: 000 ha)

Year	Total Crop Land	Eroded Land
1940	26.0	
1960	447.0	
1970	650.0	168.4
1980	1,021.0	
1990	1,337.0	561.5

This survey shows that a total of 49.4 thousand ha of land on 48 farms in nine *aimags* have become desert. Its humus has completely disappeared rendering them non-arable. Soil erosion is causing annual decreases in crop yields of 197,500 mt. However, it is difficult to carry out a complete survey on the impact of soil erosion on nature and society.

ADAPTATION OF HERDERS TO CROP PRODUCTION

Mongolian nomadic pastoralists are a dominant group amongst the different types of nomads throughout the world. These nomadic groups are a people who practice pastoral animal husbandry in a nomadic way, moving their herds with the seasons to better grazing lands.

In general, this style of nomadic pastorals and nomadic life style has been slow to develop but there is evidence to support that the traditional Mongolian herder is now changing. Over the last 30 years, more and more herders are living a relatively settled life and is no longer moving their herds over vast distances to seek fresh pastures. This in turn is having a detrimental effect and is causing a severe problem with the overgrazing of steppe land.

As a result of the intensive cultivation campaign of the late 1950s, crop production reached its zenith at the end of the 1980s and the demand for flour was met fully from the national crop. The planting of fodder for the intensive animal husbandry sector and the planting of vegetables was made possible.

The crop production and animal husbandry sectors were the largest source of income for the country; however, these two sectors had conflicting interests:

– Pastureland was reduced by the increase of cultivation; this land was seen to be more important as it had higher production capacity.
– It became necessary to keep herds away from crop lands during the vegetation period.
– Due to the cultivation of land previously used for seasonal sites by herders, it became necessary to reallocate pastures, choosing new winter, spring, summer, and autumn sites.

In spite of the above conflicting situations, traditional animal husbandry and crop production adapted to each other. By locating winter sites close to crop lands herders were able to take advantage of the recently harvested land, by using the remaining straw as fodder.

By end of 1998, Mongolia's animal population had reached 32.9 million (by converting this figure to sheep units it becomes 69 million). Crop land area was 902,700 ha, which is less than the cultivated area of 1990 by 444,200 ha. The figures show that an enormous amount of fertile pasture area was converted into crop lands, this land will, after repeated cultivation, be rendered useless. Within the framework of the study, it was targeted to define the carrying capacity of pastureland in Mongolia.

For the above purpose, animal populations in 1998 in every *aimag* and *soum* have been converted into sheep units. Feed value units or coefficients were calculated which means one horse is equal to 6.6 sheep units, one cattle is equal to 6.0 sheep units, one camel equals 5.7 sheep units, and one goat equals 0.9 sheep units.

In the calculation of carrying capacity, unit areas needed for the pasturing of one sheep unit for one year. These figures were defined for each *soum* by the Institute for Land Policy. Table 5 shows the available pasture capacity in sheep units.

Table 5. Pasture Capacity analysis

Type	Unit	1989	1999
Total sheep units	000	52.584	62.226
Pasture needed to grazing	000 ha	108.956	139.687
Pasture	000 ha	124.157	127.099
Pasture in the one sheep unit	Ha	2.4	1.8
Pasture capacity	000 ha	15.201	-12.588

BALANCE OF INTEGRATION OF CROP FARMERS WITH ANIMAL HUSBANDRY

Before 1990, state enterprises for crop production started to breed animals to provide themselves with meat and dairy products. State enterprises employed their own staff and herders for breeding such animals such as sheep, cattle and horses.

After 1990, the privatized large-scale farming enterprises worked for many years with a wheat-fallow-wheat-fallow rotation. However during the last two years, most of these enterprises recognized that this is hardly profitable and many of them started to integrate livestock on their farms in order to supply the growing market demand. Several cases are known where farms that were cultivating about 600 ha of wheat have now established herds of up to 2,000 head of beef and dairy cattle.

Such integration of livestock and crop growing can improve the soil quality when wheat cultivation is rotated with fodder crops. Milk and meat production from farming enterprises is generally supplying better raw materials for processing than herdsmen can provide. It is foreseeable that within a transition period of five years, the major part of the meat and milk supply in Mongolia will no longer come from traditional herdsmen but from farming enterprises with integrated livestock and crop sectors.

EXTENSIVE LAND USE VERSUS INTENSIVE CROP PRODUCTION

In the areas of Mongolia with average annual temperature not less than +1ºC and with annual precipitation greater than 250 mm it is considered suitable for stabile crop production in open fields. According to the above parameters, not all parts of Mongolia are considered suitable for crop production. Approximately 84 percent of all crop lands are in areas with non-stabile conditions, 10 percent is in the areas considered as higher risk, and 1.5 percent is located in desert and desert steppe.

As result of government policy on cultivation of new areas since the 1960s, the cultivated area has increased 10 times. By the beginning of the 1990s the total cultivated area had reached 1,034,000 ha. Due to the economic and social changes and problems, crop production has decreased continually during the last decade. It can be seen in the crop land per person and the crop production figures (Table 6).

Table 6. Sown Area and Cereals per Person, 1980-99

Year	Total Sown Area (000 ha)	Total Cereals (000 mt)	Total Population (000)	Sown Area (ha/person)	Cereals (mt/person)
1980	704	287	1,682	0.42	0.17
1990	788	718	2,149	0.37	0.33
1991	709	595	2,187	0.32	0.27
1992	658	494	2,215	0.30	0.22
1993	585	480	2,250	0.26	0.21
1994	470	331	2,280	0.21	0.15
1995	372	261	2,318	0.16	0.11
1996	348	220	2,353	0.15	0.09
1997	334	240	2,387	0.14	0.10
1998	326	195	2,349	0.14	0.08
1999	298	171	2,383	0.13	0.07

PROSPECTS FOR AGRICULTURAL DEVELOPMENT AND LAND USE IN MONGOLIA

The state policy on land is a part of the "National Development Concept of Mongolia", based on state independence, and is regarded as part of the national security. This concept states that the original sources of social development are territory and natural resources. For future benefit, national environment would be protected, national territorial resources used rationally, restorations carried out and priority given to social problems; in other worlds, human population and society, as well as the surrounding environment, would be protected from natural disasters. Natural resources used within their ecological carrying capacity can lead to economic and social development, as well as ecological security. The main targets of the state policy are as follows:

- Use natural resources carefully;
- Legislate the ownership of land;
- Establish laws for the possession and use of land;
- Protect land from natural disasters and human negligence;
- Prevent land from damage and degradation;
- Correct any changes by certifying land characteristics and quality;
- Set up monitoring network systems;

- Improve land records;
- Promote the use of land on the basis of a payment system;
- Use advanced technology in order to improve conditions of damaged land; and
- Strengthen land management policies.

There is a requirement for land-use policy. It should be based on improving the conditions of the land, be bio-ecologically effective, and should evade the methodology of using land, which is solely based on 'profits' without knowing the long-term harmful effects.

Agriculture is main source of income for 2.4 million people in Mongolia and it currently produces 37 percent of GNP. Nearly a third of the income in hard currency is gained by the export of agricultural production. About half of the population is employed in the agricultural production sector, and it is the main source of income for families in rural areas of Mongolia. Mongolian agriculture consists of two sub-branches:

- Pastoral animal husbandry, which is based on a systematic use of pastures throughout the four seasons; and
- Crop production – most of the larger mechanized companies are situated in central Mongolia.

Vegetable production (potatoes and other vegetables) is largely undertaken by families on small plots of land or on greenhouse farms. The breeding of pigs, poultry and milk production is mainly carried out by intensive forms of animal husbandry.

In 1990, when state subsidies came to a halt, the volume of agricultural production decreased drastically. The volume of GNP dropped to 84 percent of the level in 1989 and in 1999 to 50 percent of the level in 1998. In 1990, 33 percent of the population was employed, one way or another, in the agriculture sector and by 1998 this percentage had reached 49 percent. Due to the lack of social service organizations in rural areas, many people found it harder to support themselves and their families and therefore moved out of rural settlements and became herders. This, in turn, caused not only an increase in the number of herding families but also a significant increase in the number of livestock. Between 1990 and 1998 the percentage of rural inhabitants had increased from 40 percent to 50 percent.

The impact of the transition period on the sub-branches of agriculture is different. The share of animal husbandry in the total agriculture output increased from 77 percent in 1989 to 88 percent in 1998. The total population of animals increased three times within the same period reaching 33 million. Due to the sudden increase of raw cashmere prices, the population of goats is increasing rapidly. After the privatization of agricultural cooperatives, the number of herders increased by 150 percent. This increase is one of main influencing factors on the growth of the animal population. The number of families with herds of under 50 animals was 80 percent. This figure has decreased to 37 percent due to the increase of families with herds over 100 animals from 4 percent to 40 percent in 1998. In the 1990s, processing and sales of agricultural products decreased drastically. For example, meat production in 1998 is only 10 percent of that seen in 1989. Exports of meat, wool, cashmere and skins have also decreased.

The share of crop production in total agricultural production (crops and livestock) has decreased drastically. The share was 30 percent in 1989 and it decreased to 12 percent in 1998. The share of cultivated crop lands to total crop lands was 60 percent in 1998 but decreased to 25 percent in 1989. Production of cereals in 1998 reached only 28 percent of the mean production in 1989 and it was respectively 3 percent in fodder production. The production from unit crop land also decreased.

In Mongolia, one would reasonably expect that land reform would make significant nation-wide changes in economic, political and social life. Consequently, state government needs to pay special attention to land reform and implement it as a comprehensive national program.

Land reform in Mongolia will be aimed at developing land relations which are compatible with the requirements of a market economy and capable of ensuring sustainable production and effective resolution of social problems.

It is of great practical importance of understand land reform in the sense of not only ownership reform, but in the broader sense of land usage patterns which are based on the whole spectrum of property rights down to possession and various land usage rights, whether formal or informal. In this sense, land reform inevitably includes changes in organization that form the basis of the overall economic, social and political structure and determine a great, if not the most, part of it. Their change entails changes in the whole pattern of the economy and society, including its non-agricultural parts.

It should be noted that those who are against the introduction of private ownership of land in Mongolia still have notable political weight. The main argument used by them is the idea that the introduction of private land ownership will harm the national security of Mongolia. But during the implementing of the law there was a need for improving and developing land relations. For example, the Land Fee Payment Law says "the free of charge possession and use of pastures as well as hay-fields by herders was not a correct decision" because people still had a strong tendency towards careless and cost-free use of land. Considering the recent degradation of land and pastures, particularly the land of cities, villages and other settlements, there is a requirement to charge for pastures near water bodies in order to manage pasture capacity, minimizing reloading of pastures, and keep in ecological balance.

A release of pastures from payments has badly effected the ability to use the economic mechanisms for limiting great migration of the population to towns and cities which decreases the amount of money which could be concentrated in a budget and as a result the possibility for the restoration of land and irrigation of pastures. If some amounts of money for using pasture land are directed to supporting and developing hospitals, schools and other social activities, herders would benefit. It is worth saying that it is already time to begin real changes in practice, to demonstrate the feasibility of such changes, and thus stimulate others towards such changes.

CONCLUSIONS

The latest history of agricultural development in Mongolia was dominated by two features which both had significant negative impacts on the Mongolian ecological system. The intensive development of Soviet style agricultural industrial complexes lead to extensive erosion of fertile pastoral land which will take centuries to recover. After the breakdown of the command economy in the 1990s, the uncontrolled increase of nomadic cattle breeding lead to overgrazing of pastures, which threatens the ecological system of most parts of Mongolia.

The restoration of eroded former agricultural land as well as the prevention of further overgrazing requires a legal framework of land utilization in combination with efficient control mechanisms on both the local and regional levels. The nomadic nature of the Mongolian agriculture sector does not allow Mongolia to simply copy legal frameworks, but additionally takes into consideration the demands of nomadic and semi-nomadic cattle breeding. This includes especially, traditional informal and newly authorized formal rights of land and water usage.

Due to the urban settlement pattern, Mongolian municipalities will be the controlling and law enforcing authorities for agricultural and nomadic activities within the municipal boundaries.

The Land Distribution and City Planning Authority of Ulaanbaatar is grateful for the assistance and support of the Asian Productivity Organization and is looking for further cooperation in this sensitive but important topic.

9. SRI LANKA

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INTRODUCTION

Location and Climate

Sri Lanka is situated in the Indian Ocean between 5º and 10º north latitude and between 79º and 82º east longitude, just at the south end of the Indian Sub-continent. Sri Lanka is an island that covers an area of 65,610 km^2.

Being a tropical country, the average temperature in Sri Lanka is 26-34ºC. Different climatic conditions can be seen in various parts of Sri Lanka.

Sri Lanka's land area is broadly divided into three major agro-climatic zones: the Dry Zone comprising the bulk of the island in the north, north central, east, north west and south east; the Wet Zone is in the central and south west quadrant; and the Intermediate Zone is sandwiched between the Dry and Wet Zones. The annual rainfall limits of the Wet, Intermediate and Dry Zones are 2,400-4,500 mm, 1,800-2,400 mm and 850-1,800 mm, respectively (Figures 1 and 2).

There is only a slight variation in the annual range of temperature for the Island, but this is exceeded by the diurnal range of temperature. The coastal areas have the smallest amplitude for the diurnal range of temperature while the highest range occurs in areas situated towards the interior away from the coast. The highest diurnal range of temperature is recorded during the months of February and March. The average temperature varies from a minimum of 23-32ºC maximum in the low country and 10-23ºC in the hill country (Figure 3).

Population

The total population in Sri Lanka is 19 million with a growth rate of 1.4 percent per annum. Population density is around 289/km^2, varying from higher density in the western and central provinces to lower densities in north and east. The literacy rate in 89 percent. Life expectancy remains at 72 years, with females showing an average above males. By sector, rural population is 72.2 percent, and urban is 21.5 percent, and estates 6.3 percent.

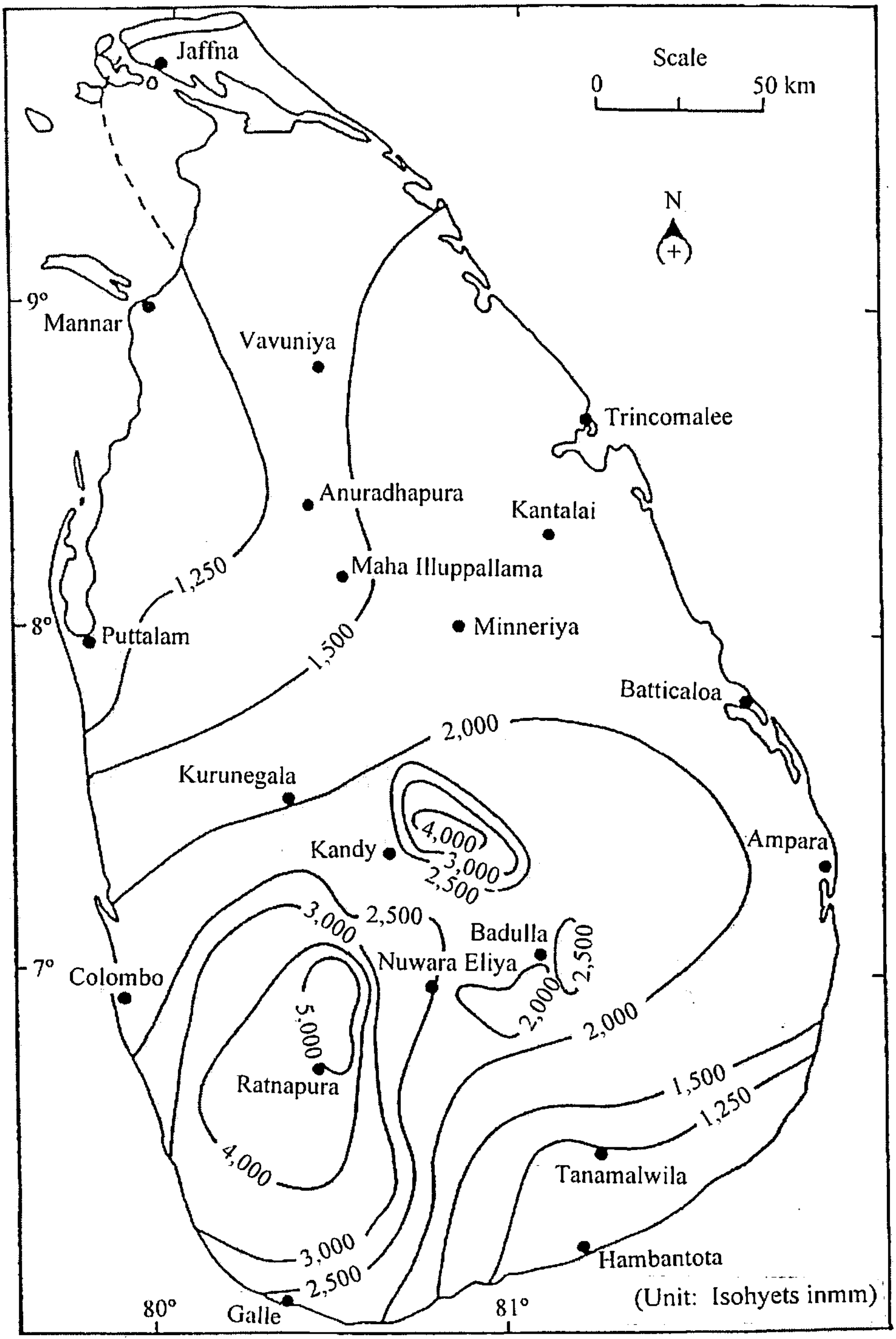

Figure 1. Mean Annual Rainfall

Source: M. Domros, 1974.

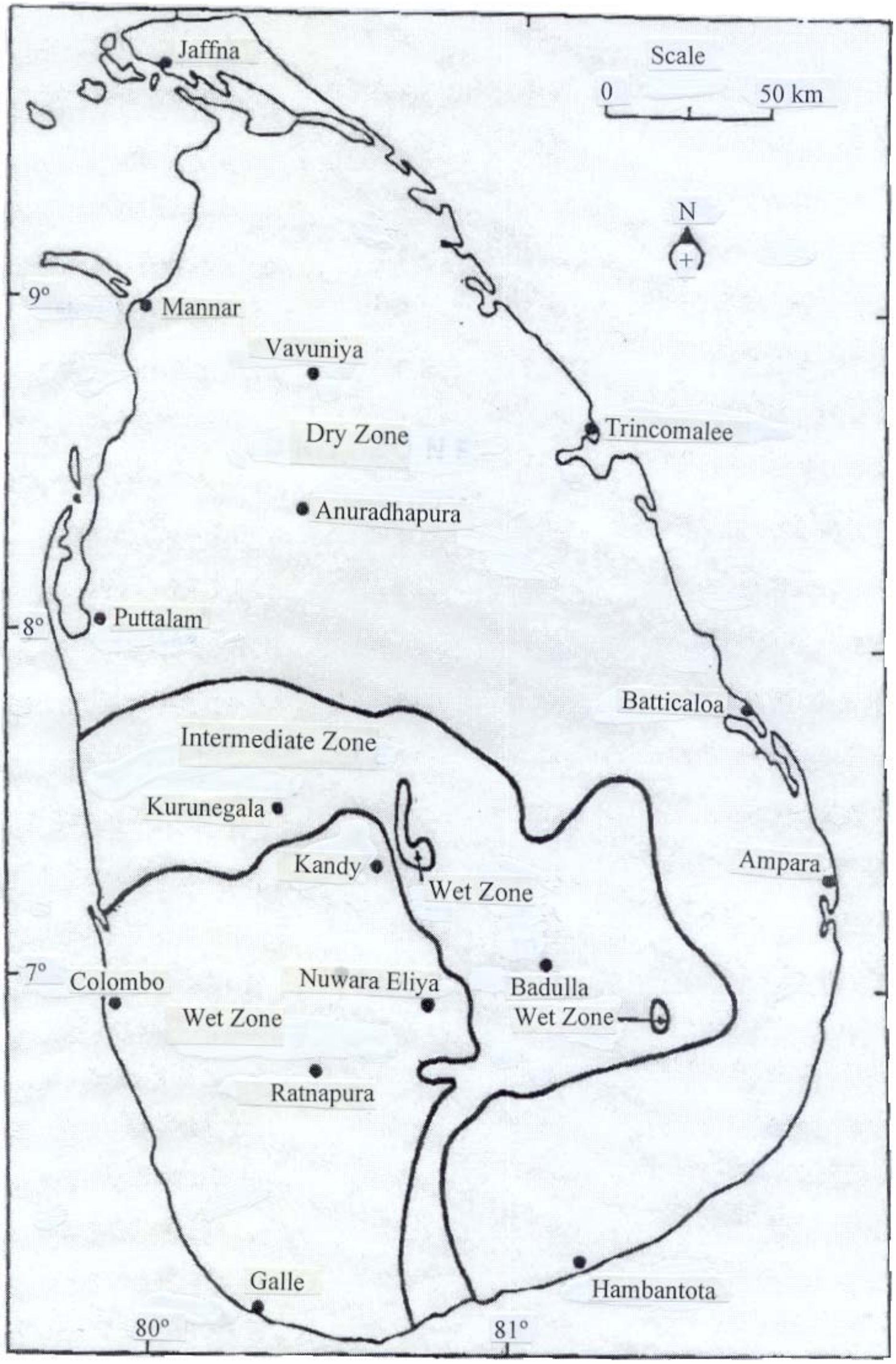

Figure 2. Demarcation of Wet, Dry and Intermediate Zones

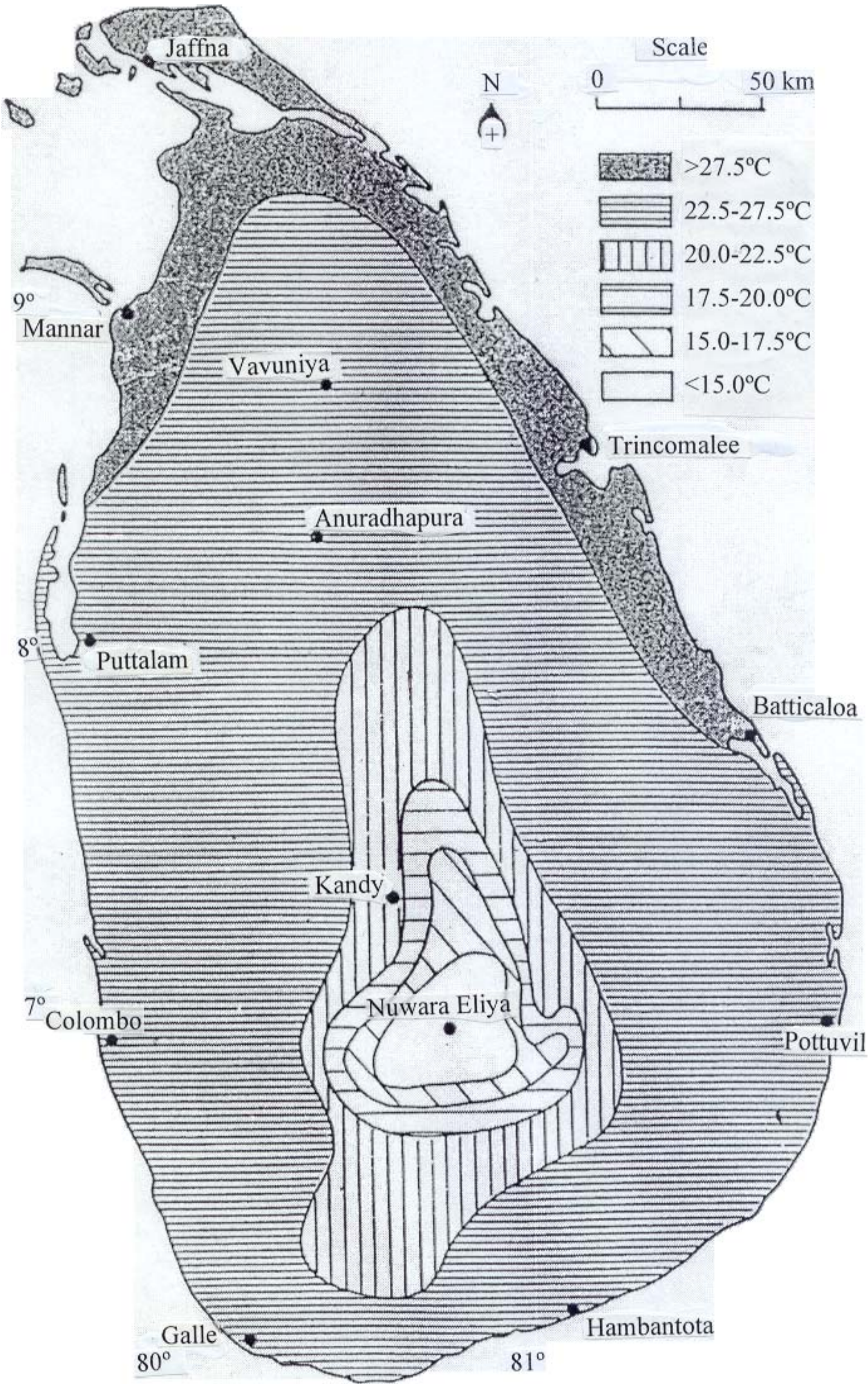

Figure 3. Mean Annual Temperature

Source: R. Kannangara, 1982.

Economy

Sri Lanka's economy has experienced mixed results following varying policy changes during the last 50 years since independence. It presently follows open market policies vigorously. Economic growth rate was 4.3 percent in 1999. GDP current market prices increased by 9.1 percent and per capita income was US$829. For economic growth in 1999, the agriculture sector contributed 23 percent and the manufacturing sector contributed 18 percent, while domestic trade, tourism, and informal services contributed 53 percent. Other sectors contributed the balance of 6 percent. The sectoral composition of the GDP from 1978 to 1999 has shown some variation in the agriculture and manufacturing sectors and an increase in services (Table 1).

Table 1. GDP Sector Shares as Percentage

Sector	1978	1987	1996	1999
Agriculture, forestry and fishing	28.7	23.6	18.6	23.0
Manufacturing	15.3	16.2	21.0	18.0
Services	45.3	50.3	51.2	53.0
Mining/quarrying	2.4	2.7	2.5	2.6
Construction	8.3	7.2	6.9	3.4

Source: Central Bank Annual Report.

Sri Lankan agriculture is dominated by smallholders. Nearly 73 percent of all agricultural land is under smallholdings (except for about 8,000 plantations mainly tea, rubber, and coconut). It is evident that over 85 percent of agriculture holdings are less than two ha in size. The population employed in agriculture, livestock and fisheries was about 38.5 percent of the total number of persons employed in 1998.

In the livestock sector, the recent survey data places the animal population at the following: cattle, 1.8 million; buffalo, 0.86 million; goats, 0.46 million; poultry, 9.3 million; and a few sheep. Nearly 400,000 small farmers are in dairy with only a very few large dairy farms in operation.

LAND CLASSIFICATION SYSTEMS IN SRI LANKA

Land Classification Studies

In the past, Sri Lankan soil scientists directed their efforts to classifying the land according to its capability and the suitability. A few foreign funded projects carried out some interesting studies to evaluate the land suitability in few selected parts of the country. The UNDP Master Plan for the Mahaweli Development Project was based on soil surveys and land capability classification studies. These studies were based on modified United State Bureau of Reclamation (USBR) method where five land capability classes were differentiated. Similar studies based on the same method, but in more detail and on a larger scale of 1:50000-1:25000 are being carried out for all major Irrigation development projects in the country. Under Integrated Rural Development Projects, several studies were carried out to evaluate the land suitability of few selected districts in the country (Matara, Ratnapura and Nuwara Eliya). The FAO land evaluation framework was employed for such studies.

The principles of a system of land suitability classification for Sri Lanka have been proposed and clearly articulated by De Alwis in 1977. The classification system was based on the following basic assumptions:

1. Each classification is an interpretive grouping of land with respect to the potentialities and limitations for the particular use or purpose being considered.
2. A land suitability classification is not a land-use recommendation, it is only a prediction regarding the behavior of land under a particular use and defined management.
3. A high level of management for sustained use, but one that a majority of users are capable of attaining, is assumed.
4. The land is classified according to its current condition, not taking into account future improvement involving expensive investment (e.g. irrigation, major land leveling).
5. Only physical factors contributing to or limiting the productivity or use of the land are considered in this classification. Size of holding, location, transportation facilities, availability of markets, service organizations, utilities, labor, etc. are not taken into account.

In this classification, the following three groups can be identified,

1. ***Suitability Class***: Grouping of lands having the same degree of the hazard or limitation for the use being considered.
2. ***Suitability Sub-class***: Grouping of lands within each suitability class having the same kind of hazard and limitation for the use being considered.
3. ***Suitability Units***: Basic unit of suitability classification and provides the most detailed information on individual tracts for all lands.

Lands Suitability Classification for Selected Crops

1. ***Land Suitability Classification for Tea***

According to the land classification system suggested by De Alwis, country tea lands were classified into four land suitability classes (Table 2).

Table 2. Land Suitability Classes for Tea

Sustainability Class	Degree of Limitation of Hazard	Sustainability
1	No significant limitation or hazard	Very suitable
2	Moderate single limitation or hazard	Suitable
3	Moderate, non-interacting or mildly interaction, dual limitations	Fairly suitable
4	One or more severe limitations or strongly dual limitations or multiple, moderate limitations	Unsuitable

Source: De Alwis, *et al.*, 1980.

Table 3 shows the yield potentials of tea in different land suitability classes where highest yields can be obtained from the Suitability Class 1 of the upcountry and the low country.

Table 3. Yield Potentials of Tea in Land Suitability Classes

Suitability Class	Up Country	Mid-country	Low Country
1	>2,500	>2,500	>2,750
2	2,000-2,750	1,750-2,500	2,000-2,750
3	1,250-2,000	1,000-1,750	1,250-2,000
4	<1,250	<1,000	<1,250

2. ***Land Suitability Classification of Coconut***

Land suitability assessment for coconut growing areas of the country has been developed by Somasiri, *et al*. It recognizes five suitability land classes (S1-S5) and two unsuitable land classes (N1-N2). Potential yields and extents are shown in Table 4.

Table 4. Land Suitability Classes for Coconut

Suitability Class		Potential Yield (nuts/ha/year)	Extent (ha) (approximate)
S1	Highly suitable	>15,000	12,000
S2	Suitable to highly suitable	12,500 – 15,000	202,000
S3	Suitable	10,000 – 12,500	110,000
S4	Moderately suitable	5,000 – 10,000	166,000
S5	Marginally suitable	2,500 – 5,000	78,000
N1 and N2	Unsuitable lands		80,700
Total			648,700

LAND UTILIZATION AND FARMING SYSTEMS IN SRI LANKA

The physiography of Sri Lanka can best be described as consisting of a central mountain mass, the central highlands, rising in a series of tiers or ramparts from a low, gently undulating plain surrounding it in all sides and extending to the sea. One could recognize three peneplains cut in the rocky framework of in the island such as:

	Elevation
Lowest peneplain	0 – 125
Middle peneplain	125 – 750
Highest peneplain	750 – 2,500

The lowest peneplain surrounds the central hill country on all sides and is a gently undulating mantled plain stretching down to the coast.

Rising from the inner edge of the lowest peneplain in a steep step of about 300 m is the middle peneplain with a maximum elevation of about 800 m above sea level. Within it and rising from it is another steep step of 1,000 m to 1,300 m is the highest peneplain at a general level of about 2,000 m but rising in places to 2,300 m or 2,700 m. The principal physiographic regions that make up the island are the above three peneplains and the coastal plain (Figure 4).

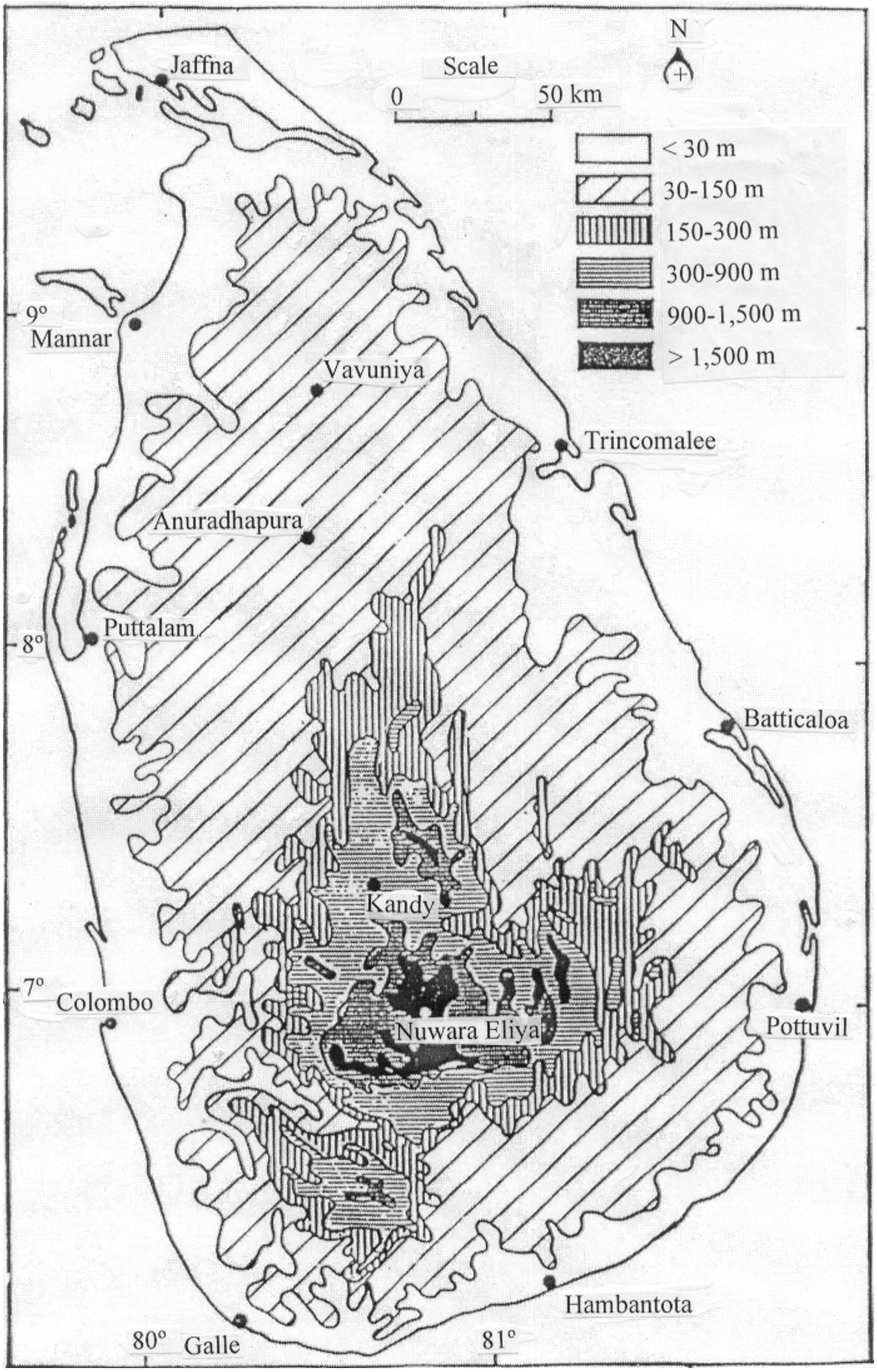

Figure 4. Generalized Relief Map of Sri Lanka

The coastal regions of Sri Lanka are 100 percent fishing areas within four miles from the coast and fishery populated area and entire land is utilized for fishery purposes; such as habitation of the fishing population, fishing grounds, affiliated fishing industries, etc. These areas most suitable for coconut cultivation.

Beyond the four-mile range, the land is utilized for agricultural purposes, depending on the adaptable agricultural vegetation such as paddy, coconut, and other vegetable cultivation. The highlands of Sri Lanka over 1,500 ft above mean sea level are very much suitable for rubber and tea cultivation which is the major foreign exchange earning industry in Sri Lanka.

Table 5 shows that major agro-ecological regions in Sri Lanka divided into three zones with different elevations, mean temperatures, and annual rainfall ranges. Table 6 shows the total land utilization statistics for Sri Lanka.

Table 5. Major Agro-ecological Regions in Sri Lanka

Agro-ecological Regions		Elevation (m)	Mean Temperature (ºC)	Rainfall (mm)
Wet Zone	Up country	1,000 – 2,000	10-15	2,500 – 5,000
	Mid-country	500 – 1,000	20-15	2,000 – 3,000
	Low country	0 – 300	20-25	2,000 – 3,000
Intermediate Zone	Up country	1,000 – 1,500	15-22	1,500 – 2,250
	Mid-country	350 – 500	24-26	1,500 – 2,250
	Low country	0 – 300	25-29	2,000 – 2,200
Dry Zone	Low country	0 – 300	28-30	900 – 1,000

Table 6. Land Utilization in Sri Lanka

Category	Extent (000 ha)	Percent of Total Extent
(a) Urban Uplands		
Built-up lands	203.9	3.11
Associated non-agricultural lands	220.3	3.36
(b) Agricultural Lands		
Homestead	627.7	9.57
Tea	222.1	3.39
Rubber	199.0	3.03
Coconut	588.7	8.97
Mix trees and other perennial crops	454.3	6.92
Paddy	817.6	12.46
Spartially used crop lands	907.2	13.83
Other crop lands	52.9	0.81
(c) Forest Lands		
Natural forest	1,208.6	18.42
Forest plantations	134.3	2.05
(d) Range Lands	547.5	8.34
(e) Water Bodies	254.0	3.87
(f) Barren Lands	74.3	1.13
(g) Wet Lands	48.6	0.74
Total	6,561.0	100.00

Farming Systems in the Different Agro-ecological Zones

1. ***Dry Zone***

The Dry Zone covers nearly three-fourths of the country's land area. Rainfall is bimodal and is often intensive and erosive on exposed soil. Potential evapotranspiration exceeds rainfall. Alternating with the rainy seasons, are two dry spells during which soil and air temperatures are fairly high.

Shifting cultivation has been the traditional form of rainfed upland farming in the Dry Zone. This involves the clearing of forests, growing annual food crops such as grain legumes, coarse grain cereals and vegetables for a period of two to three years with very little input, abandoning the land and then moving to new forest lands to begin the process all over again. Farmers prefer this type of farming because the newly cleared lands are easy to cultivate compared to lands continuously cropped, where fertility declines rapidly and weed control is a serious constraint. However with increasing population and decreasing forest reserves shifting cultivation is becoming more difficult and is being gradually replaced by more settled forms of farming.

The rice lands in the Dry Zone which comprise about 370,000 ha (60 percent of the country's rice lands), are located in the gently sloping valleys in an undulating catenary landscape on reddish brown earth and low humic gley soils. They are the most productive rice lands of Sri Lanka. The greatest increase in rice yields during the past decade has been recorded on these soils. In the 1991 *Maha* season, yields averaged 4.4 mt/ha and the *Yala* season yields were 4.0 mt/ha. In *Maha*, 80 percent of the rice lands are cultivated under major and minor irrigation schemes, while 20 percent are rainfed.

The rainfed rice lands of the Dry Zone are mostly in the northern and eastern regions on alluvial and low humic gley soils. In rainfed farming farmers normally use short-age varieties and the risk of incurring heavy losses is reduced by restricting fertilizer application and other inputs. Land preparation is done before the onset of rains. Rice seeds are broadcast while the lands are dry. Yields obtained in these rainfed rice tracts are very low. If the farming system is purely dependent on rain then only one crop of rice is grown during the period form October to December when rainfall is heavy. Thereafter the lands lie fallow and are used to graze cattle and goats.

In the northern part of the Dry Zone, in areas where irrigation water is available, very intensive cultivation is practiced with as many as four crops a year. Grain legumes, coarse grain cereals, chili, ginger, onion, and vegetables are grown in rice fields in the *Yala* making use of the residual soil moisture, and also in the highlands. If sufficient water is not available, the lands lie fallow. Land holdings are usually small, about 0.1-0.4 ha per family. Usually livestock form an integral part of the farming system and large amounts of cattle manure are added to the fields at extra cost.

2. ***Low Country Wet Zone***

A fair amount of the land in this region has been used for non-agricultural purposes. The total cultivated extent of this zone is about 865,000 ha. The landscape varies from hilly in the interior to undulating and flat in the coastal region. Rainfall is bimodal and high intensity showers are a common feature resulting in soil erosion in the highlands and flash floods in the lowlands. During dry weather, salt water intrudes into lands that are less than 50 cm above mean sea level.

Highlands are predominantly under cultivation of tea, rubber and coconut, and to a small extent, are under fruits, vegetables and spices. Lowlands are almost exclusively cultivated with rice. There are about 138,000 ha of rice lands of which 122,600 ha are under rice-rice cultivation. Water supply is from rain and a slow discharge from the aquifer and is sufficient.

3. ***For Two Rice Crops A Year***

Land preparation and sowing operations have to be completed within a short period to avoid hazards due to flash floods affecting rice plants during their early stage of growth. Rising floodwaters in the lower parts of the valley constitute a serious constraint to rice production in this region. By proper timing of the cultural operations and selecting suitable rice varieties, moderate yields can be obtained.

4. ***Intermediate Zone***

In the low country Intermediate Zone farming systems are similar to those in the north central and southeastern parts of the Dry Zone. More than 75 percent of the rice lands in the low country Intermediate Zone are rainfed.

5. ***Up Country***

In the up country, potato is the main crop and is grown in rotation with various exotic vegetables such as leeks, cabbage, carrot, beet root, and radish.

Rice is grown in the narrow sloping valleys and on the terraced slopes. Of a total extent of 42,600 ha of rice lands in the mid-country Wet Zone, 70 percent are irrigated and 30 percent are rainfed. Water supply for the rice lands is from rain and spring flow, and is usually adequate for two rice crops a year. In this region 30 percent of the rice lands are of the well-drained type and are subject to drought during certain months of the year, 45 percent are moderately-imperfectly drained and are the most productive rice lands, while the rest are poorly drained.

6. ***Mid-country Wet Zone***

In the mid-country Wet Zone, the farming conditions and associated problems result from a wide range of elevations, rainfall regimes, and soils which are mainly red yellow podzolic, reddish brown latosolic, and immature brown loams. Extensive soil erosion can occur in land with steeply dissected slopes.

The farming system in this region is comprised of tree crops, rice, and other annual food crops. The hill slopes are planted with plantation crops, spices, coffee, fruit trees, and trees of timber value, which help in reducing the risk of soil erosion.

MAJOR CONSTRAINTS TO IMPROVING THE CONTRIBUTION OF LAND UTILIZATION SYSTEMS TO ENHANCING AGRICULTURAL PRODUCTIVITY

Agricultural productivity improvement is a major thrust area of concern in the national development program of the country. During the last few decades the government had implemented a number of projects to improve agricultural productivity through the introduction of a standard land-use planning approach. Even though these projects were implemented through government and private organizations, objectives were not totally achieved. The following constraints were identified by various organization and individuals for failures of such projects:

1. ***Lack of Local Participation***

The initiative for land utilization programs usually comes from government officials or others outside the local community. Goals and targets were also set by such organization.

Resources and skills of local communities were not properly utilized by the government in all stages of planning and implementation of programs, which resulted in failures of programs.

2. ***Poor Public Interest on Land Utilization***

Especially in the Dry Zone of the country, the majority of the farming population is identified as small-scale subsistence farmers. Those farmers are mainly concerned with short-term benefits from their fields rather forecasting for long-term development programs, which has resulted to a very high extent of encroachment on marginal lands not suitable for cultivation. The difficulty in getting ownership of crown lands encroached on by farmers creates a very poor interest for the proper utilization of lands, for higher agricultural productivity.

3. ***Poor Coordination among the Organizations Involve in Land-use Planning***

Though various government and non-government organizations are implementing land-use programs, the coordination among such organizations is very poor. Therefore the set targets will not be achieved.

4. ***Non-availability of Updated Information for Land-use Planning***

Most of the organizations involved with land-use planning may have to use outdated technical and socio-economic data for the planning of their land-use programs. One of the major drawbacks faced by planners during the planning of such programs is the difficulty in obtaining updated data. This serious situation is very common in the country.

5. ***Lack of Research Activities on Land-use Planning***

Most of the research activities on land-use planning are carried out by a very few organizations in the country (Department of Land-use Planning, Department of Agriculture and some research institutions). Due to very poor replication, the research findings could not be generalized.

6. ***Lack of Extension and Training Facilities on Land-use Planning***

It is a common feature that most of the land-use planning programs will be implemented through a properly designed extension and training program. Due to a number of reasons, the coverage of such extension and training programs is very low.

7. ***Lack of Funds***

Even though the government has given very high priority to the improvement of land utilization systems, due to the limitation of fund allocations, those programs have had to be reduced to a certain degree.

8. ***Urban Agglomeration***

The growth of industrial production has caused far-reaching problems. There is an increasing need for space, housing areas, leisure and recreation installations, transportation, infrastructure energy and water resources. The demand for land and space leads to an expansion of urban agglomerations and causes a fragmentation of the landscape.

Problems caused by population pressure and poverty are:

- Heavy demand on increasingly scarce land, forest and fish resources;
- Expanding of cultivation into marginal areas, on steep slopes, and on geologically unstable hill sides with soil erosion;
- Rapid loss of fertility;
- Unsustainable forest harvesting leads to denuding hillsides, soil erosion, and diminishing of the forest harvesting for future generations;

– Overexploitation of fisheries can result in depleting coastal and near-shore fish stock; and
– Groundwater pollution.

SALIENT IMPROVEMENTS REQUIRED IN THE UTILIZATION OF AGRICULTURAL LANDS

Maintain a proper agricultural land utilization system is a responsibility of the government as well as the public. In Sri Lanka, a number of government, non-government, and private organizations are involved in land-use planning. The following improvements are required for an effective land utilization system to be introduced and maintained.

1. Rather than designing top-down land-use programs, more effective participatory land-use planning programs need to be introduced. Strategies must be developed to get the maximum participation of the public throughout the program period and to keep the sustainability of such programs.
2. Organizations involved with development of land utilization systems need to be well-equipped with modern technology. Such technology may help the organizations to improve their capacity and the quality of the output.
3. Agricultural extension workers are responsible for the implementation of land-use planning programs in the country. It is very important to improve their skills and knowledge on land-use planning. Regular training programs are needed for them.
4. Current land utilization policies need to be reviewed.
5. Develop integrated agricultural development approaches for the enhancement of agricultural productivity in low productivity land classes.
6. Community-based land-use planning programs and watershed development programs need to be introduced and implemented.

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10. THAILAND

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INTRODUCTION

Thailand occupies some 320.6 million *rai*[1] or 513,115 km^2 of Southeast Asia and shares borders with Lao DPR, Myanmar, Malaysia, and Cambodia. It comprises four administrative regions: Central, including Bangkok; Northeast; North; and South. The major geographical regions include the central plains, the west and northeast hills, the northern highlands, and the southern peninsular.

Thailand is one of those countries that is not only food self-sufficient but is also a big food exporter, once the biggest tapioca exporter (usually over 75 percent of world market share) and competed fiercely with the U.S.A. to be the number one rice exporter. Food self-sufficiency attainment, the threat of famine and the vulnerability of food imports are not central to Thailand's food policy formulation.

In 1989, the Kingdom of Thailand has forest coverage of 89.6 million *rai*, corresponding to a relative cover of 27.95 percent. It had declined to 82.1 million *rai* or to 25.6 percent in 1996. In international terms, the pace of deforestation in Thailand had been fast, although it has slowed down lately.

LAND RESOURCES

Thailand is endowed with much cultivable land, representing some 65 percent of its total area. Land utilization up to 1995, forced the forest cover down from a much higher percentage in the past (Table 1) to 27.5 percent of the total land area, as the farm-holding land expanded to marginal land frontiers or encroached upon forest areas rather than an increase in crop yields. Partly due to physical, chemical, and biological degradation of soils, 46 percent of farm-holding land is classified as having special problem soils.

Land Utilization and the Impact of Deforestation in Thailand

There have been studies showing that demand for land was found to be positively related to the price of main crops, the farm population and the degree of industrialization. Population growth was found to be the major factor affecting the demand for land. The demand for agricultural land helps explain the conversion of forests into farm use. However,

[1] 1 *rai* = 0.16 ha.

it is not only cited as the single main cause for deforestation, but also affects policies favoring extensive agriculture and expansion of upland crop exports together with commercial timber harvesting. All these factors are cited as the main contributors to the declining forest cover.

Table 1. Forest Cover in Thailand, 1977-96

(Unit: Million *rai*)

Year	Forest Cover	Farm-holding Land
1977	116.6	113.8
1987	91.3	131.2
1989	89.6	131.8
1992	84.3	132.1
1993	83.4	131.3
1994	82.8	131.8
1995	82.2	132.5
1996	82.1	n.a.
Average rate (percent per annum)		
1977-87	-2.2	1.53
1987-92	-1.58	0.07
1992-95	-0.826	0.129

Source: Office of Agricultural Economics, *Agricultural Statistics of Thailand*, various issues, Ministry of Agriculture and Cooperatives (MOAC).

In the 1980s, deforestation in Thailand appeared to be slower than before; the average annual rate of deforestation during 1977-87 was 2.2 percent (Table 1), but by then the environmental and economic consequences of deforestation had already reached alarming proportions. There has been a nationwide logging ban in Thailand since 1989. Since then, the rate of deforestation has been slower (i.e., 1.58 percent during 1987-92 and even slower to 0.83 percent between 1992-95.)

Some of the most serious consequences of deforestation in Thailand have been:

– Soil erosion, salinization, and an insufficient supply of water are reducing agricultural productivity in many regions, and soil erosion and sedimentation are increasing the costs of hydropower generation. It was estimated that about one quarter or 125 million *rai* nationwide suffered from soil erosion (Thailand Development Research Institute [TDRI], 1987) and the tendency is such that the erosion should be increasing.
– Irregular supply of water resulting in droughts and continually more flash floods year by year.
– The effective life span of irrigation channels and dams has been shortened, the Bumipol dam being a good example of the negative impacts of sedimentation.
– Scarcity of construction wood and other wood raw materials for the forest-related industry. Thailand, once the world’s largest producer and exporter of teak, has been a net importer of wood.
– Scarcity of forest fodder and litter that are important inputs to the agricultural and livestock production systems.
– Reduction in biodiversity because of the destruction of wildlife and plant habitats.

Deforestation is not necessarily always a negative phenomenon. The most important benefit is the availability of new land for agriculture as well as energy and construction wood to meet the immediate needs of the growing population. If the converted land is suitable for sustainable agriculture, benefits to society will also accrue in the long run; otherwise they are short-term benefits and can be considered as costs from the viewpoint of the future generations.

In the case of Thailand, deforestation has gone so far that there appears to be no question that the social costs of deforestation and forest degradation far outweigh the benefits, and that deforestation and forest degradation maybe the most serious environmental problems facing Thailand today, with severe implications on the sustainability of the Thai rural economy and the welfare of the current rural populations. The seriousness of the situation is demonstrated by the attention forestry has received in the National Development Plans, and by the initiation of the Thai Forestry Sector Master Plan by the Royal Thai Government in 1990.

Thailand's relatively rich and fertile soils have been taken under cultivation decades ago. As suitable agricultural land is scarce, increasing land demand can in most parts of Thailand be met only through clearing forests. Tables 1 and 2 display the developments of forest cover, total farm holding land, the area of planted upland food crops, export of field crops and number of farm households. It should be noted, however, that Table 2 suggests that, in the more recent past, from mid-1980s to mid-1990s, the field crop areas came to be relatively stable; whereas areas under trees and fruit crops rose considerably due to expansion of the oil palm plantations in the South and para rubber plantations in the South, the East, and the Northeast, where the later two newly recommended regions have a great production potential. Similarly, the areas planted to vegetables also expanded as Thailand moved toward producing high-value added processed vegetables for export.

Table 2. Farm-holding Land, Export of Upland Food Crops and Number of Farm Households in Thailand, 1989-98

Year	Total Farm-holding Land (million *rai*)	Export of Field Crops (000 mt)	No. of Farm Households (million)
1989	131.83	48,317	5.06
1991	133.08	50,950	5.13
1993	131.27	37,546	5.17
1995	132.50	47,531	5.25
1996	n.a.	52,836	n.a.

Source: Office of Agricultural Economics, *Agricultural Statistics of Thailand*, various issues, MOAC.

Instead of trying to intensify agricultural production, the response of Thailand has been to expand the area under cultivation and convert forestland for farm use.

1. ***Northeast***

Livestock land utilization has been such that in large areas, overgrazing has resulted in forest degradation. In 1988 the total area under field crops was rapidly increased to13.4 million *rai*. The major field crops were cassava, maize and sugarcane, in this order, fueled by increased export demand. In 1990, cassava produced 59.9 percent of the nation's total cassava output. Raw sugar is also an important export product.

The area under upland rice and paddy has also been increasing, though most of the cleared forestland has been converted into field crop production. On the basis of land-use statistics, expanded cash cropping accelerates deforestation.

Timber harvesting has also been very extensive in the past in the Northeast. Illegal timber harvesting has also been very common and is well organized.

2. ***North***

Small intermountain basins surrounded by a series of steep-sided ridges limit the area of lowland agriculture. Due to population growth, lowland Thais have started moving into the hill areas to clear forests for cash crops, mainly for maize and mungbean but also for upland rice. The area under cassava has also increased.

The number of hill-tribe people actually living in the forests has grown rapidly. This has resulted in increased pressure on the forestland: the fallow periods in shifting cultivation have become too short for cultivation to be sustainable, and marginal forestland, often on very steep slopes has been taken into agricultural use. However, many tribes involved in shifting cultivation are known for their skills in sustainable forest management.

Forest degradation and deforestation in watersheds in many areas has reduced the stable supply of water, and in some provinces, erosion is already very severe, up to one-seventh of the annually encroached area is being used to replace land that has been seriously eroded or degraded.

3. ***Central***

The Central Plain has traditionally been the rice bowl of Thailand, and most of the fertile land was converted into rice production several decades ago. However, increased demand for cash crops has added pressure on forested areas outside of the (irrigated) lowland areas. Sugarcane is the most important field crop in terms of value, followed by cassava and maize.

4. ***South***

Much of the "deforestation" in the South is due to the establishment of rubber and oil palm plantations and orchards, which are not included as forest area in the statistics. This means that the area covered by trees is actually larger than statistics show.

The relative importance of major factors contributing to deforestation in the major regions in Thailand vary. Population density (through the increased demand for food) and the price of wood were found to be the major factors underlying the decline in the forest cover in Thailand. A third important factor having a negative impact on the forest cover was found to be an increase in agricultural productivity that increased the demand for land, implying that profit and export-oriented cash cropping causes more forest clearing than subsistence farming. The profitability of cassava and maize production is also demonstrated by the profitability statistics in the agricultural statistics of Thailand.

On the basis of land-use statistics, expanding cash cropping appears to be a more important factor in inducing deforestation in Thailand.

COASTAL RESOURCES

The coastal zone of Thailand with a 2,600-km coastline is very rich in natural resources which include fisheries, coral reefs, mangroves, beaches, mineral deposits and brackish water areas along the coastal lines; both in the Gulf of Thailand and Andaman Sea. The marine fisheries and coastal aquaculture had been widely practiced for many decades. The marine products were considerably increased from half a million metric tons in 1965 to one million mt in 1968 and reached more than two million mt in 1996. Thailand, in its annual monitoring survey of demersal fisheries in the Gulf of Thailand found that the catch per unit of effort has practically reduced from about 300 kg per hour in 1961 to only around 25 kg per hour in 1995. It is expected that these downward trends will continue in the future.

Situation and Management of the Coastal Resources

Coastlines of both the Gulf of Thailand and the Andaman Sea are characterized by mangrove swamps and tidal mud flats. Several large rivers drain into them, creating extensive estuarine areas. These swamp lands, mud flats and estuaries, together with the coastal lowlands, constitute an enormous potential area for both marine capture fisheries and coastal aquaculture.

COASTAL AQUACULTURE

In the past, the coastal areas were largely used for subsistence fishing using small or stationary gear, like bamboo traps, cast nets, etc. Coastal aquaculture developed recently by learning from the natural phenomenon and by importing agricultural technology from other countries. The main causes of coastal fishery resource depletion are overexploitation and environmental deterioration.

Coastal aquaculture is becoming more and more important due to the depletion of the coastal fishery resources and the accelerated development in aquaculture technology resulting in the rapid expansion of coastal aquaculture areas. Moreover, some of the species cultured have a relatively high price and have a great market demand.

The main coastal aquaculture species include fish such as sea bass, grouper, shrimp, mollusk, and mud-crab that have been cultured and have progressed on culture technique development. Shrimp culture, particularly tiger prawn and banana shrimp, has been developed and expanded very rapidly in Thailand in the last 10 years. In 1986 shrimp production was only 19,300 mt from a culture area of about 41,000 ha. It increased to 241,000 mt from a culture area of 72,664 ha in 1996.

Coastal Aquaculture Management

With regard to coastal aquaculture in the country, it was found that there were 30,528 coastal aquaculture establishments, which consisted of 27,592 establishments exclusively engaged in coastal aquaculture and 2,936 establishments engaged in both coastal aquaculture and marine capture fishery. Most of them particularly are engaged in one species culture being 97.2 percent and only 2.8 percent had more than one species but are engaged in shrimp culture accounting for 82.9 percent of the production. The total area under culture in the country was 71,608 ha, where most of the area (94.1 percent) was under shrimp culture and the remainder was the area under mollusk culture, crab culture, and fish culture.

1. ***Shrimp Culture***

The total number of shrimp culture establishments in the country was 25,210 and the area under culture was 73,617 ha. In classifying the method of shrimp culture by seed stocking, there were three categories: intensive, semi-intensive and extensive. The majority of shrimp culture establishments in the country that are under intensive culture accounted for

79.2 percent of the production. This was followed by extensive and semi-intensive methods with 14.6 percent and 7.1 percent, respectively.

2. ***Fish Culture***

The total number of fish culture establishments in the country was 2,985 and the area under culture was 727 ha. Approximately 87 percent of the total fish establishments were engaged in sea bass and grouper culture with cages.

3. ***Mollusk Culture***

In the whole country (24 coastal provinces), the total number of mollusk culture establishments was 2,831. Most of them were establishments doing oyster culture with 1,604 or 56.6 percent of the total, and mollusc cockle culture 259 (9.2 percent). Of the total area under mollusc culture of 2,492 ha, the area under cockle alone occupied 47.3 percent of the total, 25.7 percent under green mussel culture, 25.4 percent under oyster culture and the rest were under other mollusk cultures.

For new aquaculture management to succeed, farm entries should be located in a suitable farm site with appropriate technology for the farm design. Many farms were over-fry stocked, as the result of a low survival rate (SR), a very high food conversion ratio (FCR) and very low production. The effluent from agricultural operations has high concentrations of polluted materials which would directly affect the environment and water quality in the coastal area. Later, the effect will happen to the farmers themselves. According to a study, the ideal farm planning and operation must be adopted as follows:

1. Water storage and treatment area would be around 40 percent of the culture area.
2. Stocking density of the shrimp fry should not be over 50 PL/m^2.
3. Culture techniques would be managed to get FCR of 1.6 and SR of 80 percent. The BOD 5^{20} in the effluent should be less than 10 mg/ℓ.

Government Regulations for Shrimp Aquaculture Stability

Maintaining marine shrimp culture along the coast is one of the economic roles of the country. Shrimp farming provides good employment and earnings for the national income. The Department of Fisheries (DOF) has very strong policies to promote shrimp farming as a sustainable profession. Regulations for shrimp farming in Thailand as announced by the DOF in 1991 under the Fisheries Act 1947 are:

1. Shrimp farmers are required to be registered with DOF at the Fisheries District Office.
2. Shrimp farms over eight ha must be equipped with wastewater treatment or sedimentation ponds covering not less than 10 percent of the pond area.
3. Water released from the shrimp pond area must contain a BOD 5^{20} not exceeding 10 mg/ℓ.
4. Saltwater must not be drained into public freshwater resources or other agricultural areas.
5. Sludge or bottom mud sediment should be kept in a suitable area and would not be pumped out to the public area or canal.

The shrimp hatchery and shrimp farm registration requirements must be strengthened in order to get the information about the culture activities. The law enforcement about the effluent can be done effectively along with the registration process.

CONSTRAINTS TO IMPROVING LAND UTILIZATION SYSTEMS TO ENHANCE FARM PRODUCTIVITY

The government has been relatively inefficient in enforcing land and forest policies, which in many areas has resulted in public lands becoming “common property”. Everyone wants to use these lands, but no one wants to take the responsibility of long-term land management that the statistics state. According to the land-use classification used by the Royal Thai Government, land under rubber, coconut and oil palm plantations are classified as agricultural land.

1. ***Farm Policies***

Farm policies were ambiguous and ill-defined. When land reform was chosen as the first-priority policy, little effort was made to clarify the meaning and the extent of land reform. In addition, government policies were formulated in such a way that they would primarily meet short-term objectives. Under these circumstances, long-term policies were lacking.

2. ***Public Land Policy***

Public land may fall into one of two broad categories – that which is classified as arable and that reserved as forest area. The first category encompasses land suitable for farming, and after a specified period of time of occupancy, farmers may request title deeds. Full ownership rights are therefore granted. In contrast, the second category should theoretically remain forestland. But, at least a million farm households permanently live in so-called forest areas. The critical question is whether the land should be re-classified so as to reflect the true situation. Land cooperatives and other settlement schemes mostly allocate denuded forest reserves to farmers. Much of the forest reserve area is regularly used in farming and apparently there is no feasible way by which it can be reforested. This is due to the sheer size of the population and the reallocation problems involved. It is more desirable that land be re-classified in such a way that it reflects the optimal pattern of land use. Arable land should be put into farming, whereas watershed areas must be kept under constant protection from illegal uses. In so doing, the extent of land available for farming would be known and could be used for planning purposes.

SALIENT IMPROVEMENTS REQUIRED IN THE LAND UTILIZATION SYSTEMS TO ENSURE CONSERVATION OF THE RESOURCES AND SUSTAINABLE FARM PRODUCTIVITY

Land Reform Activities

Under the Agricultural Land Reform Act of B.E. 2518, the Agricultural Land Reform Office (ALRO) is divided into central and regional administrations. At present, there are 69 provincial land reform offices.

The major objectives of agricultural land reform in Thailand are as follows:

1. To enable landless farmers to have their own land for cultivation;
2. To increase the agricultural production and improve credit and marketing facilities to ensure better economic and social conditions for the farmers;
3. To promote farmer organizations in order to foster growth of the agricultural economy;

4. To promote education, public health, public utilities, and public facilities for rural betterment; and
5. To reduce the income gap between the rural and urban population.

Area under land reform, 38.9 million *rais* had been proclaimed for land reform by Royal Decree during the year 1975-97 and can be divided into public and private lands, of the size 36.3 million *rai* and 2.6 million *rai*, respectively.

The ALRO was able to distribute 10.1 million *rai* of public lands and 0.5 million *rai* of private lands.

Policies and Measures for Sustainable Agriculture

The MOAC has initiated several programs that, if implemented, would lead to more appropriate and sustainable development, fitted to the new framework for international trade and development. With assistance from the World Bank, the Government of Japan, the Danish Cooperation for Environment and Development (DANCED), UNDP, FAO, and other donors, activities are either ongoing or planned, that will ensure improvements in natural resources management and the strengthening of policy formulation and implementation among key planning and policy-making agencies of the MOAC. Natural resources areas that have been targeted include watersheds, coastal zones and conservation forests with their adjacent buffer zones. Human resource development initiatives are underway that will lead to strengthening sustainability. Agricultural systems must rely, as much as possible, on use and effective management of internal resources. Thus, in recognition of the urgency to protect the environment and natural resources, Thailand's MOAC has adopted the concept of sustainable agriculture as the underlying basis for its agricultural development strategy. Production systems must be developed to suit the existing resources, for both large and small farmers. Farmers' ability to utilize the newly developed production technologies, and at the same time safeguard the environment and natural resources, must be enhanced and strengthened. Alternative agricultural systems such as integrated farming, mixed cropping, agro-forestry and organic agriculture should be evaluated under different agro-ecosystems for proper recommendation. A sustainable system must be both economically profitable and environmentally compatible.

The MOAC, as an agency which is responsible for the country's agricultural planning and development, has established a National Committee for Sustainable Agriculture to develop a long-term national strategy for agricultural development (1993-2002) with several sub-committees being set up to study and integrate research activities undertaken and the experience gained in the various departments and offices within the Ministry, in order to enhance their relevance and impact along the directions outlined in the national policy.

In order to achieve the objective of Natural Resources Conservation and Sustainable Agriculture Development, the MOAC has set up various measures during the Eighth Plan period as follows:

– Promote environmentally friendly agricultural activities.
– Prepare plans for biodiversity management, related to activities of the MOAC.
– Change planning and budgeting processes to correspond to management requirements of natural resources, for example management of watersheds and appropriate management of soils.

- Promote soils and fertilizer policies to ensure results at the implementation level and to promote production of pesticide-free agricultural produce.
- Designate agricultural production zones in order to ensure that agricultural lands are being utilized appropriately.
- Decentralize authority for conservation and protection of natural resources to local level organizations and communities.
- Consider establishment and collection of an environmental ("green") tax on users of natural resources whose activities have negative environmental impacts.
- Establish transparency in linkages between international trade and the environment.
- Focus on improving organizations, institutions and legal instruments concerned with natural resources management to make them more appropriate and effective.

Investment in the programs for Natural Resources Conservation and Sustainable Agriculture Development during the Eighth Agricultural Development Plan is estimated as follows:

1.	Water Resources Development Plan	฿97,000 million
2.	Forest Rehabilitation Plan	฿55,000 million
3.	Coastal and fishery resources management plan	฿11,110 million
4.	Soils, fertilizer and agriculture chemicals management plan	฿21,500 million
5.	Saline Soils Area Development Plan	฿8,600 million
6.	Biodiversity Conservation Plan	฿2,500 million
7.	National Park, Wildlife Sanctuaries and Aquatic Life Conservation Management Plan	฿1,000 million
	Total	฿196,700 million

The total proposed public investment in the programs related to conservation and preservation of natural resources and promotion of sustainable agricultural development will be approximately ฿196,700 million in the Eighth Plan period.

THE COMMON LAND CLASSIFICATION SYSTEM IN CURRENT USE

The system can be described as follows: in connection with land utilization, the figures in Table 3 under the section of land utilization and the impact of deforestation in Thailand, major classes of land use appear to be paddies, fields for upland crops, land under fruit trees, vegetables, grassland and idle land. In the period from mid-1980s to mid-1990s, paddy fields and field-crop lands were on the decline whereas that for fruit trees grew remarkably. In the late 1980s, vegetable land expanded and remained steady afterwards while part of the idle land was added to the utilization system after the beginning of the 1990s.

Production Potentials of the Farmlands

The Department of Land Development undertakes designation of the soil groups having similar production potentials, constraints and consistently necessary measures for developing the agriculture.

As a result, 20 soil groups with similar production potentials have been defined that fall into the soil properties of fertility, depth, drainage, slope, acidity, land-use recommendations, environmental constraints and investment needed.

Table 3. Land Utilization, 1985-95

(Unit: Million *rai**)

Farm-holding Lands	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Paddy	73.9	74.2	72.2	74.2	70.2	69.4	69.2	68.8	68.3	68.3	68.2
	(58.9)	(58.6)	(56.5)	(52.8)	(54.7)	(54.0)	(53.5)	(53.6)	(53.5)	(53.3)	(53.0)
Field crops	31.6	32.1	33.4	35.7	33.1	33.4	33.5	32.8	32.2	32.1	32.0
	(25.2)	(25.3)	(26.1)	(25.4)	(25.8)	(26.0)	(25.9)	(25.6)	(25.2)	(25.1)	(24.8)
Fruit trees	13.5	13.9	16.0	19.5	18.6	19.4	20.2	20.8	21.0	21.6	22.3
	(10.8)	(11.0)	(12.5)	(13.9)	(14.5)	(15.1)	(15.6)	(16.2)	(16.5)	(16.9)	(17.3)
Vegetable	0.5	0.5	0.7	0.8	0.7	0.8	0.8	0.9	0.9	0.9	0.9
	(0.4)	(0.4)	(0.6)	(0.6)	(0.5)	(0.6)	(0.6)	(0.7)	(0.7)	(0.7)	(0.7)
Grassland	0.8	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8
	(0.6)	(0.7)	(0.6)	(0.6)	(0.5)	(0.5)	(0.5)	(0.5)	(0.6)	(0.5)	(0.6)
Idle land	3.7	3.5	3.5	7.7	3.8	3.7	3.6	3.2	3.2	3.2	3.2
	(2.9)	(2.8)	(2.7)	(5.5)	(3.0)	(2.9)	(2.8)	(2.5)	(2.5)	(2.5)	(2.5)
Others	1.5	1.5	1.3	1.7	1.3	1.2	1.4	1.1	1.3	1.3	1.4
	(1.2)	(1.2)	(1.0)	(1.2)	(1.0)	(0.9)	(1.1)	(0.9)	(1.0)	(1.0)	(1.1)
Total	125.5	126.6	127.9	140.4	128.4	128.6	129.4	128.3	127.6	128.1	128.8

Source: Office of Agricultural Economics, *Agricultural Statistics of Thailand*, various issues.

Note: * 6.25 *rai* = 1 ha.

Figures in parentheses are percent.

Soil groups S_1-S_5 are found to be suitable to field crops with constraints and necessary improvement measures. In particular, groups 3-5 have conservation needs. Groups S_6-S_{11} are in general suitable to paddy farming. Groups S_9-S_{11} relate to problem soils of acidic and saline nature. Groups 8 are the soils being shallow. The other 3 groups of soils relate to the amount of water availability for growing rice. In addition, there is seven other soil groups that are found not suitable for cultivation as follows:

S_{14}-S_{15} are shallow soils and should be set aside for pasture and forestries.
S_{16}-S_{17} are the groups of water logged soils.
S_{18}-S_{19} are the groups of sandy soils.
S_{20} is the shallow to deep soils that should be set aside for protection of watersheds.

Regarding the use of remote sensing technology, the Land Development Department has carried out the Regional Land Cover Maps by digital analysis using PCI software. The maps should now be brought to the attention of policy- and decision-makers in the field of land-use planning and agricultural development at the regional level. The study also provides information on the status of up-to-date land cover types in demand in the country in demand.

COMPREHENSIVE ENVIRONMENTAL STABILITY

Integration of the strategies in the ongoing policies are proposed in the following manner:

– Increase of efficiency in the use of natural resources, coordinate any utilization of natural resources and reduce conflicts. Accelerate rehabilitation of degraded natural resources to be the basic inputs for sustainable development.
– Enhancement of administration and management of natural resources by systematic decentralization of power and authority from central offices to regional offices, in addition to strengthening relationships among government agencies, the private sector, NGOs, and local people.
– Support of the application of resource economics for effective management of natural resources and the establishment of social justice.
– Amendment of the legal and regulatory framework enabling support for more effective administration and management of natural resources, and the recognition of rights and responsibilities of local people to demonstrate ownership of resources.
– Support of the study, research, and establishment of a standardized database network for natural resources. Increase conservation awareness of senior government officers, politicians at all levels, the private sector and the general public in order to integrate concepts of natural resource development and conservation, ensuring their movement in the same direction.
– In order to control water pollution, projects and activities should be located within designated zones and are required to submit reports on environment impact to concerned authorities for approval prior to their operation. They are the National Research Council, Department of Health, Department of Pollution Control, Department of Medical Science, Department of Industrial Works, and a number of universities. With respect to declared and protected areas for conservation of coastal

resources, they are the Office of Environmental Policy and Planning, Royal Forestry Department and Land Development Department.

CONCLUSIONS

The land-use system in Thailand has currently been aimed to produce food for cash and export even though monoculture is still widely practiced. In their attempt to get a high production, the farmers over-exploit their land resources with no awareness of improving and conserving the soil fertility. Consequently, soil degradation will lead to a general poverty. Smallholders have commonly sold their farmlands, either becoming landless or encroaching on the reserved forests. To solve these and other problems, an integrated and sustainable farm policy must be pursued together with zoning, reclassifying the lands and implementing effective land reform programs, etc.

Assuming a stable population of 85-90 million and present food levels and land resources, Thailand would be able to sustain food security provided right policies and management systems are being adopted. Land-use planning and zoning to increase land productivity is becoming increasingly critical to future efforts to secure food for the Thai people and to maintain the food exporter status.

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11. VIETNAM

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INTRODUCTION

Vietnam is located along the southeast margin of Indo-Chinese Peninsula with a total land-use area of over 33 million ha. Three-quarters of the country consists of mountains and hills. Vietnam is essentially a tropical country with a humid climate. The average annual rainfall is 2,000 mm, which falls in the rainy season. There is a wide range of latitude and a variety of landform – from swampy deltas to limestone karst and high mountains. Soils in Vietnam have been formed under a tropical climate with adequate precipitation, strong weathering, frequent changes in temperature, and therefore the soils are completed differentiated.

The population of Vietnam is now about 80 million, ranking 12th in the world and seventh in Asia. About 80 percent of the Vietnamese population lives in rural areas, employed in agriculture, forestry, fisheries, and handicraft.

According to statistical data, agricultural land in 1998 is 8,080 thousand ha, forestry land is 11,855 thousand ha, and aquaculture area is 340 thousand ha. Most of the agricultural land is in annual crops, a small part is in perennial crops. In general, the annual crops are situated in the lowlands, and the perennial crops are situated in upland and hills. Most of the sloping land is used for forestry and is unused land.

Table 1 shows the land use by area in Vietnam in 1998 divided into agricultural forestry and aquacultural uses. Table 2 shows the division of agricultural land into annual and perennial crops and the proportion of annual crop land used for rice culture. Table 3 shows the area, yield rates, and total production of the most important crops.

The main land-use systems in the hills are perennial trees, such as fruits and industrial trees. The yields of these long-term crops depend on the soil type, slope, soil depth, and soil fertility. There are some annual crops planted on sloping land but the yields are normally less than on the lowlands.

LAND-USE SYSTEM APPLICATION

According to FAO definition, a land-use system (LUS) is a combination of two parts:

1. Land-use type (LUT); and
2. Natural conditions with impacts on input and output of land use.

In this report we will present some research results of effects of the LUSs on agricultural productivity in Vietnam.

Table 1. Land Use Existing in 1998

(Unit: 000 ha)

Region	Total	Agricultural Land	Forestry Land	Aquaculture Land
Red River Delta	1,266.3	671.8	80.9	48.7
North East	6,746.3	885.4	2,519.6	30.1
North West	3,572.3	314.9	883.0	2.7
North Central Coast	5,130.4	675.9	2,122.2	15.6
South Central Coast	3,306.7	446.8	1,397.6	11.6
Central Highlands	4,464.4	737.0	2,755.1	1.8
North East South	4,447.6	1,644.4	1,918.3	17.5
Mekong River Delta	3,965.3	2,704.0	308.6	208.2
Whole country	32,899.3	8,080.2	11,985.3	336.2

Table 2. Agricultural Land Use Existing

(Unit: 000 ha)

Region	Agricultural Land	Annual Crop Land		Perennial Crop Land
		Total	Of which: Rice Land	
Red River Delta	671.8	620.9	576.4	10.1
North East	885.4	681.7	457.4	82.7
North West	314.9	263.5	58.7	31.3
North Central Coast	675.9	517.7	394.4	46.5
South Central Coast	446.8	348.3	205.8	34.6
Central Highlands	737.0	348.3	94.6	333.3
North East South	1,644.4	760.9	363.4	799.3
Mekong River Delta	2,704.0	2,221.3	2,062.7	327.9
Whole country	8,080.2	5,762.6	4,213.4	1,665.7

Table 3. Production Results of Main Crops

Crop	Area (000 ha)	Yield (quintal/ha)	Gross Output (000 mt)
Rice	4,213.0	41.0	31,393.8
Cotton	24.2	9.6	23.2
Jute	4.1	22.2	9.1
Rush	9.3	63.2	58.8
Sugarcane	350.8	508.6	17,841.7
Peanut	248.2	12.8	318.7
Soybean	192.2	11.2	215.2
Tobacco	32.5	10.9	35.0
Tea	84.6	-	291.2
Coffee	397.4	-	486.8
Rubber	394.3	-	214.8
Pepper	15.0	-	17.8
Coconut	167.8	-	1,133.7
Cashew	189.7	-	41.2
Orange	63.4	-	405.1
Banana	94.6	-	1,242.6
Pineapple	32.3	-	262.8
Logan	131.2	-	545.4

Some Main Land-use Systems in Highland

The highland in Vietnam consists of more diversified soils than those occurring in the lowland. They are classified into two main groups:

– The alluvial and valley soils; and
– The soils formed on the site.

In each geo-pedology zone, these two classes of soils occur as a complex, therefore they have a different effect on crop yields.

The alluvial and valley soils have a relatively minor extent. In general, they have a flat topography and high inherent fertility. Farmers use these lands mainly for cultivation of irrigated rice and rainfed crops such as maize, sweet potato, cassava, groundnut, soybean, tobacco, sugarcane, and cotton. The soils formed on site (by parent rocks) can be divided into several groups according to their character. Two-thirds of the highland have already lost their natural vegetation and the soils have been exposed to an intensive erosion process.

The LUSs in the highland have identified several cultivation practices with high economic returns as the following.

1. ***Sloping Gardens***

These forest gardens have been developed by the farmers who live in the hills and low mountains. They consist of annual crops intercropped with perennial trees. This system has a high yield thanks to the high labor investment of the farmers.

2. ***Rice Terraces***

The farmers belonging to the minorities in the mountainous region in the North of Vietnam grow irrigated rice on artificially created terraces.

To build such terraces on sloping land (5-10 degrees) needs 1,200-1,500 man-days for one ha. This system can grow one paddy rice crop or one paddy rice crop and one other annual upland crop each year.

3. ***Intercropping***

The farmers of the minorities in the North-west of Vietnam have developed a farming system for terra rossa soils situated at an altitude of 2,000 m on slopes from 25 degrees to 30 degrees. Farmers plant a late maize variety intercropped with soybean following the contour lines on the slope. The soybeans are harvested in June/July and the vegetative part of the crop is buried. In the end of July, a winter variety (cowpea) is planted between the maize plants. In October, the storage organ of the beans and maize are harvested, while the straw is left on the field to decompose. Intercropping can be used for perennial and annual crops. In some years of the first period of perennial crops, the farmer can plant annual crops, such as soybean and groundnut, between the rows of perennial trees. By this way the farmers can increase crop yield on cultivated areas. Table 4 shows yields of rice and maize for different LUSs.

4. ***Agro-forestry***

In the highland, normally the farmers can plant annual trees under forestry trees or mix rows of forestry trees on the fields. The forestry trees shade agricultural trees, and cause improved soil moisture conditions. The agricultural productivity is increased every year. The annual crops are a support for the growing of the forestry trees.

Table 4. Yields of Rice and Maize on Different LUSs

Crops	LUTs	Yield on Soil Types (mt/ha)	
		Acrisols	Ferralsols
Rice	Terraces (irrigated)	2.40	2.90
	Percent	150.00	156.76
	Non-terraces (rainfed)	1.60	1.85
	Percent	100.00	100.00
Maize	Intercropped with soybean	2.24	2.74
	Percent	121.08	119.13
	Mono-cultivation	1.85	2.30
	Percent	100.00	100.00

Effects of Land-use System on Agricultural Productivity in Degraded Soils

For the delta zones in Vietnam, there are many LUSs, but in this report only some LUSs that have clear impacts on agricultural productivity on degraded soils are mentioned.

Experiments were conducted on the effects of rotating paddy rice with upland crops on the degraded soils (albic acrisols) and alluvial soils (fluvisols) for three years. Table 5 shows the effects of crop rotation on yields for different soil types. The results showed significant increases of yield of the next rice crops, therefore, in areas where the topography allows, increased rice yields may be obtained through gradually changing the mono-cultivation of rice by expanding the acreage of the winter season subsidiary crops. The winter crop not only has economic significance in raising the income and efficiency of the land use, but also has beneficial effects on the yield of the next spring crop.

Table 5. Effects of Rotation Cultivation on Rice Yield

(Unit: mt/ha)

Soil Types	Mono-cultivation of Rice	Rotations		
		Peanut-Rice	Sweet Potato-Rice	Soybean-Rice
Degraded soil	1.95	2.10	2.18	2.06
	(100.0)	(107.7)	(111.8)	(105.6)
Alluvial soil	4.40	4.90	4.60	5.00
	(100.0)	(111.4)	(104.5)	(113.6)

Note: Figures in parentheses are percent.

The growing of subsidiary crops has positive effects on the yields of the following rice crop. The spring rice crop has a higher yield where a winter crop of potato or sweet potato was grown. The summer rice yield has a higher yield on soil where a spring crop of peanut was grown (Table 6).

Based on the results, intensive cultivation measures can be used for the improving of degraded soils and increasing agricultural productivity as follows:

1. To produce a subsidiary crop during the winter has not only economic significance but also produces good effects on soil improvement and increases the yield of the following rice crop as well as the total output.

2. Depending on the growing period of the early summer rice and the winter crops, rice or subsidiary crops may be cultivated in the spring season.
3. For spring crops, peanuts still have the all around best potential.
4. Intensive cultivation of rice should be promoted in order to, step by step, reduce the extent of mono-cultivated rice and to increase the proportion of the subsidiary food crops, especially the cultivars belonging to the bean family.

Table 6. Yield of Subsidiary Crops Followed by Rice

(Unit: mt/ha)

	LUSs	Sub-crops	Rice
Irrigated degraded soil	Spring rice + winter sub-crop		
	Sweet potato	5.91	6.23
	Potato	7.56	6.61
Rainfed degraded soil	Spring sub-crop + autumn rice		
	Peanut	1.56	3.96
	Maize	1.95	2.50

In another study in Ha Bac Province, the effects of mono-cultivation and rotation were investigated. It was shown that the rice yield increased 12-23 percent when rotated with spring peanut and soybean (Table 7).

Table 7. Effect of Rotation and Mono-cultivation on Crop Yields

Rotation Systems		Yield (mt/ha)	Increase Yield Compared with Mono-cultivation	
			(mt/ha)	(percent)
Spring Crops	Summer rice + spring rice	4.33	-	100.0
	Potato + spring rice	5.17	0.83	119.4
	Maize + spring rice	4.59	0.25	106.0
	Sweet potato + spring rice	4.80	0.46	110.9
	Soybean + spring rice	4.63	0.29	106.9
	Average yield	4.79	0.45	110.6
Summer Crops	Summer rice + spring rice	4.03	-	100.0
	Peanut + summer rice	4.95	0.92	122.8
	Soybean + summer rice	5.19	1.10	128.8
	Maize + summer rice	4.53	0.50	112.4
	Average yield	4.89	0.86	121.3

To compare the yield of rice and soil fertility in the rotation systems, we have carried out some experiment on degraded soil. In these studies, the measures of rotational cultivation have been thoroughly exploited. Even under the production conditions of remote areas with certain difficulties, this measure has still brought good results. Besides, the investments of labor and capital for intensive cultivation of crops and improvement of soil fertility have the results of increasing agricultural productivity.

For rice, yield has increased from 60 percent to 70 percent. For the soils, a number of the criteria of good soil fertility have been upgraded. For economic criteria, a good result and high labor productivity has been obtained while the prime cost was reduced (Table 8).

Table 8. Effects of Soil Improvement to the Yield of Rice and Other Criteria

Criteria	Unit	On Field of Farmer		On Experiment Station	
		Before	After	Before	After
Yield of Rice	Mt/ha	3.5	6.2	4.7	8.8
Yield	Percent	100.0	177.1	100.0	187.2
Soil Fertility					
PHKCl	Mt/ha	4.5	5.4	4.7	6.0
Humus	Percent	0.62	0.83	0.68	0.74
N	Percent	0.04	0.06	0.02	0.015
P_2O_5	Percent	0.035	0.05	0.02	0.05
K_2O	Mg/kg soil	5.0	7.0	5.0	8.5
CEC	Meq/kg soil	-		4.0	4.4
Economic Criteria					
Prime cost of rice	VND/100 kg	-		35.8	28.0
Invested workdays	WD/100 kg	13.1	10.6	12.8	7.2
Value of workday	VND	0.26	0.90	1.14	1.82

The Main LUSs and Agricultural Productivity in the Mekong River Delta (MRD)

The Delta region in Vietnam has contributed about 40 percent of the agricultural products, including 50 percent of the rice yields. Rice and fishery products account for about 27 percent of GDP. The production in Delta region has very high economic effects. The main cause is due to the application of suitable LUSs.

In past years, the farmers in the MRD have developed sustainable LUSs on the wetlands and these still remain. The production potential of MRD is controlled by soil properties (acid sulfate soils, saline soils) and the hydrological condition, therefore to increase the agricultural productivity we have studied the LUSs and propose the following measures to sustainable land-use. The MRD has 25 LUTs, including:

– *Use for agriculture* – 21 LUTs: of which annual crops, 19 LUTs; and perennial crops, two LUTs.
– *Use for forestry and fishery* – Four LUTs.

Twenty-five LUTs are combined with the different natural conditions (soils, hydrological) to form a total of 57 LUSs.

When we analysis the economic effects of LUSs with the criteria of input, income, and benefit, the results showed the following:

– LUT 2-3 rice crops on irrigated alluvial soils and LUT 2-3 rice crops plus one other annual crop on alluvial and light saline soils have high economic benefits.
– LUT fruit crops have higher economic effects but high input.
– LUT for breeding improved intensive shrimp has the highest economic effect.

Based on the requirement of economic development of MRD zone and the results of land evaluation, we have selected 22 LUTs to be targets of increased agro-forestry production (Table 9).

Table 9. The Characters of Selected LUTs in MRD

(Unit: mt/ha)

LUSs	Yields
Irrigated Cultivation	
Winter + spring (WS) rice	3.5 – 4.0[1]
WS rice + summer + autumn (SA) rice	7.5 – 9.6[1]
WS rice + SA rice + fish	7.8 – 9.6[1]
	0.5 (fish)
WS rice + SA rice + winter + autumn (WA) rice	11.3 – 11.8[1]
WS rice + SA rice + maize	14.0[1]
	6.2
WS rice + SA rice + vegetables	8.0[1] – 4.5
WS upland crops + SS upland crops + SA rice	3.0 – 3.5[1]
	9.0 – 11.0
WS rice + SA jute	4.0 – 4.5[1]
	1.8 – 2.0 (jute)
WS upland crops + SA rice	2.8 – 3.4[1]
	2.8 – 3.9
Other upland crops	2.0 – 24
Coconut[2]	11.4 – 12.0
Fruit tree (orange)	32 – 40
Rainfed Cultivation	
High yield autumn rice	4.0 – 5.0
SA rice + high yield autumn rice	6.2 – 7.5
SA upland crops + high yield autumn rice	2.8 – 3.4[1]
	5 – 10
High yield autumn rice + fish	3.0[1] + 0.2
High yield autumn rice + shrimp	3.0[1] + 0.17
Sugarcane	49 – 65
Pineapple	11.0 – 12.0
Shrimp	0.7 – 1.1
Melaleuca forest[3]	10 – 12

Note: [1] Yields of rice; [2] 000 fruit/ha; and [3] 000 tree/ha.

CONCLUSIONS

In general, LUSs in Vietnam have made significant progress in the last few years and have made an important contribution to increased agricultural productivity, the food supply and other products to improve living standard of the Vietnamese people and the development of the country economy.

A number of measures have been undertaken to improve soil fertility and increase agricultural productivity. These measures include the terracing of sloping lands, use of organic manure and mineral fertilizers, construction of irrigation and water drainage works, the reduction of soil acidity, salt washing and integrated management.

According to the research results in the field, we have realized that the LUSs with intercropping, rotation, intensive and irrigated cultivation have high yields and can improve soil fertility. So, the research on suitable LUSs on the different land regions to increase agricultural productivity is an important duty of Vietnam scientists.

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2. PROGRAM OF ACTIVITIES

(4 - 9 November 2000)

Date/Time	**Activity**
Sat., 4 Nov	
Forenoon	Opening Ceremony Presentation and Discussion on Topic I: *Planning Support Systems to Enhance Sustainable Land Utilization* by Dr. M. A. Sharifi
Afternoon	Presentation and Discussion on Topic II: *An Analysis of the Issues and Problems in Improving Land Utilization Systems for Sustainable Agricultural Production* by Dr. Lyman S. Willardson Presentation and Discussion on Topic III: *An Overview of Current Land Utilization Systems and Their Contribution to Agricultural Productivity* by Dr. B. Najafi
Sun., 5 Nov.	
Forenoon	Presentation and Discussion on Topic IV: *Islamic Republic Iran's Policy on Land Consolidation and Reforms of Farming Systems* by Dr. Reza Arjmandi Presentation and Discussion on Topic V: *Land Consolidation as a Movement Toward Agricultural Productivity Promotion* by Mr. Ahmad Najafi Presentation and Discussion on Topic VI: *Land Consolidation: An Important Step in Increasing of Productivity (A Case Study – Study and Implementation)* by Dr. Gh. A. Najafi
Afternoon	Presentation and Discussion on Topic VII: *New Approaches to Land-use Planning* by Dr. A. Moghaddam and Mr. Farahara Nowrouzi Presentation of Country Papers
Mon., 6 Nov.	
Forenoon	Continuation of Presentation of Country Papers
Afternoon	Continuation of Presentation of Country Papers
Tues., 7 Nov.	
Forenoon	Continuation of Presentation of Country Papers Workshop
Afternoon	Continuation of Workshop
Wed., 8 Nov	Visit the Haraz River Basin Agricultural Development Implementation Center
Thurs., 9 Nov.	Summing-up Session Closing Session