

LAND USE

Land Use and Land Cover Change: A Project on Human Dimension of Global Change

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Since its inception, the International Geosphere-Biosphere Programme (IGBP) has focused on planning and articulating a global change research programme in the natural sciences. In the process of identifying the scientific agenda for research in its core projects, it has become clear that one key and common issue is the role of land cover and human-induced land cover change in altering global cycles. In parallel to the IGBP initiatives, the International Social Science Council (ISSC) has established the Human Dimensions of Global Environmental Change Programme (HDP) in response to the need for a coherent research programme on the human dimensions of global change.

In 1991, the IGBP, together with the ISSC, established a working group to develop a research agenda on the interactions of human actions and global change. The working group is to focus specifically on human land use and examine how such land use alters land cover. The working group comprises a total of eight natural and social scientists. A final report has been issued in September 1992.

This paper briefly summarizes the report and the key research projects. Issues on the implementation of these projects in Asia are then discussed.

Background

Recent research has surfaced the significance of human-induced changes in land cover on global environmental change. The historical change of land covers for agriculture and other human use, for example, has resulted in a net release of CO₂ to the atmosphere. Such changes may also have an important influence on regional climatology and hydrology. The intensity of such environmental impact would increase as changes in the magnitude, spatial scale, and pace of land cover gain speed. To understand the relationship of land cover change as an element of global environment change requires an appreciation of the linkages between human systems generating actions that lead to land-use change and the physical systems that are affected by the resulting changes in land covers. It is on this premise that the working group has proceeded to delineate the interactions of human land use and global change.

The basic states, processes and flows involved in these interactions are summarized in Figure 1.

A certain land cover (physical system) exists in a systemic relationship with human uses (land use) and the causes of these uses. These causes or driving forces interact among themselves and lead to different outcomes depending on the social context in which they operate. At t_1 , the human driving forces lead to actions precipitating land use #1, requiring a proximate source, such as a technology or management activity, to manipulate the physical environment for that use. This manipulation is directed either to changing the existing land cover (#1) or to maintaining a particular cover (#2 or #3). In the former, the existing cover is changed to a new state that must be maintained in the face of natural processes that would alter it (physical maintenance loop). Changes to a new state are of at least two kinds: modification as in land cover #2 (e.g., degradation of grassland or planting exotic grasses in pastures) and conversion as in land cover #3 (e.g. forest to cropland or dryland to paddy agriculture). Maintenance processes sustain the land-cover conversion (#3) or modification (#4).

Proximate sources can therefore be seen as those of conversion, modification, or maintenance, and their land-cover consequences feed back on the original driving forces (environmental impact loop). Likewise, these land-cover changes (#2 and #3) can be repeated elsewhere such that they reach a global magnitude that triggers climate change, which, in turn, feeds back on the local physical system, affecting land cover and, ultimately, the driving forces through the environmental impact loop. Regardless of the stimuli (local or global environmental impact of driving forces, the driving forces themselves, or the social conditions in which they operate), changes in driving forces at t_2 may trigger a new land use (#2) with its consequences on the system as noted.

This perspective indicates that understanding of global environmental change much considers the conditions and changes in land cover engendered by changes in land use, the rates of change in the conversion-modification-maintenance processes of use, and the human forces and societal conditions that influence the kinds and rates of the processes.

Research Plan

Understanding the past and future impact of land cover and land use on the states and processes of the biosphere is central to the study of global environmental change, be it potential climatic change, loss in biodiversity, or soil degradation. Projections of land-cover change in the near future, for example, are required to assess the probable magnitude and geographic distribution of climatic impact.

The quality of these projections hinges on two broad improvements in understanding. The first deals with the scale of land-cover change over the recent past needed to calibrate some of the environmental relationships in question. The second involves the accuracy of projections of land-use changes, which in turn requires an improved understanding of the forces and conditions that create them.

The study of global land-cover and land-use change is developed around several overarching and interrelated questions:

- How has land cover been changed by human use over the last 300 and 100 years?
- How will land use change land cover from the present to the middle of the next century?
- What are the major human causes of land-use change in different spatial (and temporal) contexts?
- How will global environmental changes affect land use and land cover?

Focus 1: The "Situational" Assessment

Comparative studies suggest that the relationships among human causes, land-use change, and land-cover change vary considerably across space (and through time). This sub-global complexity is currently masked in global-scale approaches relying on global aggregate data and relationships to understanding land-cover change. This loss through aggregation undoubtedly diminishes the accuracy of models and projections of land-cover change and lessens their relevance for regional and local assessments. The dynamics of land-use/cover change is better understood at sub-global levels, and global scale models and projections will be improved if they are made regionally sensitive.

The following activities have been proposed under this focus:

- a) **Typology and Demarcation of Situations:** This activity seeks to delineate the world into a system of regions, with each regional type possessing common patterns of relationships between human driving forces in land use and land cover change.
- b) **Case Studies:** This activity will establish a common framework of study for comparative situational assessments of land use and land cover change and to identify an appropriate set of regional case studies to undertake.

Focus 2: Modeling and Projecting Global Land-Use/Cover

Global land-use/cover models are essential for assessing global environmental change. Computer models permit the use of large quantities of social and environmental information needed for monitoring and projecting land transformations, linking data and theory through formal equations. They allow us to examine the implications of current trends in driving forces and land transformations for future environmental changes, and can be used for sensitivity and policy experiments to examine the role of climatic feedbacks or policy initiatives and economic or social reform pertinent to land use.

The immediate activity proposed under this focus is to develop a framework for global land use/cover models that can be integrated with other global models and can be used to generate projections of land-use/cover change.

Focus 3 Conceptual Scaling

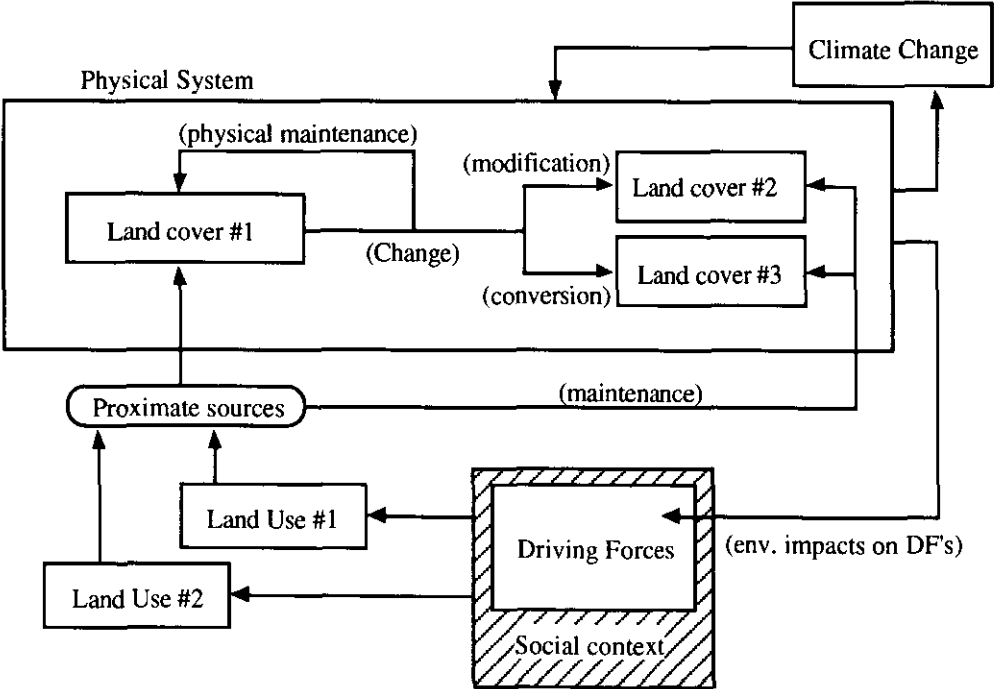
Land cover and land use are governed by variables that connect different spatial scales and do not fit the simple categories of global, regional, and local. Causal links identified at one scale may not appear at others, and relationships among scales may be discontinuous. There is a need to reconcile these differences in scales.

The activity proposed under this focus is to identify the impact of spatial and temporal scale and conceptual nesting as they impinge on connecting explanations of land use/cover change along the global to local continuum. The success of this activity would help to link studies of various scales together and to provide an explanation of the divergent manifestation of the driving forces at different scales.

Implementation in Asia

In Asia, the opportunities for discussion among the social and natural scientists are beginning to emerge. This would lead to possible collaboration in research on land use and land cover changes and their implications on the environment. With the interest gaining momentum, it would be appropriate for Focus 1 to be accepted as the starting point in the research program. In particular, the case studies would allow the region to rapidly build up a set of useful information and database for further research.

Researchers in Southeast Asia are beginning to develop proposals for the study of land use change in the monsoon forest region. Countries that the interested include Malaysia, Thailand, and the Philippines. Discussions are underway to discuss the research focus and the resources required. If successfully implemented, the studies would contribute to the understanding of land use changes arising from population changes as compared with changes induced by commercial activities. At this initial stage of discussion, it would be useful if the START programme of the IGBP would assist the researchers in building up the capacity for this type of research.



Linkages between Human Causes and Land Use and Cover

LAND USE

The Research Domain VII of IGBP in Japan and Its Perspectives

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Introduction

Environmental change arising on a global scale today is much influenced by the rapid growth of human activities. Now, it is necessary not only to analyze global environmental change and its influence on human activities, but also to analyze human activities causing environmental change. The Science Council of Japan pointed out in a report from the Special Committee on Human Activities and Global Environment that this subject should be studied as an especially important theme of international collaborative research. On the other hand, a research plan tentatively entitled "Human Dimension of Global Environmental Change" (HDGEC) is being drawn up at present. However, it is of urgent necessity to study the following two subjects:

- (1) The collection, arrangement and analysis of information on human activities necessary for a preliminary research of IGBP (International Geosphere-Biosphere Programme); and
- (2) The research field connecting IGBP with HDGEC, which is deficient in Japan.

As a result, it was decided that the research relating to the above would be developed as Domain VII in the national IGBP activities of Japan.

Initially, IGBP had no core project on issues related to human activities, but it is now preparing a core project on Land Use/Cover. The project has almost the same objective as the Domain VII of IGBP in Japan, although the two were developed independently.

The Domain VII has just started its activity, and it is still groping for what the research focuses on in this report. This paper suggests some activities of the Domain VII, introducing subjects in the research area as well as describing recent activities.

1. Research Subjects in the Domain VII at the Starting Point

The Domain VII in the IGBP in Japan took the following three main subjects with sub-subjects:

- (1) Change of Urban and Industrial Areas and Change of Global Environment
 - (1a) Human activities in urban and industrial areas on a global scale
 - (1b) Mechanism of the change of urban and industrial areas relating to environmental change on a global scale
- (2) Activities of Agriculture and Forestry and Global Environmental Change
 - (2a) Change of productivity of agriculture and forestry (deforestation) on a global scale
 - (2b) Mechanism of environmental change on a global scale affecting the change of activities of agriculture and forestry.
- (3) Change of Land Use and Global Environment Conservation
 - (3a) Regional characteristics with the change of land use in the world
 - (3b) Relationship of land use improvement by regional planning and development to environmental change.

2. Activities of the Domain VII in 1992

Based on the subjects mentioned earlier, the activities of the Domain VII started on 4-5 February, 1992 at the IGBP symposium in Science Council of Japan. In the symposium, two papers related to the Domain VII were reported as follows:

- 1) "Global Environmental Study on Agro - Ecosystem -- Methane and Global Warming --" by Toshiyuki Minami
- 2) "Global Environmental Study on Forest Land and Forestry" by Toshio Inoue

Namely, we have discussed agricultural influence by global environment.

After this symposium, we organized a research group on Human Activity and Global Environment (called HAGE group) for promoting the research of this domain.

On 9 Oct., 1992, the HAGE group had a symposium with a theme "On the Positive Role of Agriculture and Forestry for the Restoration and Conservation of Global Environment -Part I-" in which the following five papers were presented and had general discussions, especially for the Restoration and Conservation of Global Environment.

- 1) "Global Environmental Change and Agriculture and Forestry" by Zenbei Uchijima
- 2) "Food Production for Increasing Population in the 21st century and Global Environment Issues" by Hiroyasu Shimura
- 3) "On the Restoration and Conservation for Global Environment, especially related to the Paddy Field" by Makoto Kimura
- 4) "Environment Conservation and Forestry Soil" by Hisayoshi Yagi
- 5) "Conversion Strategies for the Desertification and the Degrading Land - the Expectation for the Role of Agriculture and Forestry -" by Hiroshi Kadomura.

Besides the activities of HAGE, Japan National Committee for Rural Planning organized International Symposium on "Rural Land Use in Asian Countries - Pursuing the New Ordering of Global Environment -" on 7-8 Oct. 1992, with the opportunity of the tenth anniversary of the Establishment of the Association of Rural Planning with the support of the Association of Rural Planning, Japan Committee of International Commission of Agricultural Engineering, International Commission of Agricultural Engineering, and under the auspices of Japan National Committee for the International Geosphere - Biosphere Programme (IGBP), the Human Dimensions of Global Environmental Change (HDGEC), Irrigation and Drainage Engineering, Forestry Science, Conservation of Nature, Agricultural Economics, and Inter-Agricultural Sciences.

The background and objective of the symposium were as follows:

"These days, environmental conservation is a leading issue on a global scale. Not only in developing countries, but also in industrialized countries, slums are being formed due to gravitation of the population toward urban cities, and land use is in disorder in suburban areas. Also, forests are being cut down because of economic development in industrialized countries and agricultural development in developing countries. Thus, land use in rural areas holds various issues. It would be an important subject, as part of environmental conservation on global scale, to improve rural land use.

Researchers on land use planning and administrative officials from 14 Asian countries participate in the Symposium. The experts report present conditions of land use in their country and the measures they are taking to solve their land use problems. With their reports, the Symposium aims to find, through the interdisciplinary and international comparative discussion, what rural land use planning should be in a broader sense, including what the ordered use of rural land should be, the method of land use planning and how the rural development should be proceeded. It aims not only to find the problem solution, but also to discuss issues on global environmental conservation in Asian countries and the recovery. The Symposium also hopes to contribute to making a network between related researchers and administrative officials for global environmental conservation, as well as to contribute on the international program of IGBP - HDGEC".

In the symposium, two keynote papers were presented :

- 1) "The Significance of Rural Land Use Study in the IGBP - HDGEC Framework" by Dr. Masatoshi Yoshino, Professor of Aichi University and the Chairman of Japan National Committee for IGBP.
- 2) "Land Use Conservation and Sustainable Land Management by Dr. Tongroj Oncha, Professor of Kasetsart University, Thailand

The following nine experts of Asian countries each presented a paper on the same theme, "Rural Land Use and Planning in each country", by Dr. Chitta Ranjan Pathak, Prof. of Indian Institute of Technology, Kharagpur, India; Dr. Dipak Prasad Dhungel, Chief of Small Farmers Development Division of Agricultural Development Bank Central Office, Nepal; Dr. Lutfi Ibrahim Nasoetion, Director of Research Institute, Bogor Agricultural University, Indonesia; Dr. Yik Kuan Chan, Assistant Director of Dept. of Agriculture, Malaysia; Dr. Rogelio N. Concepcion, Project Manager of Soil Research Development Center, Philippines; Dr. Veerapong Saenjan, Lecturer of Khon Kaen Univ., Thailand; Dr. Kwong-lin Andrew Tse, Agricultural Officer of Hong Kong

Government, Hong Kong; Dr. Motoyuki Goda, National Research Institute of Agricultural Economics, Japan; and Dr. Jung-Keun Park, Professor of Chonbuk National Univ. Korea.

Moreover, the following two papers were presented:

- 1) "Trends in Land Use and Its Impact" by Dr. David Kummer, Assoc. Prof. of Clark Univ. and
- 2) "Rural Land Use and Environmental Conservation" by Dr. Frank J. Dent, FAO of the United Nations Regional Office.

Following those paper presentations, general discussion was held, through which the significant role of local government for the practice of rural development, land use ordering as well as planning techniques, disordered land use in each country and so on were discussed.

In October 1992, the SC-IGBP decided to set up a Core Project Planning Committee (jointly with HDP) concerning Land Use/Cover with Prof. B. Turner II as the Chairman. Taking a growing interest in land use, the Science Council of Japan organized a Special Committee for Land Use in Japan National Committee for IGBP. This Special Committee for Land Use was inaugurated on 9 Nov., 1992 When the Domain VII officially obtained the status of an activity.

3. Global Environment and Human Activities

Through the activities until today, land use issues were recognized as the important subject of the Domain VII. Therefore, our research activity of the Domain VII is on the stage of being newly organized. This paper offers reference materials for the research structure of Domain VII.

3.1 Two Patterns of Global Environmental Issues

Agriculture and rural areas will be among the things concerned with human life, that will be most affected by global environmental change. Rural areas occupy the greater part of land area on the earth, where agriculture is the principal role in human activities. The clarification of the role of rural area would be of great importance.

Issues on agriculture and rural area concerned with global environment are classified broadly into two kinds of patterns, at least for its easy understanding.

The one as shown in Figure 1, is influenced by global atmospheric change, namely warming arising in the atmosphere, destruction of ozone layer (increasing of ultraviolet rays), acid rain, gas (carbon dioxide, chloro-fluoro-carbon, sulfurous acid gas, etc.) exhausted by human activities in urban and industrial areas. With such phenomena, the quality of water resources, soil (land resources) and solar energy is likely to deteriorate, with major changes to natural ecosystems. Such phenomena of agricultural environment and resources influence much on agricultural production (including crop production, forestry production, fishery and livestock).

Agricultural production studies should therefore become a vital subject in order to assess responses to the warming of temperature, destruction of ozone layer, acid rain. These phenomena, however, will be considerably improved by removing pollutants in urban and industrial areas. From the agricultural viewpoint, agricultural production and the cause of global environmental change should be clarified. In order to solve these problems, much attention should be given to inhabitants in urban and industrial areas by appealing for dangers of agricultural production as food, instability of the supply of agricultural production, so as to reduce global environmental pollution by their own efforts.

The second pattern, as shown in Figure 2, puts the starting point on the extension of living sphere in rural area and human activity as resources development of human beings, essentially different from the first pattern. More than enough development of the resources of agricultural production, namely the overcutting of forest, the overpasturing of livestock, the overinput of agricultural chemicals is human activity for increasing agricultural productivity. However, these activities drive land too hard. The land becomes infertile and finally ends in desertification, or in along-along at a good manner. This results in the reduction of living sphere, exhaustion and depletion of resources. In the course of agricultural activities, methane is produced, absorption sources of carbon dioxide decrease and the first pattern is included. This second pattern, however, is different from the first pattern, and the only way to solve the problems produced is to reduce the development of resources and the living sphere in rural area. Especially tropical areas of the third world, high rate of increase in population, face the problems, which arise as a result of desperate living activities of poor farmers in vast area. Regulation and management are not well attended to at the area, which discloses the difficulty in coping with the situation.

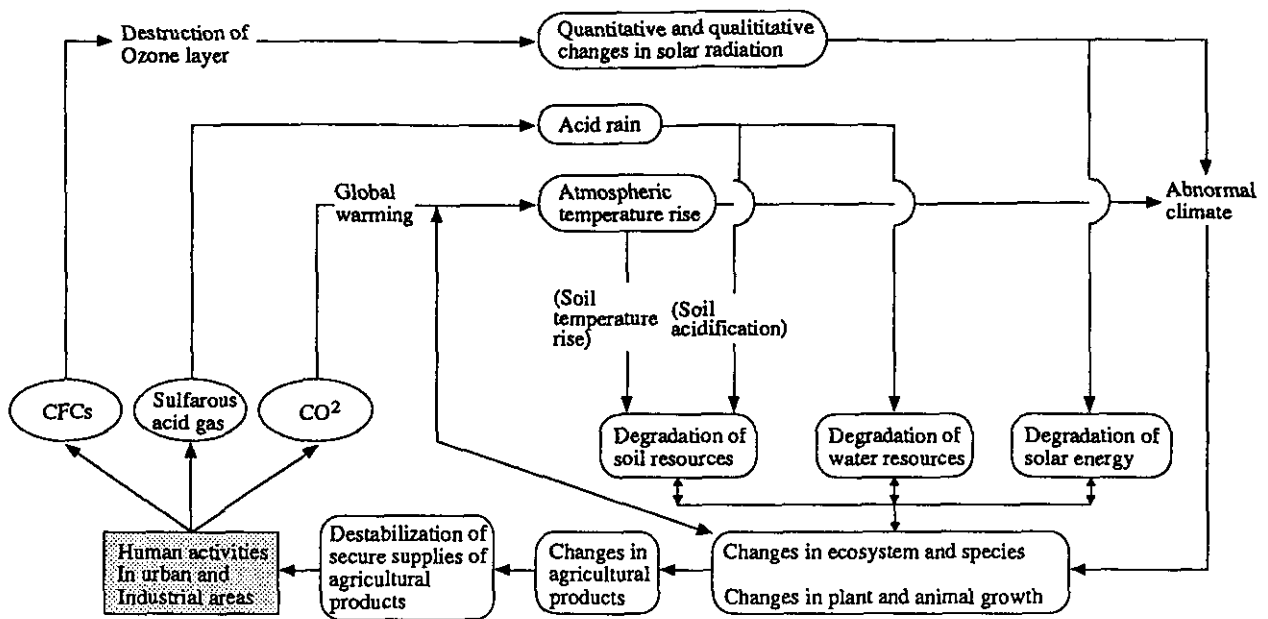


Figure 1 Global Environmental Issues and Agriculture/Rural System (Pattern 1)

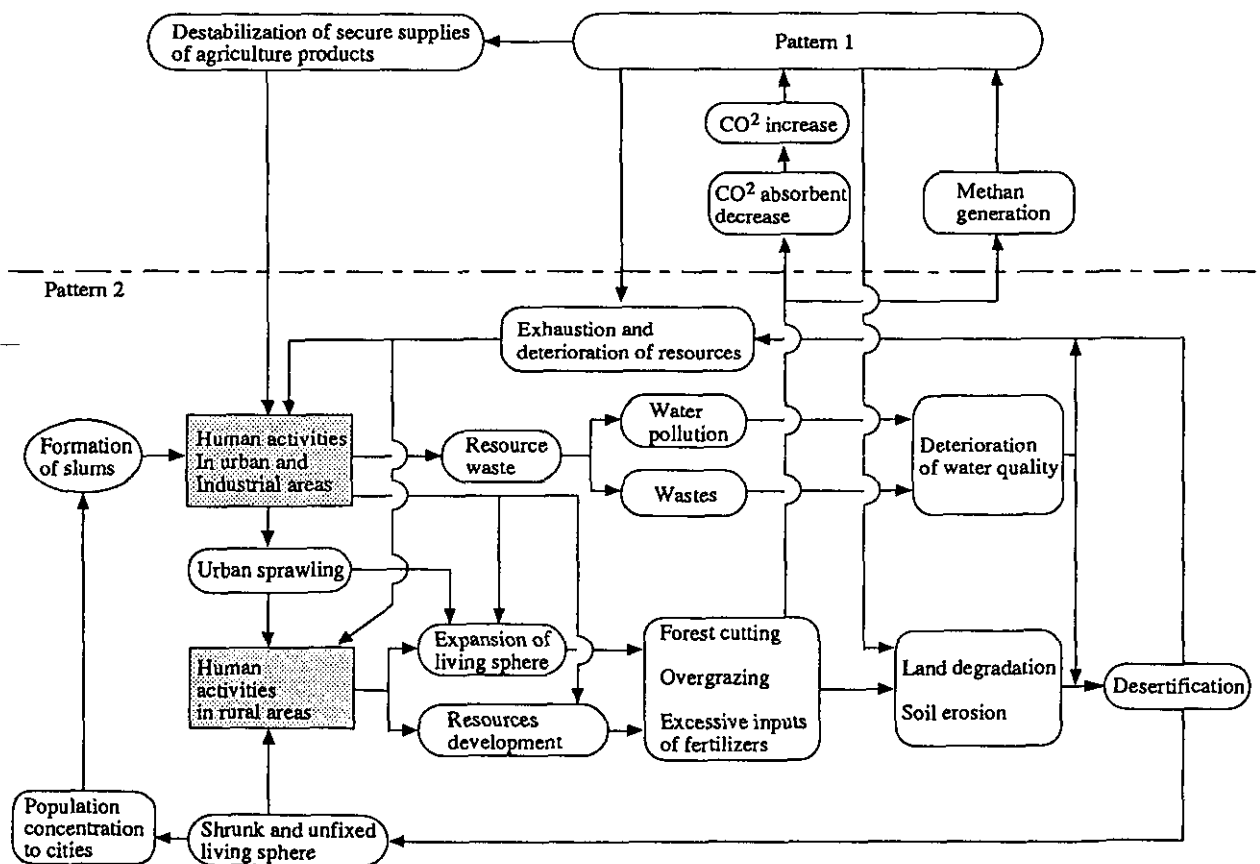


Figure 2 Global Environmental Issues and Agriculture/Rural System (Pattern 2)

3.2 Land Use Changes in Asian Countries

The research subject of the symposium was focused on Asian Countries. Our activities of the day are directed to Asian Countries. Some information on land use in Asian countries is introduced as a starting step of our research. The results are parts of the papers presented at the International Symposium on "Rural Land Use in Asian Countries" which Asian Productivity Organization held from 29 Sept. until 6 Oct., 1992. The data are based on AGROSTAT, a database software published by FAO (1990).

Land is the most fundamental natural resource for the sustenance of every human life. It provides nearly all the food we use today, space on which to live, and other important human needs such as recreation, water supply, wildlife habitat, etc. Most of these utilities come from particularly rural land use. Thus, rural land use can be considered very important in sustaining human life. The importance is abruptly increasing along with population increase which is demanding more food, space and other human needs; consequently, competition among these needs often forces rural land use to be sacrificed for space and other developments resulted in land use changes. The sacrifice is considered as critical point in human welfare development. Even though an increase of human welfare is expected from the conversion of rural land use, in the same way the welfare may be lost due to environmental problems caused by poor management of land use.

The change of land use can be generally outlined as conversion from forestry area especially nature preservation area to other uses particularly agriculture, and from agricultural uses to especially settlement and industrial uses. In many cases, such process is irreversible. Once converted to settlement or industrial uses, loss of agricultural land will be permanent. The following paragraphs will describe and illustrate how the changing process of land use is going on in the ten Asian countries.

Forest Land

Forest land here refers to land under natural or planted stands of trees, whether productive or not, and includes land from which forests have been cleared but that will be reforested in the foreseeable future. In term of coverage, there is almost no change in forest land in Hong Kong, Japan, South Korea, India, Nepal, and Pakistan in the past three decades.

In Japan and South Korea, the forest land covered more than 60 % of total country area, while in Hong Kong, India, Nepal, and Pakistan, the coverage is less than 20 %. The least coverage is in Pakistan which is under 5 % of the country. However, in other countries including Indonesia, Malaysia, Philippines, and Thailand, the forest land has been decreasing. The decrease is very fast in Malaysia, Philippines and Thailand. Malaysia's forest which covered about 80 % of the country in 1961 has decreased to less than 60 % in 1989, a loss of about 25 % of forest land within three decades. Thailand and Philippines' forests which covered more than 55 % of the countries in 1961 have decreased to less than 40 % in 1989, a loss of more than 28 % of forest land within three decades. In Indonesia, the forest land has decreased from about 65 % of the country in 1961 to about 60 % in 1989, a loss of no more than 8 % of forest land within the same period. However, since the area is large, the magnitude loss is presumably significant, not to say the decrease in tree stand intensity.

Agricultural Land

Agricultural land here includes arable land, land under permanent crops, and permanent meadows and pastures. Arable land refers to land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing pasture, land under market and kitchen gardens (including cultivation under glass), and land temporarily fallow or lying idle. Land under permanent crops refers to land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber. It includes land under shrubs, fruit-trees, nut trees and vines, but excludes land under trees grown for wood or timber. Permanent meadows and pastures refer to land used permanently (five years or more) for herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

Each country shows a different feature of changes in agricultural land (Figure 4). In almost all the countries except Hong Kong, Japan and South Korea, agricultural lands increased. The highest increase was recorded in Thailand, in which the coverage changed from less than 25 % of the country in 1961 to more than 45 % in 1989, a more than 80 % increase of agricultural land within the last three decades. This resulted from high conversion of forest area as mentioned above. The increase of agricultural land indicates that agricultural development is still important in the economy.

Other countries from East Asia, especially Hong Kong are experiencing a decreasing process of agricultural area. Along with rapid industrialization, share of agriculture to the economy has been decreasing. Agricultural land has been left out and converted to non-agricultural uses such as housing, industrial and commercial areas.

According to the present coverage of agricultural land (Figure 4), these countries can be divided into three groups, i.e.:

- (1) Large coverage (more than 50 %): India;
- (2) Medium coverage (between 25 % and 50 %): Nepal, Pakistan, Philippines, and Thailand;
- (3) Little coverage (less than 25 %): Indonesia, Malaysia, Hong Kong, Japan, and South Korea.

Moreover, agricultural land potentiality to produce agricultural products is now decreasing. That is one of environmental issues in Agriculture. If agricultural land potentiality index of country i in year j (ton/ha), LPI_{ij} , is defined as follows:

$$LPI_{ij} = Y_{ij} / F_{ij}$$

where: Y_{ij} = Cereals yield of country i in year j (ton/ha)

F_{ij} = Fertilizer use (N, P_2O_5 , K_2O) per irrigated agricultural land of country i in year j (kg/ha)

LPI_{ij} in the past three decades, is shown in Figure 5. Tropical countries, especially Pakistan followed by Nepal, Thailand, India, and Indonesia, have higher potentiality for agricultural production than of non-tropical countries. However, over the years the potentiality is decreasing. This is what could be called the marginalization of agricultural land. There are at least two reasons why the marginalization process is going on:

- (1) Good agricultural land which is often also attractive for residential and other non-agricultural uses, has been converted to provide the land needed for housing, commercial development, transportation, etc., which are ever increasing along with population growth and economic development. Then, agricultural activities have been moved into marginal land. Introduction of an effective land use control policy and a save-land development technology are necessary to overcome this problem.
- (2) Land degradation is naturally happening over time, especially when land use is excessive. Decreasing clay and organic matters from the soils through erosion decrease soil capacity to retain inputted fertilizers, thus reduce their efficiency. New consideration for land improvement technology and innovation of high yield varieties is important in solving this problem.

Non-Agricultural Land

Non-agricultural land includes built-up areas, waste land, parks, ornamental gardens, roads, lanes, sparsely inhabited regions (barren lands), and any other land not included in forest land, agricultural land, and inland water bodies. Excluding barren lands, the rate of increase of this land indicates the level of urbanization in a region. Decreasing barren land may indicate some conversion of this land into more intensive uses. Setting total non-agricultural area as 100 in 1961, Figure 6 shows trends in several Asian countries.

Changes in non-agricultural land vary from one country to another. In South East Asian countries especially in Malaysia and Philippines, the changes are very high. The land increased in Malaysia by almost three times within the last three decades. In Philippines, the land increased by almost two times in the same period. Assumed reliability of the data, these indicate that an excessive urbanization process in the two countries is taking place.

In South Asian countries of India, Nepal, and Pakistan, there was decrease in coverage of the non-agricultural land. This is probably due to some conversion of the barren lands as mentioned above. Some sparsely inhabited regions which were common in the past, have been reclaimed and converted into other uses; and scattered houses were consolidated.

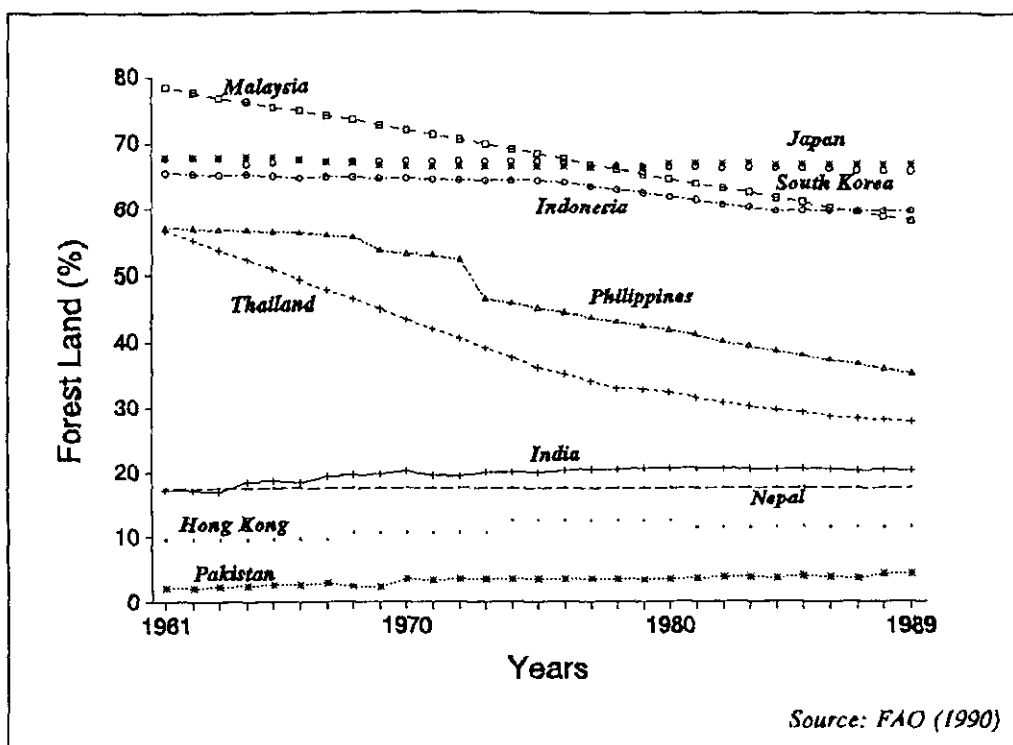


Figure 3 Changes in Forest Land

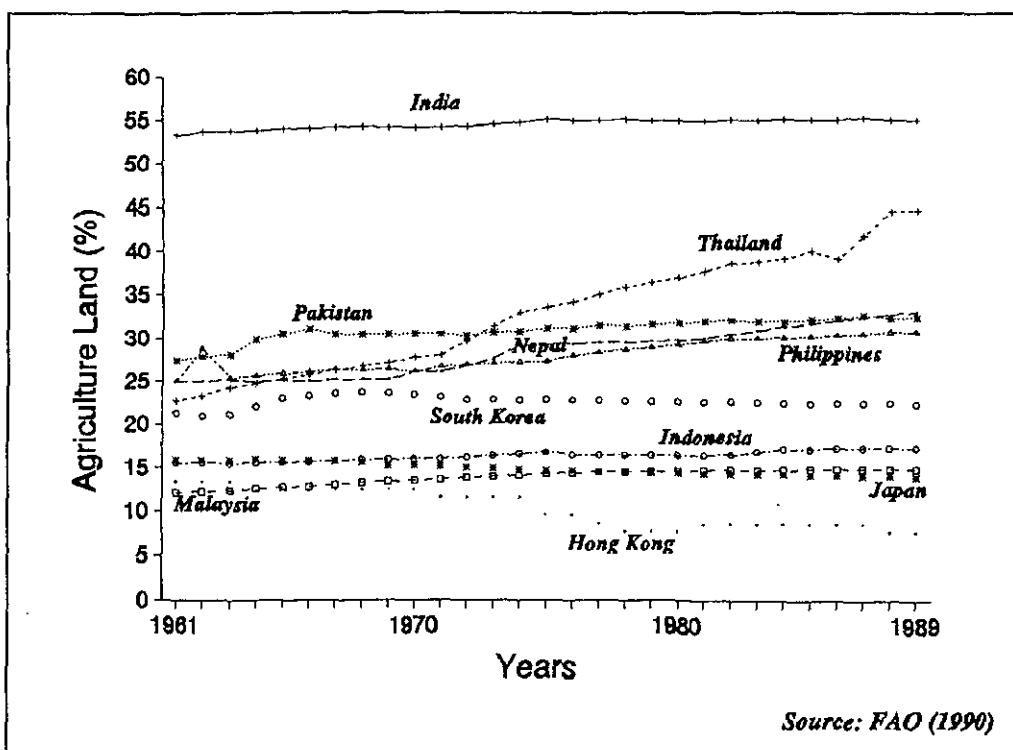


Figure 4 Changes in Agricultural Land

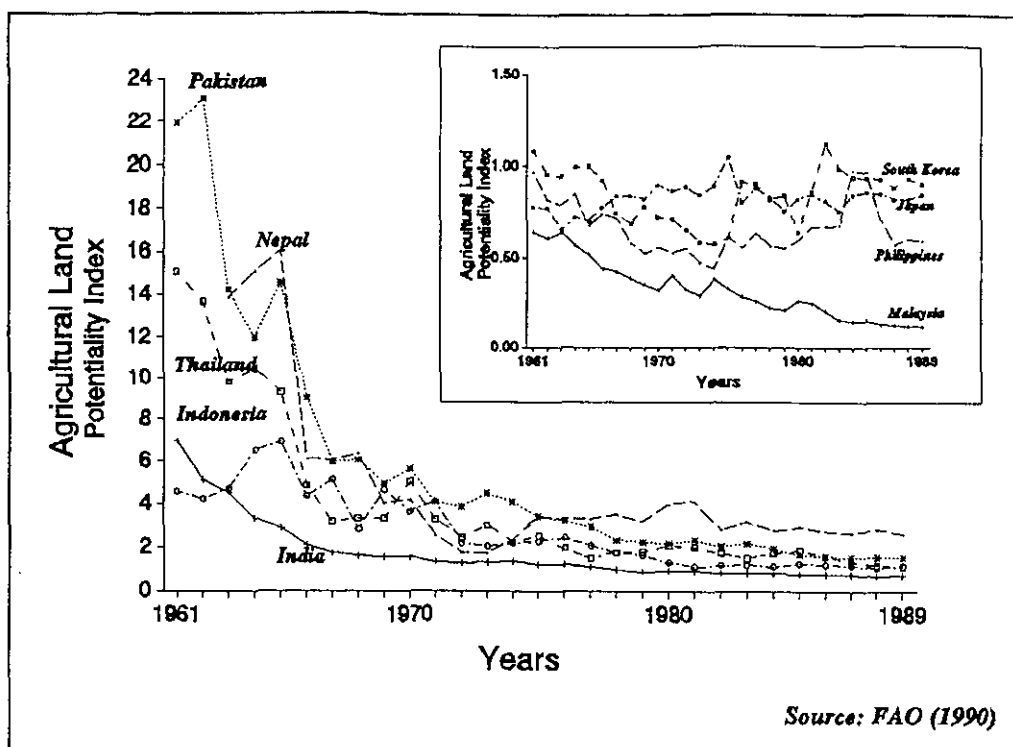


Figure 5 Changes in Land Potentiality Index

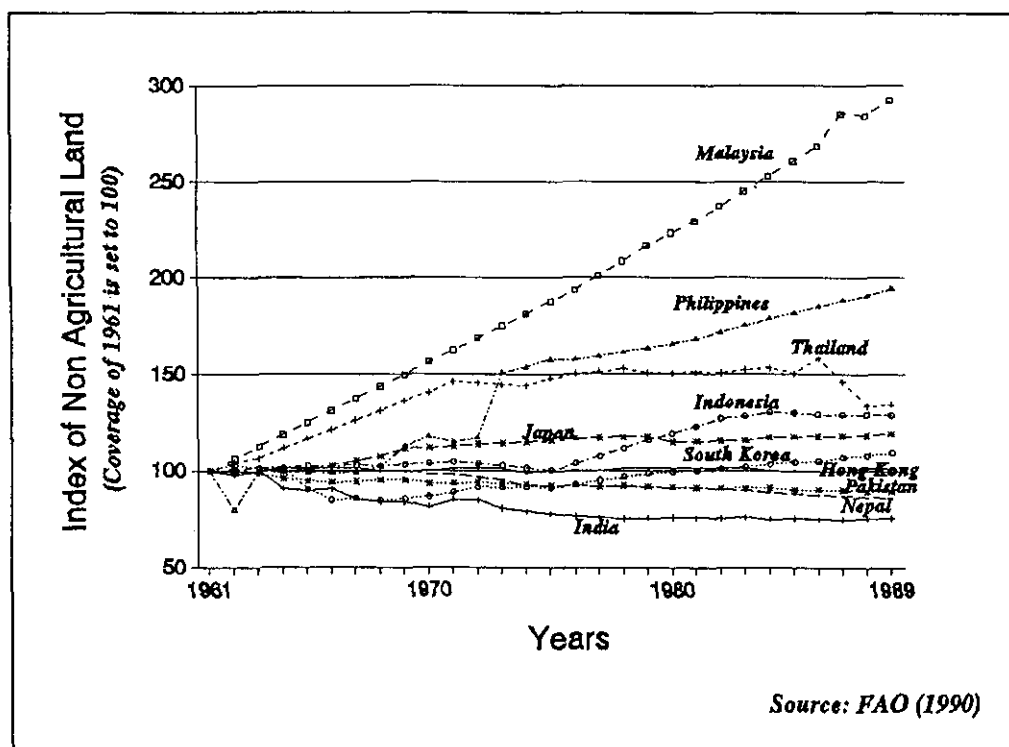


Figure 6 Changes in Non - Agricultural Land

In the East Asian countries which are more developed, share of non-agricultural land is almost steady. There is little increase of settlement land in these countries. The change is probably in term of more intensification rather than extension process as happened in the South East Asian countries. Multistory buildings, roads and subways are examples of this intensification as commonly developed in Japan.

4. Future Framework

In the Report of the Ad Hoc Committee of IGBP and HDGEC, the conceptual systems of land use/cover are imaged as Figure 7. The report mentions as follows: "Global Land Cover Change as an element of global environmental change requires an understanding of the linkages between human systems generating actions that lead to land-use change and the physical systems that are affected by the resulting changes in land covers."

As seen in the figure 7, the research subject of the Domain VII concerns with how to seize social context and how to control the driving force. This is mainly significant for the research of the second pattern mentioned earlier. The fall of human culture and civilization caused by desertification should be by all means checked. From such viewpoint, the structure of the research subject of the Domain VII is suggested as debating material.

The research Domain is broadly divided as Figure 8. Environment is studied mainly in other domains of IGBP in Japan. Accordingly, Domain VII puts its main research on Resources, Human Activities and Land Use (Space). From this conceptual framework of the domain VII, the following main research themes are suggested.

Theme I: Environment and Resources

The first subject is how much human beings can be available as human resources in global environment. Not only natural resources but also labor resources of human beings, economy resources as capital including the possibility of resources regeneration should be included among resources. Soil, water and energy would be especially important for agriculture and rural area.

Theme II: Human Activities

Human Activities should be studied in reference to land use. The following four fields are examined for the time being.

- 1) Urban Activities including Industry, Commerce and Living Activities
- 2) Agricultural Activities
- 3) Forestry Activities
- 4) Desert Modification
- 5) Wet Land Modification

Not only to study just Activity, but Resources and the like of each activity are studied relating with environment in each region.

Theme III: Land Use Change and Modeling

This theme III is the right study of the Domain VII, but the requisite for sustainable development is to make a balance of resources and activity. Accordingly, it is indispensable to make the modeling of land use by using the results obtained from the study of resources and activity. The actual conditions of land use changes should be pursued as the examination material.

Theme IV: Land Use Conversion

With the knowledge of the mechanism of Land Use Change studied at the theme III, how to improve bad conditions should be studied with the themes I, II and III and each feedback. This study domain is broadly divided as follows:

- 1) Regional Planning and Land Use Planning
- 2) Activity and Resources Control
- 3) Infrastructure Construction
- 4) Land Use Control

5. Concluding Remarks

This paper describes mainly the working conditions of Domain VII, and it also touches upon the future subjects. It should be our pleasure if our research, with our lively discussion on the future perspectives, could contribute to the making of the international project of Land Use/ Cover which is now being pursued.

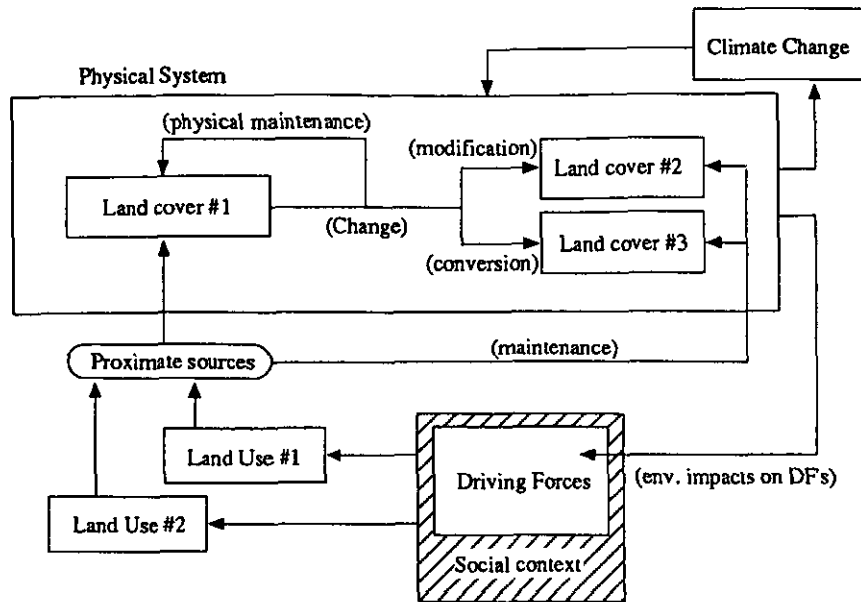


Figure 7 Linkages between Human Causes and Land Use and Cover

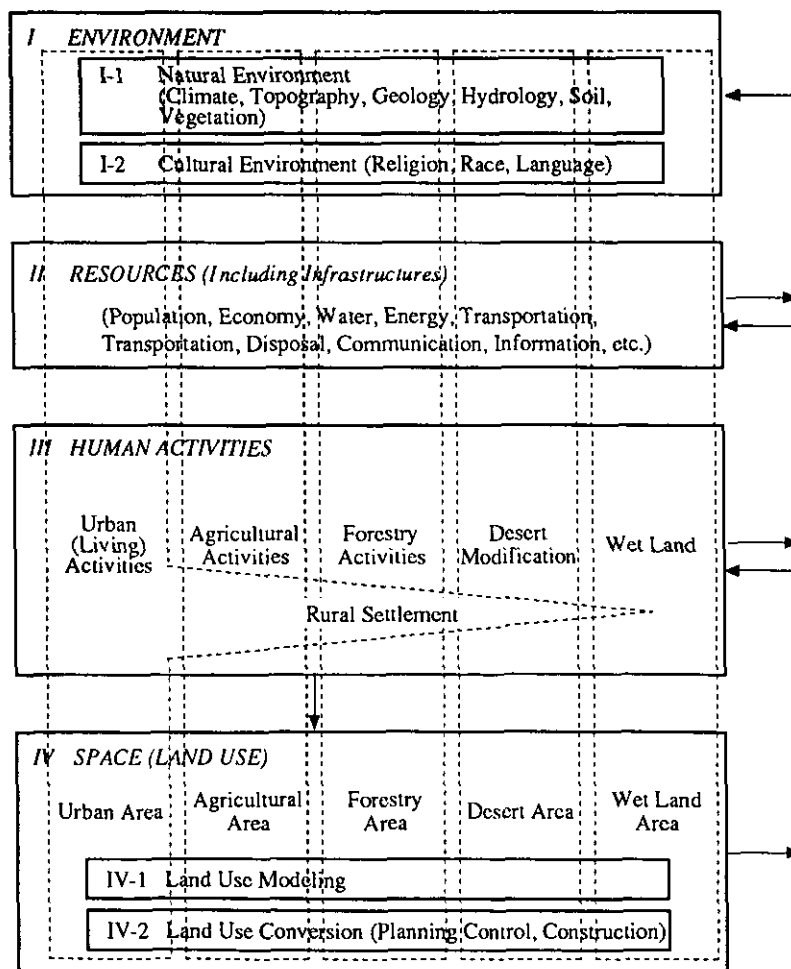


Figure 8 Environment, Resources, Human Activities, and LAND USE

References

1. Japan National Committee for IGBP (1991);
National Plan of IGBP-Japan, 1-42.
2. Kitamura, T (1991);
Global Environmental Problems in Agriculture and Rural Areas, Journal of Geography 100 (6) 837-842 (in Japanese)
3. Science Council of Japan(Feb. 1992);
The Present State on Japanese IGBP Study and Its Perspectives, Report of IGBP Symposium, 1-45 (in Japanese)
4. Kitamura, T and Kobayashi, S (Sep. 1992);
Rural Land Use in the Asian Region (I) -Land Use Characteristics and its Perspectives-, APO Symposium in Tokyo
5. Report of an Ad Hoc Committee of IGBP (ICSU) and (HDGEC) (ISSC)(Sep. 1992);
The Case for the Study of Global Land Use/Cover Change
6. Japan National Committee for Rural Planning (Sep. 1992);
The Report of International Symposium on Rural Land Use Asian Countries--Pursuing the New Ordering of Global Environment, 1-233
7. HAGE Symposium Report (Oct. 1992);
The Positive Role of Agriculture and Forestry for the Restoration and Conservation of Global Environment, 1-56 (in Japanese)

LAND USE

Land Use Change in Thailand and Its Impacts on Environmental Change

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1. Significance and Background of the Problem

It is accepted that human activities and their way of life affect both directly and indirectly the changes of environment in their societies. On the other hand, the changing environment has also influenced human activities and human lives. This can be proved and confirmed by the results arising from the following cited situations: for example, overpopulation, inappropriate land use and land use planning and deforestation in such sensitive areas as in the watershed or catchment areas and coastal zone. The degree of environmental crisis mentioned above is serious and is increasing rapidly due to economic growth and technological progress. Agricultural land use change from that of subsistence system to the modern one is characteristic of land use change from rural area to urbanization and industrialization. These can bring not only problem of natural resource depletion, but also problem of pollution, including global environmental change.

Thailand is a good example to study about the two systems of land use change causing environmental change. The majority of Thai people, about 80 percent 50 years ago and not less than 60 percent now, are farmers and farm laborers. The increase of population during the last 50 years from 18 to 57 million (statistic 31, Dec. '91) occurs mostly in the rural area.

From the National Economic and Social Development Plan 1 till now (NESDP 1-7, 1961 - 1992) it is evident that farmers still practice extensive agriculture as a major method for increasing production even though the intensive agricultural practice is necessary and has been promoted for more than 10 years. For this reason, natural vegetation or forest resources are annually destroyed and depleted. The destruction is believed to be about 12.8 million ha. (80 mill. rai) during the last 6 NESDPs, while the agricultural land or farm holding land has increased to more than half of forest land or 6.4 million ha. (40 mill. rai). This situation becomes most serious in the northeastern part of Thailand which is considered the poorest region. The major causes of deforestation in Thailand, however, are not different from those of other tropical countries. These causes are shifting cultivation (on highland or mountainous areas in the north); changing patterns of land use by conversion of forest areas to subsistence agriculture or rainfed one (on upland or foothill in every region), to cash crops or commercial agriculture (on the plain and upland near the town or city), to building of infrastructure (example from development projects of the government and private sectors in every region), and to land settlement (example from projects of government and private sectors and some individuals in surrounding areas of the cities). This includes opening forest land for mining (in the south and other regions), for coastal fisheries and for fossil fuel or charcoal in mangrove forest areas along the shoreline of the south, east and central at the Gulf of Thailand). As a result, watershed areas have been disturbed, loss of biodiversity has been detected, and eventually man will have no more wood for fuel, construction, and other industrial uses. A major impact in the tropics, including Thailand, will be the inability of agriculture and rural populations to adapt the changes due to the loss of ecosystem diversity caused by forest destruction and the removal of choice of species for cultivation and use. Apart from this, deforestation will contribute to climatic change both locally and globally and may also be exacerbated by such climatic changes, as very dry or drought period caused forest fire and air pollution and warmer temperature.

Moreover, the changing of agricultural land use system from the subsistence to the modern or commercial and industrialized one concentrating on using mechanization and high technology causes more serious problem on environmental change. These farming systems such as farms of field crops and horticulture, fowl and pig raising farm, fish and shrimp culture farm, etc. are well known as to affect not only natural resources namely soil/land, water and natural vegetation depletion, but also water and soil pollution due to such chemical substances as fertilizer, pesticides, insecticides, and suspended solid and dissolved solid which affected living organisms and human lives, in particular, through food chain.

Another changing pattern of land use that occurs at the same time as agricultural land use change is the conversion of rural area to urban area or urbanization and industrialization. The economic growth and technological progress toward being NICs can be seen clearly through the policy and planning of NESDPs during the past 30 years. It will be the first time in Thai history that the urban population increase will be higher than that of the rural population (51:49 percent) after the year 2000. The growth rate of industrial sector during The Last National Plan 6 (1987 - 1991) is higher than the goal or 13.7 percent per year, while the growth rate of agricultural sector is less than 3 percent per year. Apart from this, the government policy to establish the principle center and the peripheral cities for each region in order to help reduce or decrease problems of overcrowded population and such primate cities as Bangkok in the central plain, Chiang Mai in the north, Khon Kaen in the northeast, Chonburi in the east and Songkhla - Hadyai in the south. Problems that we are facing today from the growth of those cities are inappropriate land use and inefficient conservation measures. In

the other words, the city planning at present and in the future has not worked out efficiently, and even the laws related to the matter are not effective. The more the scale of city or urban and industrialization is enlarged along with economic and technological growth and progress, the more the environmental problem, in particular pollution crisis has increased. The degree of environmental crisis will depend on how critical and fragile the expanded or growing urban and industrialized areas are. This refers to such conditions as highland with steep slope, coastal zone, river bank and open or fallow land. The ecosystem of such areas which has normally been destroyed by natural hazard or erosive agents, will be worsened by human activities. Moreover, the number of industries established and started during the NESDP 3 (1967) has increased rapidly. There have been about 2,544 factories set up during the last 20 years (631 factories in 1969 and 51,500 factories in 1989). Even though there are such laws as conservation measures for opening factories to control them, there is no monitoring and evaluation system to guarantee the standard and to control their treatment system. At present or during this five-year plan of NESDP 7 (1992 - 1996), the government aims to emphasize or promote 6 types of industries, namely agro-industry, textiles, electronics, metallic, petro-chemical and iron and steel, which are known well for their serious effect of toxic substances and heavy metal pollutants discharge.

The results from the development at both national and local level during the last 6 NESDPs show not only the larger scale of modern and commercial agricultural land use or agribusiness and the rapidly growth of industrial sector and urbanization, but also all components supported such as enormous using of fossil fuel and of biomass fuel, using modern mechanization, providing facilities in communication, transportation network and all other infrastructures related including building big dam and reservoir as a multi-purpose project to serve hydro-electric power plant, industry and agriculture. The statistics of last year, 1991 confirms that Bangkok, the capital of Thailand, which is listed in the first 25 biggest cities of the world, consists of not less than 2 million cars; with the increasing rate of about 400 - 500 cars being registered daily. And Chiang Mai, the second to Bangkok in economic growth with only one fifth of the population of Bangkok, consists of 366,573 cars and motorcycles in its municipality area. What is important is that communication route or network and areas served for those transports is in incomparable ratio. The number of cars in Chiang Mai municipality area requires more than 6 times of the available facilities. Communication route of 177.50 km long of Chiang Mai municipality area is suitable for or can serve only 59,168 cars.

Human activities in changing the two systems or patterns of land use as explained are all parameters or causes of environmental change both locally and globally. Such changes affect human lives in both urban and rural area of Thailand. The degree of crisis depends only on their ecosystem and developed activities. If Thai people do not realize or are not aware of and not responsible for taking care of, conserving and managing our land and other resources and environment properly, more and more problems will rise and threaten the country's present and future as it is well known in all developed, and developing countries. The greenhouse effect or global warming problem which is one of the major problems now, is caused by greenhouse gases such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbon (CFC's) and ozone. It is often mentioned that as the world population increased, industry and agriculture were developed and as a result a large quantity of these gases, including CFC's (which are only produced industrially) are released. Industrial development requires great amount of fossil fuels which contribute large amount of carbon dioxide to the atmosphere and may also further contribute to the problem by atmospheric chemical reactions. Methane, at the same time, is produced from anaerobic reactions in agriculture and from energy programs, including paddy fields, cattle rearing, biomass burning, coal mining and the natural gas industry. CFC's are now commonly used in daily life (started in Thailand since 1930) as in spray cans, refrigerators, air conditioners and foam producing equipment. Moreover, the problem of global warming caused by human activities which have continued since the industrial revolution till now, has increased rapidly with the higher rate of about 100 times than the last 10,000 years before or from the ice-age (temperature high up only 5°C). For seventy years during A.D. 2030 - 3000 it has assumed that the world temperature will increase for 25°C, if the carbon dioxide is emitted into the atmosphere at the same rate as now. Deforestation and forest fire will also accelerate higher world temperature.

Water pollution is another major environmental problem in Thailand which affects environmental change and crisis to a certain degree depending on the causes and the area where the discharged water flows, in particular in dense community and industrial areas. Waste water originated from several sources as houses, condominium, markets, department centers, restaurants and hospitals in the community amounts to 75 percent of total waste water of Chao Phraya river. It causes serious problem to the environment downstream because it discharges to rivers without undergoing any pre treatment. Though there are laws and institutions controlling all factory pollution problems especially toxic substances and heavy metal pollutants, treatment is still below the standard and specified quality. National Environment Board or NEB mentioned that only 60 - 68% industrial factories with waste treatment and disposal systems of Changwat Sumutprakarn is at work their systems efficiently. NEB also states that in 1987 there were 90,000 registered industries around the country and up to 30,000 industries were located in and around Bangkok. Small electro-plating and dyeing industries in Bangkok area generate approximately 12 metric tons of heavy metal associated in the effluent and 40,000 - 60,000 metric tons per year of solid wastes which partially contain hazardous chemical each year. Problem of water pollution caused by solid waste is now evident in Bangkok and in other municipalities of regional center cities and coastal tourism center cities. Data from NEB showed that Bangkok produced solid waste per day at the highest load of

more than 5,000 tons in 1990, and it increased in one year (1992) to 6,000 tons. The city can manage to treat only 86 percent, the rest was left as soil pollution at its location or flowing into the waterways as water pollution. Other municipalities of main and tourist cities can collect and transport the waste with the average of 80 - 90 percent per day, e.g., Chiang Mai can collect about 140 tons of waste per day from the total of 180 tons (78 percent). Chiang Mai city like other municipalities, has no correct measurement to deal with the waste. Most of the waste was left piling on open space causing waste or polluting water in surrounding areas. Apart from this, though the great part of waste water or domestic effluent from the community is trapped in ponds for biological treatment, it still causes increasing problem of water pollution and spreading of as well as destroyed landscape because it is drained out through pipeline or natural and man-made waterways. However, the polluted water from agricultural practices also causes severe problem as mentioned before, in particular when it adopts modern system. Though the intensity of pollutants or waste from agricultural activities is less than that from industrialization and urbanization, the fact that it drains out in great volume to inland water sources and coastal zone makes its effect enormous. Not only does it affect the quality of water such as that in the Gulf of Thailand, the lack of management and controlling system of waste water treatment also worsens the situation.

Air pollution problem cannot be overlooked where increasing population changes system of land use from rural to urbanization and industrialization. It generally occurred together with noise pollution in big city with crowded population as in Bangkok, Chiang Mai, Chonburi, Songkhla - Hadyai etc. Toxic substances that cause polluted air which affect our health (both body and mind) are carbon monoxide, hydrocarbons, sulphur dioxide, nitrogen oxide, lead, black smoke, dust, bad smell and chemical substances from vehicles, industrial factories, transportation and communication, and construction as well. Besides, we, Thai people, have to realize and be aware of this air pollution problem as a lesson from industrial and developed countries such as acid rain problems in Scandinavia which is caused by high content of sulphur or sulphur dioxide emission from burning coal.

Those are just only a few of local and global problems on environmental change caused by land use change in Thailand. We all know well or accept that the climatic change today such as warming of the Earth's surface, changing precipitation pattern and seasonal patterns, changing soil moisture regimes, changes in cloud cover, changing wind directions and wind stress over the sea surface and raising of sea levels may be affected, at least in part, by human activities. And at the same time, nobody can deny the influence and effect of climatic change on human activities and land use change. So, it is time now for us to cooperate to study and analyze global and local problems on changing patterns of land use affecting environmental problem in our countries. With different fields of expertise related, our research team plans to propose suitable land use management to prevent the destructive affects of human activities and to promote eco-development.

2. Objectives

- 2.1 To study and characterize the human activities affecting the environmental change and problems in the following changing land use systems and areas:
 - 2.1.1 farming system change from an old to a modern one as from subsistence to agribusiness
 - 2.1.2 land use area change from rural to urbanization and industrialization
- 2.2 To propose suitable land use management in both systems of agriculture and rural-urban/industrial area.

3. Methodology

This study will depend mainly on data collection from documentary research and field surveys as its important components. The research will involve two levels of area analysis, country or national-regional level and provincial level.

3.1 Data Collection

Due to the objective, both physical and socio-economic data related during the last 10 years will be collected.

- 3.1.1 Physical data consists of natural resource such as soil, water, natural vegetation and minerals; and physical features as topography, climatology, meteorology, geology and natural hazard.
- 3.1.2 Socio-economic data consists of population and their occupations; land use classification in both rural and urban area such as agricultural or farm holding land, housing and community area, and commercial and industrial area; irrigation; types, number and production of agriculture and industries; environmental pollution occurring in rural and urban area as well as in agricultural and industrial area etc.
- 3.1.3 Maps, aerial photographs and satellites are all data collected as an important tool for study and analysis.
 - (1) Thematic maps of data related as water sources, natural vegetation and geology.
 - (2) Aerial photographs covering particular areas and problems analysis as forest and agricultural areas and urban and industrial areas.
 - (3) Satellites data from NOAA, LANDSAT-TM, MOS and SPOT

3.2 Data Preparation

- 3.2.1 Maps will be organized in layers of information as a raw data for using Geographic Information System (GIS) as a tool to analyze.
- 3.2.2 Data collected from documents and field surveys will be organized into tables, models, diagrams, etc., and specific descriptive data for analysis.

3.3 Data Analysis

Mapping from using GIS-technique and documentary data will be interpreted and analyzed as well as data from surveys, observations and field interviews. This is an analysis of both large scale or national-regional level and small scale or provincial level on the two systems of land use change affecting environmental change and environmental problem.

- 3.3.1 At national-regional level will give the overall picture of the two systems of land use change and its impact of environmental problem as mentioned in the criteria. This analysis will emphasize all 6 geographical regions with major or minor variables in physical and socio-economic. These variables are related to or have direct and indirect effects on land use that benefit the development of its conservation measures and suitable management.
- 3.3.2 At provincial level, an analysis will concentrate on major and outstanding characters representing the two systems of land use change in the main or center province of each geographical region as follows:
 - (1) Northern region, Chiang Mai as a sample area with emphasis on the study of agricultural land use systems of both highland and lowland, urban growth on the former rural area and its impact on environmental change.

- (2) Northeastern region, Khon Kaen will be selected to study with emphasis on agricultural land use and problem of soil resources and human resource (poverty and seasonal migration).
- (3) Central region, Bangkok as an example, will concentrate on problem of urbanization and industrialization together with environmental pollution.
- (4) Eastern region, Chonburi as an example area with emphasis on the study of the growth of industrialization and its effect on environmental pollution.
- (5) Western region, Kanchanaburi as an example, will concentrate on the study of agricultural land use on upland, the growth of agro-industries with the problem of environmental pollution and also the problem of big dam construction.
- (6) Southern region, Songkhla - Hadyai will be selected to study on agricultural land use system both inland and coastal zone, industrialization as fisheries and mining and its impact on environmental pollution.

4. Anticipated Benefits

The research findings can be a good recommendation for proposing a suitable land use management at present and in the future. It can help everybody to realize, to be aware and responsible for what has been done or is planned because it can affect all life on Earth.

5. Time Schedule

Operational Stages	1st YEAR			2nd YEAR			3rd YEAR		
	1 - 4	5 - 8	9 - 12	1 - 4	5 - 8	9 - 12	1 - 4	5 - 8	9 - 12
Data Collection and Field Survey	→	-----→							
Compilation of Basic Data of Mapping		→	-----→						
Data Processing and Analysis			→	-----→					
Workshop/Seminar					→				→
Map Reproduction and Report								→	

----- Continuation of field survey at time available for necessary additional data.