

**GCTE**  
**Global Change and Terrestrial Ecosystems**  
**Progress Report and Prospects for Asian Contributions**

Will Steffen  
GCTE Core Project Office, Lyneham, Australia

## **1. Introduction**

GCTE is a global research programme aimed at understanding how the rapid environmental change now underway on Earth will affect terrestrial ecosystems, and how these effects will lead to further change. GCTE's effort requires expertise in a wide range of disciplines, from the social sciences to physics, and will be carried out in every major biome of the world, from the Amazon to the Arctic.

The GCTE research programme offers many opportunities for contributions from Asian scientists, and will provide significant benefits to the Asian region in terms of a better understanding of both the particular impacts of global change on the region's terrestrial ecosystems, including agricultural systems and forests, and of the consequent feedbacks to further global change.

Before we discuss further GCTE's role in the Asian region, we first review the objectives and structure of GCTE, describe its implementation strategy, and outline the present status.

## **2. Objectives and Structure**

The objectives of GCTE are:

To predict the effects of changes in climate, atmospheric composition, and land use on terrestrial ecosystems, including agricultural and production forest systems.

To determine how these effects lead to feedbacks to the atmosphere and the physical climate system.

GCTE's operation definition of "global change" encompasses far more than just predicted climate change alone. It includes changes in atmospheric composition, such as the concentration of CO<sub>2</sub> and other greenhouse gases, which have increased and will continue to increase and which have direct effects on vegetation with or without climate change. It also includes land use, as driven by demographic, economic, technological and social pressures.

GCTE is organized into a hierarchy of Foci, Activities, and Tasks (see Figure 1). The four Foci are:

Ecosystem Physiology  
Change in Ecosystem Structure  
Global Change Impact on Agriculture and Forestry  
Global Change and Ecological Complexity (proposed)

The first two Foci are designed to provide a fundamental understanding of the impacts of global change on ecosystem function, composition and structure, and their feedback effects. The third Focus, on agriculture and forestry, and the proposed fourth Focus on ecological complexity, are designed to examine the more specific impacts of global change on systems of great importance to humans - for the production of food and fibre, and for the maintenance of the Earth's biological diversity and ecosystem complexity.

## **3. Implementation Strategy**

The GCTE Operational Plan provides the framework for its core research programme. The individual projects which contribute to the core research programme come primarily from two sources:

### National/Regional Contributions.

National IGBP committees and other national and regional groups of research organizations have developed their own global change research programmes. While many of the projects within these programmes are designed for specific national objectives, some projects contribute directly to GCTE's international core research programme as well. These are adopted by the GCTE Scientific Steering Committee (SSC) as part of the GCTE core research programme.

Figure 2 shows the strategy for incorporation of national/regional projects into GCTE. A package of projects is submitted by a national IGBP committee to the GCTE SSC for consideration. The proposals should describe clearly how the project will contribute to specific Tasks in the GCTE Operational Plan. The SSC evaluates the proposals on the basis of scientific quality and relevance to GCTE objectives. Those that meet these criteria are accepted as official contributions to the GCTE core research programme.

#### GCTE-Initiated Research.

Synergistic and national/regional projects will form much of GCTE programme. However, gaps will still exist in the implementation of the Operational Plan. The GCTE SSC will initiate the research needed to fill these gaps by coordinating the scientific teams needed to carry out the work and obtaining the resources for them to do it.

#### **4. Current Status**

GCTE has made strong progress during 1992 with the publication in April 1992 of the GCTE Operational Plan (IGBP Report No. 21) and the approval of the first set of contributing research projects. A compendium of GCTE research, describing this initial set of projects, will be available in early 1993.

The major developments within each Focus are:

- Focus 1: Establishment of elevated CO<sub>2</sub> network
  - Initiation of major GCTE biogeochemistry study in the Amazon
  - Bulk surface conductance project - literature survey and model development
- Focus 2: Establishment of LEMA (Long-term Ecological Modeling Activity) network
  - Selection of first two GCTE study areas for model development
  - Linkage of global vegetation models to GCMs
- Focus 3: Establishment of wheat research network
  - Appointment of Task leaders
  - Initiation of global forestry research programme
- Focus 4: Selection of planning committee
  - International conference on global change and ecological complexity, mid-1993

#### **5. GCTE and the Asian Region**

START (Global Change System for Analysis, Research and Training) has selected the Southeast Asian region for initial emphasis. GCTE welcomes this decision, and is collaborating as much as possible with the START initiative to develop a strong GCTE research programme in the region, including also the temperate Asian region to the north. GCTE has two scientists from the region (Prof. Tadaki Hirose, Tohoku University, Japan; Dr. Paul Teng, International Rice Research Institute, Philippines) on its SSC; GCTE representatives have contributed to regional IGBP meetings (Singapore, Dec. 1991; Chiang Mai, Jan. 1992; Tokyo, Feb. 1992); and the location of the GCTE Core Project Office in neighbouring Australia enhances interaction between GCTE and Asian researchers.

There are many opportunities for Asian scientists to contribute to GCTE. Some possibilities are listed below by Focus (cf. GCTE Operational Plan):

- Focus 1: Elevated CO<sub>2</sub> experiments on rice using FACE (Free-Air Carbon Dioxide Enrichment) technology
  - Study of effects on carbon and nutrient cycles of land clearing in Southeast Asian forests and subsequent land use practices
  - Research along a tundra/boreal/temperate transect in north Asia on the interactive effects of increased temperature and altered nutrient availability on carbon and nutrient pools and fluxes

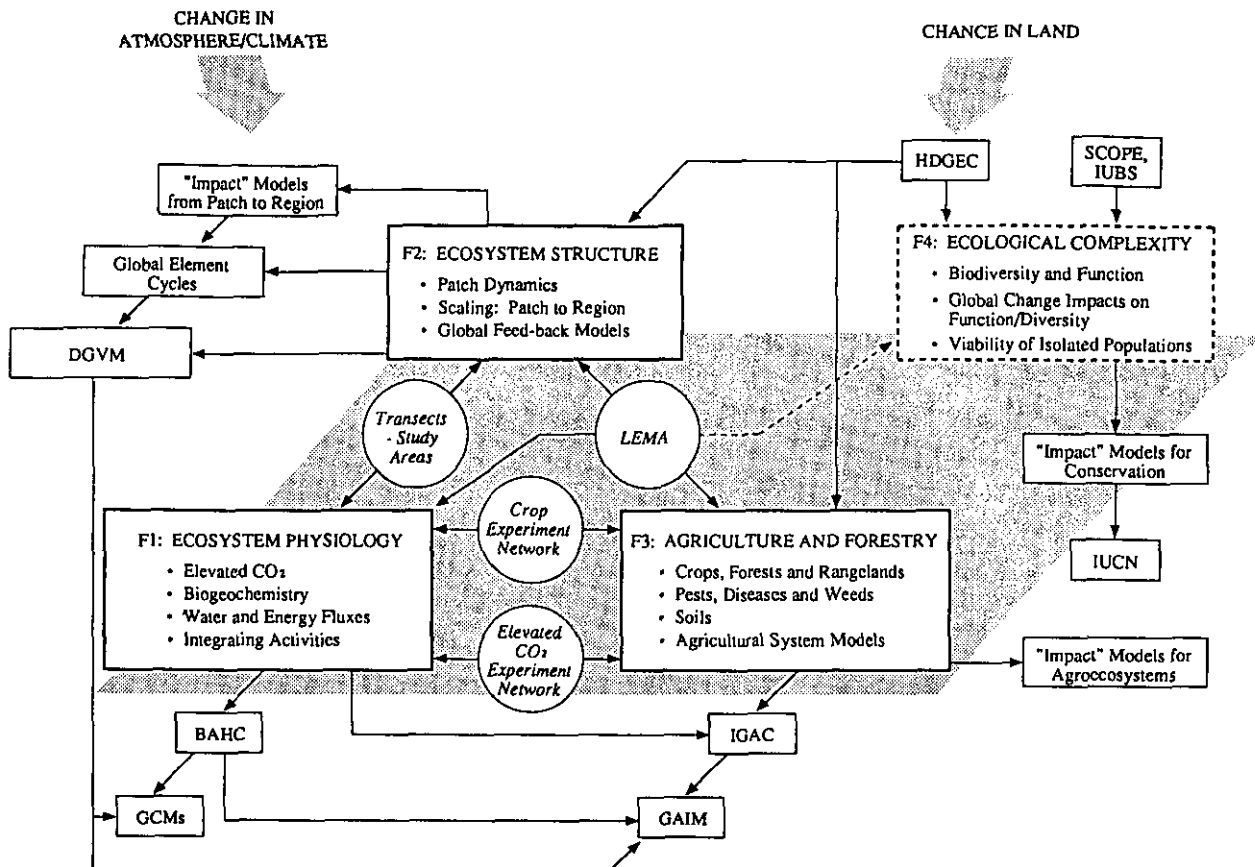


Figure 1 Global Change and Terrestrial Ecosystems

The structure of GCTE. Large boxes represent the four Foci. They are strongly linked through shared modeling efforts, common experimental sites, and several cross-cutting issues (such as water and soils). Specific integrating facilities (shown by circles in the figure) further bring the overall GCTE research effort together. Small, bold boxes identify the products of GCTE, and the others are some of the major groups with which GCTE interacts.

- Focus 2: Experiments on plant and ecosystem responses to elevated CO<sub>2</sub>, increased temperature, and changed moisture regimes to determine plant functional types for ecosystem dynamics models
- Linkage of ecosystem dynamics modeling centres in the region to LEMA (centres in China, Japan, Southeast Asia?)
- Joint HDP/GCTE (HDP = Human Dimensions of Global Environmental Change Programme, the social science companion programme to the IGBP) pilot studies to project human-driven land use change in (i) tropical forests of Southeast Asia (Malaysia and Indonesia, for example), and (ii) temperate East Asia.
- Focus 3: Research network to study global change impacts on the rice ecosystem, including pests and diseases and soil structure and fertility
- Study of global change impacts on production forestry
- Research on increased water erosion potentials in Asian agricultural systems due to climate change
- Study of global change impacts on the rangelands of western China
- Modeling of complex agro-ecosystems
- Focus 4: Studies of the combined influence on biological diversity of climate and land use along gradients of each with different, but known, histories of disturbance

There are already some initiatives in the region that will contribute to these topics. A Japanese-led project, "Global Change Impacts on Terrestrial Ecosystems in Monsoon Asia" (TEMA), is relevant for several of the potential projects listed above. The Thai National Committee for the IGBP has offered to host a GCTE workshop in 1993 to establish the GCTE rice research network. START has allocated resources for GCTE to run a training course on ecosystem dynamics modeling of tropical systems for scientists in the region.

GCTE hopes that more projects are rapidly added to this initial list of contributions, and that GCTE and the rest of the international research community can establish close collaboration with Asian scientists and research institutions on global change studies.

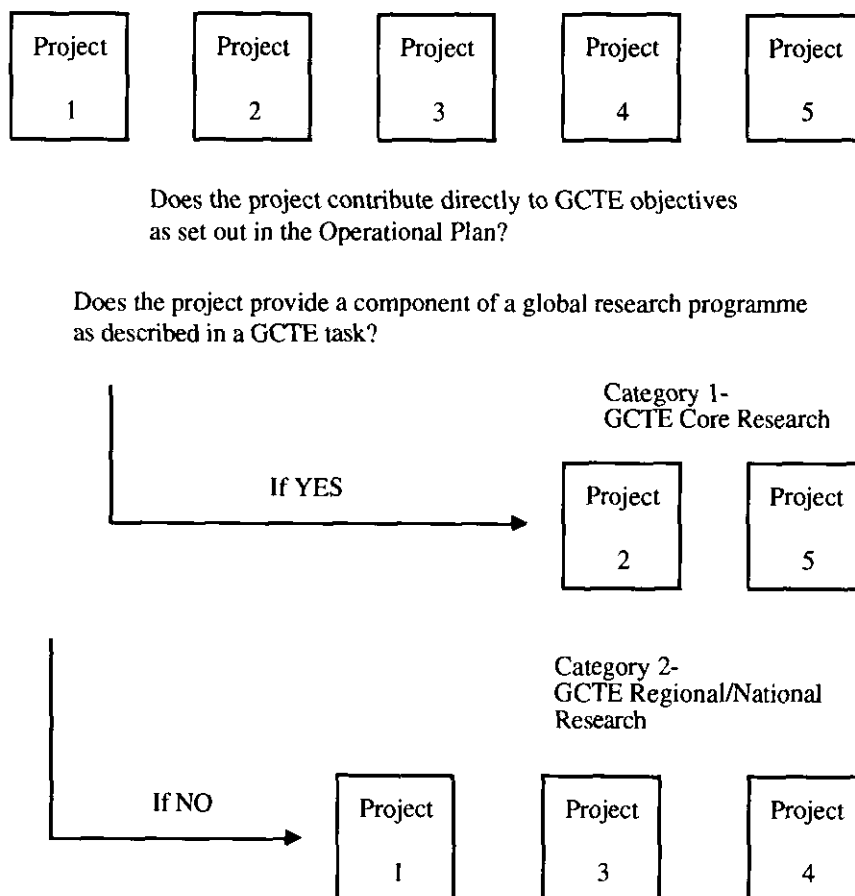


Figure 2 Progress for adoption of national/ regional projects into the GCTE core research programme.

**GCTE**  
**Greater Coordinated Research Necessary to Solve Various Problems**  
**Related to Global Change and Terrestrial Ecosystem**

A.N. Rao  
Asian Network of Biological Sciences, Botany Department,  
National University of Singapore

**Introduction**

The problems of global change are analyzed from different perspectives. A considerable amount of literature is published emphasizing that many regions in the world face the risk of increasing damage to human environment which threatens human progress. Biospheric processes affect both the air that envelopes the Earth's green mantle and water cycles. The programme of work outlined by international organizations should be made well known in the developing countries. Both national and regional scientific activities are most important and essential to make the global programme a success. These are mainly discussed in this paper and some suggestions are offered.

**Background**

In preparation to the Rio meeting and thereafter considerable number of papers, books and newsletters have been published to create an awareness and to launch action plans for reducing uncertainties in global change and to safeguard terrestrial ecosystems as well as biodiversity of species. Many of these are written by world experts and the details given are very authentic and correct. IGBP Report no. 22 and the discussions held at a preparatory meeting of IGBP at Singapore in Dec. 1991 also have direct bearing for the deliberations of this meeting.

**The Scientific Challenge**

The scientific challenges of global change research are summarized in the IGBP publication on "Global Change - Reducing Uncertainties". How the Earth system works under conditions of global change is briefly explained. The human activities and their impacts have created many disruptive changes in global climate and the various life systems. Many of the damages have reached crisis proportions and levels (IGBP, 1992).

The air that envelopes the globe, Earth's green mantle and water cycles are all involved in the functioning of the Earth system, with many interactions between biological and physical processes. It is a complex topic and we know only some of the details.

**Biological Aspects**

The objectives and overall aim laid down within the research agenda of IGBP have many biological aspects. People who conduct research on various topics have to break down, analyze and classify the various topics into smaller working units. This helps to envisage the different types of research personnel required to conduct and complete the multidisciplinary research projects. To illustrate the point and for further clarification the IGBP Core Project Global Change and Terrestrial Ecosystems (GCTE) has four subheadings with various components.

**1. Ecosystem Physiology**

- a) To test the effects of significant environment parameters on the functioning of ecosystems as a whole.
- b) Mutual relationship and exchange of energy, water, greenhouse gases, nutrients and the effect of these on - Various organisms, ecosystems and biomass accumulation or loss.
- c) Increased CO<sub>2</sub> level increases plant growth and reduces water loss - as determined with crop plants especially monocultures; But how about the other vegetation types? Temperate grasslands, Savanna, tropical forests? Research has to be conducted to find out the answers.
- d) Soil nutrient levels - especially nitrogen and phosphorous. Can they be sustained when increased CO<sub>2</sub> levels increase growth?

## 2. Change in Ecosystem Structure

- a) In the context of global change it is necessary to understand the relationship between structural form and ecological function of the major biomes. This would help to set up landscape scale models and vegetation models appropriate for any given area towards a sustainable relationship.
- b) The rate of climate change as seen through seasonal and regional fluctuations will help to determine biospheric responses to global warming.
- c) Increasing temperatures may promote new forests in tundra regions. Tropical and subtropical forests may be reduced in area, location and structural compositions.
- d) Accurate or precise documentation towards establishing a comprehensive database.

## 3. Global Change Impacts on Agriculture and Forestry

- a) To determine the impacts of global change on crop production and forestry. Crop yields in future can be predicted. Optimum ratios between natural and managed ecosystems.
- b) The different types of land use will be critically examined including monocultures, intercropping systems, pasture lands and natural forests.
- c) Conceptual change in thinking from species conservation to habitat conservation.

## 4. Global Change and Ecological Complexity

- a) To understand the impact of global change on ecological complexity within different terrestrial ecosystems.
- b) To understand viability of populations isolated by habitat fragmentation.
- c) Relationship between species richness and nutrient cycles within the ecosystem.

After going through these various topics and questions mentioned above it becomes very clear that at least for 80 % of the topics listed, there is no reliable data available from or for most of the developing countries. Whatever data that published are either very sketchy or done very briefly based on the observation or study conducted over a short period of time. Occasionally data obtained in one station are extrapolated over the other, even though the two stations are located thousands of miles away. To fill the gap in our knowledge or to fill up the details with whatever that may be available either as data unpublished or not well recorded, the local scientists in each country should gather the information either in a workshop or at small meetings and build up the details. This is an urgent task and persons who are in charge or the scientific steering committee of the topics identified should try to arrange such meetings in different developing countries. The weather pattern including rainfall is changing in the equatorial region, which certainly would have considerable impact on the biomes and their functions. No attempt is so far made to record the effects of such changes in S.E. Asian countries.

## Biodiversity

As said before recently published literature on the importance and conservation of biodiversity is vast and informative. Some of these are - Biodiversity (Wilson, 1988), Biological Diversity (McNeely, 1990) Global Biodiversity Strategy (1992) and from Genes to Ecosystems - A research agenda for Biodiversity (Solbrig, 1991). Each one of them carries a wealth of information. The problems of biological conservation or preserving the biological wealth in the world is not a biological problem any more but mostly due to overpopulation, and all the socio economic and political problems connected therewith. Trade, import and export of raw and forestry materials also play a major role. It is clearly pointed out that the human species is damaging the life support system of our planet Earth. Danger is imminent and everyone should think and participate wisely to save whatever biological wealth that is still remaining in good condition.

## Global Environment Facility - GEF

The United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP) and the World Bank have jointly launched a three year pilot programme GEF to assist developing countries to protect the global environment. GEF was established in 1990 with four priority objectives 1) Reduction of greenhouse gases, 2) Protection of biodiversity, 3) Protection of international waters and 4) Protection of the ozone layer. The facility became operational in 1991 and many of the projects for funding are considered. Projects are prepared and submitted for the consideration of GEF and another committee of GEF, the Scientific and Technical Advisory Panel (STAP). STAP also prepared a set of criteria to judge project eligibility and set up priorities for funding.

While considering the projects for award it is becoming increasingly clear that many of the developing countries do not even have adequate information to prepare the project and to give details about the extent of biological wealth present, how to improve or restore them, their economic value, further prospects for conservation, sustainable development and the related aspects. Manpower development and availability of well trained local staff to conduct research is totally or partially lacking in most countries. Some of the shortage of well trained scientists is world wide. The problems would not wait to be resolved till the scientists are trained. Therefore the problems should be tackled immediately to find suitable solutions, with whatever facilities and manpower that are available.

At present most of the planning work is done in Europe and USA. Naturally the information is concentrating at certain quarters. As we all know there is considerable time lag; sometimes as much as 1-2 decades, before the scientific data reaches the education and research institutions or to reach the common man in developing countries.

The planning phase of the IGBP has taken about 5-6 years. Many meetings and workshop were conducted to identify the core projects. Many national committees have been set up to plan and conduct research but actual work is yet to begin in many of the developing countries because only a small number of developing countries are involved or participate with IGBP projects. Both national and regional working groups should be set up to conduct research and produce the relevant data locally. It is only after obtaining some good data in each country that the regional centres can coordinate the information to complete the global study. The World Climate Research Programme (WCRP) is set up to describe and understand the various interactions between the physical processes that regulate the climate system. The IGBP and WCRP have many complementary objectives, and it will take 1 or 2 decades to understand or predict the regional patterns of climate change. But it is not possible to wait that long. The environmental changes that are occurring and how they influence human life in different parts of the world should be made known to all concerned.

Therefore there is an urgent need to spread the message up to the level of working scientists and technicians and formulate working groups in each developing country. The existing arrangement and progress made are no doubt very laudable but the number of people involved is very small and limited. Scientists in developing countries should be encouraged to take part and all should work together more cohesively to solve the global environmental problems.

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