

INDIAN PROGRAMME FOR IGBP

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Indian National Committee for IGBP India, National Physical Laboratory

1. National Committee

India has been quick to establish a National Committee for the IGBP under the auspices of the Indian National Science Academy. The previous Chairman, Prof. R.R. Daniel, had organized a number of workshops and seminar discussions to activate work in national laboratories and universities on different aspects of global change programme. The present Chairman is Dr. A.P. Mitra (National Physical Laboratory, New Delhi-110012). *The National Committee is organizing a major National Symposium on Global Change (December 14 to 17, 1992) in Madras at Anna University.*

In addition, there are several bodies concerned with global change activities. One is the Advisory Committee on Global Change at the Ministry of Environment and Forests. An Inter Ministerial Group on Global Change was also set up sometime back with the then Minister of Science and Technology, Prof. M.G.K. Menon as its Chairman. The committee's role is to integrate the activities of major implementing agencies.

2. Major Institutions

Major institutions involved in the IGBP programme are the following:

(i) Council of Scientific and Industrial Research(CSIR):

- National Physical Laboratory (NPL)
- National Institute of Oceanography, Goa (NIO)
- Regional Research Laboratories at Bhubneswar, Jorhat and Trivandrum
- Central Leather Research Institute, Madras (CLRI)
- National Botanical Res. Institute, (NBRI), Lucknow
- Industrial Toxicology Research Centre, (ITRC), Lucknow
- Centre for Mathematical Modeling and Computer Simulation (C-MACCS)

(ii) Department of Space(DOS):

- Physical Research Laboratory, Ahmedabad (PRL)
- Vikram Sarabhai Space Centre, Trivandrum (VSSC)
- Satellite Application Centre, Ahmedabad (SAC)
- National Remote Sensing Agency, Hyderabad (NRSA)

(iii) Department of Science & Technology(DST):

- India Meteorological Department (IMD)
- Birban Sahani Institute of Paleobotany (BSIP)
- Survey of India (SOI)
- Wadia Institute of Himalyan Geology (WIHG)
- Indian Institute of Geomagnetism (IIG)
- Indian Institute of Tropical Meteorology (IITM)
- National Centre for Medium Range Weather Forecasting (NCMRWF)

(iv) Indian Council of Agricultural Research (ICAR)

(v) MST Radar Facility at Tirupati

(vi) Indian Institute of Sciences, IIT Delhi and Universities of Calcutta, Varanasi, Madras (Anna University), Cochin, Madurai and several others.

3. Special Facilities

The following special facilities of interest to IGBP are available:

- (i) Three Rocke Ranges at Thumba, SHAR and Balasore
- (ii) A High Altitude Balloon Facility at Hyderabad
- (iii) An MST Radar at Tirupati (ST mode in operation)
- (iv) Two Indian Remote Satellites: IRS-1A and IRS-1B
- (v) Two Research Vessels: Sagar Kanya & Gaveshni

4. Special Publications

The major participating organizations (CSIR, DST, DOS) have brought out the following documents on their programme:

- (i) CSIR Programme on Global Change, July 1990
- (ii) Geosphere-Biosphere Programme, Dept. of Science & Technology, Feb., 1991
- (iii) Geosphere-Biosphere Programme: ISRO/DOS Plan, Oct. 1989

Documents of interest to IGAC programme brought out recently:

1. Greenhouse Gas Emissions in India: 1991, Methane Campaign, Ed. A.P. Mitra, Sci. Rep. No. 2, CSIR, June 1992.
2. Greenhouse Gas Emission in India-1992 update, ed. A.P. Mitra, Global Change Sci. Rep. No. 4, August 1992.

5. Specific Programmes

5.1 Programmes relating to IGAC

5.1.1 1991 Methane Campaign

- (i) A special campaign was organized in 1991 for measurement of methane fluxes for the entire kharif season (May to October) from various stations located in major rice growing regions in the country. The detailed results are brought out in the Document mentioned above.
- (ii) Total Inventory of CO₂ and CH₄ over India
An updated inventory has been completed which includes carbon dioxide emissions from fossil fuels, methane emissions from animals, paddy fields and coal mines. The results are detailed in the document mentioned above.
- (iii) Specific Gas Emission Study for prediction of methane emission in mines: 1980 - 1992
This study has been conducted by the Central Mining Research Station, Dhanbad.
- (iv) Forest biomass burning in India
Prepared by Forest Research Institute, Dehradun.
- (v) Road Transport & Global Climate Changes, Central Road Research Institute, Delhi
This is a study of emission from road transport from the period 1980 to 1990 and covers particulates, NO_x, HC, CO, CO₂
- (vi) N₂O fluxes from oceans, wetlands and paddy fields
This programme has been initiated.
- (vii) Ozone Measurements
Of several measurements, measurements on ozone have been the most comprehensive in India and include Dobson spectrophotometers, surface ozonesondes, balloon and rocket ozonesonde flights. New techniques such as laser heterodyning system and UV-B photometers were introduced during mid-80s. It is planned to augment this network by setting up three Brewer Spectrophotometer Stations in India and by extending the UV-B network to cover a few more sites. A millimeter wave radiometer is under construction. Four stations for surface ozone measurements using UV absorption based instruments are planned. One is now in operation at Ahmedabad and another at Poona. Other sites will be the MST radar site (planned to be set up in 1993) and at Dehradun (in 1993).

(viii) Vertical distribution of trace gases

Physical Research Laboratory of Ahmedabad initiated this programme in collaboration with Max-Planck Institute for Aeronomy, Lindau, Germany during the period 1985 - 1990. Indigenous cryogenic sampler is under development at Ahmedabad and is likely to be ready by 1992 end. A number of balloon flights are expected to be made during 1992 to 1997 timeframe with this instrument.

5.2 Programme on Modeling Related to Climate

Chemical-climatic modeling efforts are in progress at several centres: NCMRWF, C-MACCS, NPL, NIO, IIT-D, IITM, IISC

(i) Global Circulation Models of Atmosphere

The studies include:

- (a) refinements of numerical techniques (Nested Grid/Model, improved acceleration, parallel processing etc.)
- (b) refinement of parameterization schemes
- (c) impact on a regional scale including monsoons

(ii) Regional Circulation Models of Atmosphere

These studies are aimed at studying phenomena of local/regional interest such as development and movement of cyclones.

(iii) Global/basin Scale Ocean Models

(iv) Coastal Ocean Circulation Model

(v) Statistical Empirical Models

To examine effect of environmental changes on parameters such as crop yield.

5.3 Land-Ocean Interaction in Coastal Zone (LOICZ)

(i) Geomorphology, Material Transport Estuarine Dynamics and Hydrology

Institutes involved are principally: PRL, NIO, NRSA.

The workplan is:

- (a) Catchment - coastal zone studies;
- (b) Dynamics, hydrology and bathymetry; and
- (c) Modeling.

(ii) Common JGOFS Programme

Organizations which are already engaged in data collection for NIO (marine CO₂, N₂O) and NPL (CO₂, N₂O and CH₄) on terrestrial atmosphere.

Workplan includes:

- (a) detailed data collection at a few selected locations in the Hooghly river, along the Andhra coast, at Lakshadweep and Andamans;
- (b) exhaustive input on biological components;
- (c) ocean-coastal region modeling including roughness characteristics;
- (d) Sagar island as a barrier island to examine storm surge effect; and
- (e) effective implementation of IMD's programme to measure atmospheric CO₂.

(ii) Coupled Surge-Wave Model

NIO has a group active in both conceptual and measured-data modelings of the Arabian Sea and the Bay of Bengal with particular emphasis on circulation pattern. IIT-D has an ongoing programme on coastal and large-scale circulation model.

5.4 Past Global Changes

1. Earth History during the last 2000 years (Stream I)

In India, this period has been the most eventful in terms of human civilization but little objective data are available on the Indian climate/environment earlier to about 150 years when the instrumental records commenced.

1.1 Historical Accounts of the last 2000 years

A multi-Institutional effort is being taken up involving national libraries, archives, professional societies and academic institutions in documenting authentic historical accounts of droughts, floods migration of population and records of other environmentally sensitive events and put them in proper time frames.

1.2 Dendroclimatology

Data on tree-rings are available in India for many regions starting from 1400 A.D. Implementation is planned in the following steps:

- (i) Tree-ring cores and disc collection, processing and archival of source material.
- (ii) Extraction of ring width and ring density data and building of master chronologies for different regions: densitometry facility to be added to the existing ring-width measuring laboratories for seasonal resolution.
- (iii) Measurement and analysis of stable isotope ratio of carbon, hydrogen and oxygen in tree-rings and their use in reconstruction of past precipitation and temperature series.
- (iv) Climate-tree growth response function models using climatic data of last 100 to 50 years to be used for climate reconstruction for about 1000 years.
- (v) Proxy Climatic Signals from the Coastal Sediments
 - i) Study of benthic foraminifera from the sedimentary deposits in the coastal shelves along the coasts of India to reconstruct the past precipitational changes.
 - ii) Chemical and isotopic study of annual growth layers in corals from the coastal regions and islands: study to include estimates of relative amounts of Cd and Ba and $18\text{O}/16\text{O}$, $13\text{C}/12\text{C}$. These may indicate the seasonal changes in sea surface temperature in the past.
- (vi) Study of Ice Cores

10Be data from ice cores in the Himalayan glaciers to provide information on past changes in solar activity and climatic change.
- (vii) Changes in the Atmospheric Concentration of CO_2 , CH_4 , N_2O and Other Trace Gases

From the stable isotope analysis of samples collected from ice cores, tree rings, peat bogs, lacustrine sediments, coral and speleothems.
- (viii) Volcanic Eruptions during the Last 2000 Years and Major Climatic Variations Associated with Them

Evidences of volcanic eruptions and their climatic signals from existing data or volcanic ash deposits can be subjected to detailed examination using ice cores, tree rings, high resolution lacustrine and marine sediments.

Glacial - Interglacial Cycles in the Late Quaternary (Stream-II)

(i) Response of the Oceans to Monsoon Circulation

Sediments cores along the continental margins are important source material. 25-50 metre long cores will be collected. They are to include such palaeo-oceanographic samples as diatoms, foraminifera, radiolaria and sedimentological assemblages.

(ii) Long-Term History of Sea Level Changes

Ice sheet mass balance studies are essential to estimate the sea level changes. Stable oxygen isotopic record from deep sea sediments and ice cores along with the isotopic analysis of coral and other coastal deposits and coastal geomorphological studies are being taken up.

(iii) Studies on the Evolution of Deserts

Study of sand dunes, their movement stabilization and other geomorphological aspects of the past few hundred thousand years in several parts of Western India.

(iv) Palynological Studies of Lake Deposits

The lakes selected for study are Didwana, Sambhar and Lunkaransar in Rajasthan, Nainital, Bhimtal and Naukuchital in Utter Pradesh, Chilka in Orissa, Palicot, Ooty and Palni Hills in Tamil Nadu and Tsokar in Jammu & Kashmir.

(v) Recent Geomagnetic Reversals and Related Climatic Changes

Geological samples collected from some of the fast rate thick sediments of lakes such as Karewa in Kashmir can provide data on changes in the ambient magnetic field which can be studied for changes in associated climatic forcings.

(vi) Palaeohydrological Studies

Studies relating to past water channels, ground water sources, past floods and hydrological cycle using palaeosols, sedimentation and radioactive tracer techniques.

Palaeoclimate and Palaeo Environmental Modeling

- (i) Simulation of the regional climate patterns from 2,000 BP to the present, using available palaeoclimatic indicators for the Indian region.
- (ii) Simulation of glacial-interglacial transitions, using data on possible forcing factors corresponding to the glacial periods of the past i.e. 120 kyr BP, 70 kyr BP and 18 kyr BP.

5.5 Global Change and Terrestrial Ecosystems (GCTE)

Preliminary experiments on temperature effects on terrestrial ecosystem are in progress at NBRI, CO₂ enrichment study (short-term growth chamber experiments as well as field scale studies) will be taken up later. Two types of studies were undertaken. (i) Field study and (ii) Laboratory study.

Field study involved evaluation of the enhanced UV-B effects on several crop plants, viz: Paddy and Mustard, using UV-B doses 15 to 25 % higher than ambient for paddy and 50 to 100 % for mustard. Various assays i.e. plant growth analysis CO₂ uptake, photosynthetic electron transport, RuBP carboxylase activity, pigments, proteins, shoot biomass and grain yield were performed.

Laboratory study was undertaken on *Brassica napus* to understand the molecular mechanism of UV-B action in crop plants. The analysis of psbA (encoding for one of the subunits of the reaction center complex of photosystem II) transcript was carried out by isolation of RNA, northern blotting and hybridization with ³²P labeled psbA sequences.

5.6 Joint Global Ocean Flux Studies (JGOFS)

5.6.1 Focus on the Arabian Sea

The role of the Arabian sea, a highly biologically productive region of the ocean. Specific areas are:

- (i) Role of the Arabian sea in controlling atmospheric CO₂ content
- (ii) Processes that control the downward transport of carbon and associated elements in the Arabian sea and their fluxes. Does the presence of the denitrification layer alter the magnitude and/or the composition of settling particulate flux?
- (iii) The burial rate of carbon and associated elements in the margins and deep regions of the Arabian sea and their relation to water column processes, the temporal and spatial variations in the palaeo-fluxes of biogenic elements vis-a-vis present day fluxes measured via traps
- (iv) Role of the continental margin in the removal/supply of materials to the deep Arabian sea. Does it have any significant control on the formation and maintenance of the denitrification layer at mid depths?

5.6.2 Air-sea Exchange of CO₂: The Biological Pump

To study the removal of atmospheric CO₂ via the Biological Pump, through measurement of total (using satellites) and net productivity.

Atmospheric CO₂ concentrations over the ocean will be obtained by flask sampling method of Francey et al. and in cooperation with CSIRO, Australia. CO₂ content of the air in the samples will be determined by non-dispersive infrared analyzer and its isotopic contents will be determined by stable isotope mass spectrometer.

5.6.3 Material Transport in the Water Column and Particle Transformation Processes

NIO has a major programme (jointly with University of Hamburg, FRG) to determine vertical fluxes of biogenic and inorganic materials in the Arabian sea, the Bay of Bengal and the Central Indian ocean using traps. This programme has been underway for the past 3-4 years. The results show considerable spatial and temporal seasonal variations in the settling flux of material, which are related to monsoon wind forcing. This programme is being continued. A special study will concentrate on the seasonal forcing of the Arabian sea by the monsoon wind systems and its effect on the chemical and biological make-up of the waters.

PRL Contribution

PRL will work on:

- (i) determination of the nature and extent of radiative disequilibrium between various members of U-Th series nuclides such as ²³⁴Th, ²³⁸U, ²¹⁰Po and ²¹⁰Pb, ²²⁶Ra in the Arabian sea water column with emphasis in the top-1,000 m.
- (ii) the relation between the extent of disequilibrium, settling fluxes of radionuclides at the base of euphotic zone, and primary and export production. To assess the utility of ²³⁴Th, ²³⁸U disequilibrium as a global survey monitor of export production.
- (iii) the role of oxygen deficient layer of the Arabian sea in scavenging of radionuclides.
- (iv) modeling the results to obtain "effective diffusion coefficients", new production and particle aggregation break up kinetics.

5.6.4 Role of Continental Margins as Sources/Sinks of Materials to the Deep Arabian Sea

The Arabian sea is one of most biologically productive oceanic regions. The sediments of the margins contain high concentrations of organic carbon and are often reducing. These sediments also have distinctly different concentrations of several nutrients and trace elements. It is also well known that the waters of the entire Arabian sea are characterized by oxygen depletion at mid-depths. Do the shelf and marginal sediments containing high concentrations of organic matter have any role to play in the formation and maintenance of the denitrification layer? Can one use chemical and isotopic tracers to quantify the exchange of materials between the open Arabian sea and the margin sediments? What is the global significance of Arabian sea margin processes on the removal/supply of carbon, nutrient and other biogenic elements to the ocean interior?

5.6.5 Cruise Plans

- Total ship days : Three cruises of approximately 30 days each of ORV Sagar Kanya.
- Cruise schedule : First in April 1993.
Second in August 1993.
Third in January 1994.
- Stations : Total eight stations including present three trap stations, i.e. east, central and west.
- Time at each station : Approximately 48 hours.